High-level Critical Infrastructure Risk Assessment (CIRA) in the Region of Çukurova (Turkey)

Technical Report

May 2018

1 2 3 4 18 17 16 15

Table of contents

Executive Summary

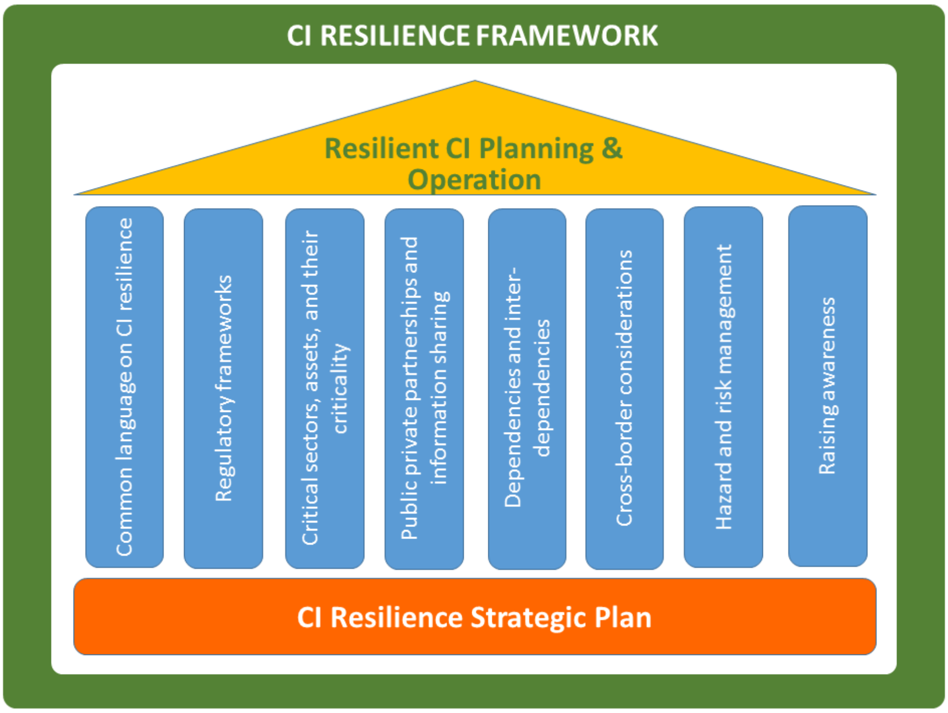
Critical infrastructure plays a fundamental role in the economic and social development of national, regional and local economies. It provides essential services which, if they are disrupted, can have severe impacts on health, security and economic performance. In an increasingly interconnected world, failure in critical infrastructure can have cascading impacts within and across sectors, and even transnationally.

The World Bank and Çukurova Development Agency (ÇKA) have collaborated on a study which assesses the risks posed by natural hazards to critical energy and transport and logistics infrastructure in Çukurova Region, and provides recommendations for improving resilience. Çukurova Region is prioritized in Turkey's Tenth National Development Plan as one of the most promising economic development regions in the country. It is a critical hub for energy and transport and logistics, connecting Europe, Middle Asia and the Mediterranean Basin, and there are plans for large investments in critical infrastructure. However, Çukurova is a well-known seismically active region and is at high risk from climate change induced events, making investments in critical infrastructure (CI) resilience vital. The study assesses risks to selected CI facilities in the region from a range of geological and climatological hazards for the present day, 2030s and 2050s, taking account of how climatological hazards may change in the future due to man-made climate change. The hazards assessed included earthquakes; earthquake-induced landslides; coastal, riverine and flash floods; heatwaves; windstorms; tornadoes; and precipitation-induced landslides.

Coastal flooding and heatwaves, both of which are exacerbated by climate change, emerge from the study as the most important natural hazards for critical energy and transport and logistics facilities in the region, now and in the future. These hazards were found to have the largest effects on the economy, due to temporary loss of the essential services provided by the infrastructure. Furthermore, the study found that climate change impacts will intensify over time, unless action is taken to improve resilience. The effects of disruption due to flooding and heatwaves on some CI facilities in the region, including major power plants and ports, could be felt nationally or even transnationally. While earthquakes rightly garner a lot of attention, the study found that they appear to pose lower risk to critical infrastructure in Çukurova than climate hazards, due to their relatively lower chance of occurring and because infrastructure is designed to withstand them.

The current state-of-play in Turkey is that the legislative, planning, design and operational processes driving and supporting critical infrastructure investments are yet to fully address the issue of a changing natural hazards landscape. International best practice shows that planning policy frameworks at all scales – local, regional, national and across national borders – have critical roles to play in integrating multi-hazard resilience, including climate change. International experience also shows that site selection decisions, infrastructure feasibility studies, design standards and environmental impact assessments are key instruments for incorporating resilience into CI. However, in Turkey, climate-related risks that could jeopardize investment decisions in the medium and longer term remain largely unaccounted for. There is little evidence that changing climate risks are being explicitly considered in CI projects financed or commissioned by the public and private sectors. Despite there being a national climate change adaptation plan and strategy in Turkey, there is no requirement for infrastructure owners and operators to assess climate change risks and implement adaptation action plans.

Key principles have been identified for national and regional policymakers in Turkey, together with the private sector, to improve critical infrastructure resilience. The principles work together towards the overall objective of increased resilience in CI planning and operation. Drawn from international best practice, they encompass better knowledge and information sharing, strengthening existing policy frameworks, and partnership working between public and private sector stakeholders. As a unitary state with highly centralized political, governance and administrative structures, national planning objectives in Turkey cascade down to the regional level through Regional Development Agencies (RDAs) via regional plans. RDAs such as ÇKA can also promote a bottom-up approach for CI resilience requirements from the regional level towards the national level. With more and more infrastructure in Turkey being owned and operated by the private sector, partnership working on resilience between government and private sector stakeholders is increasingly important.



Key principles of a critical infrastructure resilience framework

A CI resilience strategic plan, backed by strong political commitment, needs to be developed in close consultation with all relevant stakeholders and communicated effectively. A common understanding of CI resilience should be defined among stakeholders, and existing policy frameworks and standards should be evaluated. This would lead to identification of the gaps in the policy arena, resulting in recommendations for policy improvements. Critical sectors and critical infrastructure facilities also need to be defined and their level of criticality should be evaluated.

Public-private partnerships (PPPs) are essential for effective implementation of the CI resilience framework and should be its centrepiece. Partnership working is important for identifying and evaluating risks fully, for defining optimal sector-specific CI resilience plans, and for targeting effective policy interventions. Strong partnerships can also help prevent or at least mitigate disruption to essential services through coordinated planning, using instruments such as Business Continuity Plans. An information sharing mechanism needs to be established through the partnership, to improve cooperation and collaboration among stakeholders. Academic institutions can undertake research and development addressing knowledge gaps identified by the partnership.

System-wide risks, cascading impacts and cross-border impacts need to be evaluated. CI dependencies and interdependencies are increasing, between sectors, regions and countries. CI dependency and interdependency are major challenges for risk management and make entire systems inherently vulnerable to disruptions due to cascading impacts. The bridging role of Turkey, and Çukurova Region specifically, between Europe and the Middle East, Caucasus and Asia drives the need for cross-border interdependencies to be taken into account in CI resilience planning. This is a key principle of the EU critical infrastructure resilience framework with which Turkey wishes to align.

Policy-making and decision-making on critical infrastructure should be 'risk based', informed by sound evidence on natural hazards and robust risk assessments. Improved understanding of natural hazards, the associated risks to CI and the consequences of service interruptions for the economy and society can feed into planning policies, infrastructure development processes and operating procedures for existing facilities. Awareness raising and capacity building should aim to enlighten public and private stakeholders on international best practices in CI resilience, and to address knowledge gaps which are impeding action.

At the level of individual CI facilities, a broad suite of non-structural and structural measures can be implemented by critical infrastructure owners and operators to build resilience to natural hazards. Non-structural measures, such as management and operational changes, can contribute to *ex-ante* resilience, and they are often less costly than structural measures. They are also inherently flexible, contributing to adaptive management in the face of future climate change uncertainties. Structural measures should be considered at the early stages of design and planning for new CI investments, or during rehabilitation or renovation of existing facilities, to minimize costs.

International sources of climate finance are available to support improvements in policy-making, together with investments in non-structural and structural resilience measures at CI facilities. Climate finance can potentially be accessed by national government, regional development agencies such as ÇKA, local (municipal) planning authorities, and owners and operators of critical infrastructure. The study prioritized 11 international climate funds which could be viable funding options for the implementation of resilience building measures for energy and transport and logistics in Turkey, and Çukurova Region specifically. It is recommended that discussions are started with these funds so that these opportunities can be progressed.

Acronyms

ALA	American Lifelines Alliance
ASCE 7-10:	Minimum Design Loads for Buildings and Other Structures
AFAD	Prime Ministry Disaster and Emergency Management Authority
AMSL	Above Mean Sea Level
BOTAŞ	Petroleum Pipeline Corporation Boru Hatları ile Petrol Taşıma Anonim Şirketi
BTC	Baku-Tbilisi-Ceyhan Oil Pipeline
CCGT	Combine Cycle Gas Turbine
CIRIA	Construction Industry Research and Information Association
CMIP5	Coupled Model Intercomparison Project Phase 5
DEM	Digital Elevation Model
DFO	Dartmouth Flood Observatory
DHMI	Devlet Hava Meydanları İşletmesi Genel Müdürlüğü (General Directorate Of State Airports Authority)
DHS	Department of Homeland Security (of the USA)
DMP	Disaster Management Presidency
DRM	Disaster Risk Management
EM-DAT	The international disasters database
ENTSO-E	European Network of Transmission System Operators for Electricity
EPDK	Enerji Piyasası Düzenleme Kurumu (Energy Market Regulatory Authority)
EPPs	Electric power plants
EÜAŞ	Elektrik Üretim A.Ş. (Electricity Generation Company)
FAO	Food and Agricultural Organization
GCMs	General Circulation Models
GDP	Gross Domestic Product
GHCN	Global Historical Climatology Network
GHG	Greenhouse Gas
GFDRR	Global Facility for Disaster Reduction and Recovery
GLOFRIS	Global Flood Risk with IMAGE Scenarios
GWh	GigaWatthours
HAZUS	Hazards United States
HPP	Hydropower Plant
HWI	Heat Wave Intensity
HWL	Heat Wave Length
HWN	Heat Wave Number
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPCC AR4	Intergovernmental Panel on Climate Change Fourth Assessment Report
IPCC AR5	Intergovernmental Panel on Climate Change Fifth Assessment Report
ISPAT	Investment Support and Promotions Agency of Turkey
KGM	Karayolları Genel Müdürlüğü. (General Directorate of Highways)
KNMI	Royal Netherlands Meteorological Institute
LECZ	Low Elevation Coastal Zones
MENR	Ministry of Energy and Natural Resources

MGD	Meteorology General Directorate
MIP	Mersin International Port
MoD	Ministry of Development
MoEU	Ministry of Environment and Urbanization
MoEW	Ministry of Environment and Urbanization and Public Works
MMI	Modified Mercalli Intensity
MTA	General Directorate of Mineral Research and Exploration
Mtoe	million tons of oil equivalent
MVA	Mega-Volt-Ampere
MW	Megawatt
NIACC	National Infrastructure Advisory Council (of the USA)
NCEI	National Centers for Environmental Information
NEHRP	Recommended Seismic Provisions for New Building Structures
NOAA	National Oceanic and Atmospheric Administration (of the USA)
NPP	Nuclear Power Plant
OECD	Organisation for Economic Cooperation and Development
PGA	Peak Ground Acceleration
PGD	Permanent ground (fault) deformation / displacement
PGV	Peak Ground Velocity
RCP	Representative Concentration Pathways
SLR	Sea Level Rise
SRES	Special Report on Emissions Scenarios
SREX	Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SRTM	Shuttle Radar Topography Mission
SST	Sea Surface Temperature
SSP	Shared Socioeconomic Pathway
TABB	Turkish Disaster Database
TEDAŞ	Türkiye Elektrik Dağıtım A.Ş. (Turkey Electricity Distribution)
TEİAŞ	Türkiye Elektrik İletim A.Ş. (Turkish Electricity Transmission Company)
TETAŞ	Türkiye Elektrik Ticaret ve Taahhüt A.Ş. (Turkish Electricity Trading Company)
TKİ	Türkiye Kömür İşletmeleri Kurumu (Turkish Coal Enterprises)
TPP	Thermal Power Plant
TR2015	Climate Change Projections for Turkey with the New Climate Scenarios
UNEP GAR	United Nations Environment Global Assessment Report on Disaster Risk Reduction
YÖİKK	Yatırım Ortamını İyileştirme Koordinasyon Kurulu (The Coordination Council for the Improvement of Investment Environment)

1. Introduction

1.1. Project context and objectives

The region of Çukurova is of particular importance in Turkey's national development and growth agenda. It is a critical hub for both logistics and energy serving as a platform connecting Europe, Middle Asia and the Mediterranean Basin. The Tenth National Development Plan indicates the intention to have Ceyhan as an energy hub and ensure the area develops as a significant logistic center to support the integration of Turkey within the European Union (EU) Trans-European Transport Network. Accordingly, the region is seen as a potential new metropolitan area and there are plans for several large infrastructure investments, including Akkuyu Nuclear Power Plant, Çukurova Airport, Yenice Logistics Center, the Mediterranean Highway, Ceyhan Energy Specialization Zone and the Tarsus-Kazanli Coast Line Project, etc. But Çukurova is also a well-known seismically active region and is at high-risk from climate change induced events. The latest major event in the region was the 1998 magnitude 6.2 earthquake in Ceyhan, and in recent years, the region suffered numerous urban floods, hail storms which damaged crops, and landslides, etc. While the increasing investments drive up exposure, the critical nature of the infrastructure means that impacts can cascade well beyond the region and even beyond national borders. For these reasons, the region of Çukurova was selected as a pilot region for a study on critical infrastructure resilience.

To build resilience into existing infrastructure and guide the investment agenda, the World Bank, in collaboration with Çukurova Development Agency (ÇKA), undertook a high-level Critical Infrastructure Risk Assessment (CIRA) for two priority sectors: energy and transport/logistics. ÇKA is one of the first two agencies established to foster regional development in Turkey. Working for efficient and effective use of resources, it sets the regional vision and strategies and supports its implementation. To do this, it leads the elaboration of 5 and 10-year development plans for the region and has its own investment funding to assist local actors implement the development plan. The region's growth aspirations and its drive for competitiveness require action through targeted measures to strengthen the resilience of its critical infrastructure (CI) to disasters and a changing climate. This itself can only be achieved through a unified approach by infrastructure designers, developers and operators as well as leading agencies such as ÇKA. By building and promoting resilience at the structural as well as institutional levels, the region can continue to attract investments in its infrastructure which helps deliver regional, and therefore national, socio-economic aims and objectives.

The CIRA has three objectives:

(i) to develop a pragmatic approach for critical infrastructure risk management,
(ii) to improve the planning process by providing policy recommendations for risk management, and
(iii) to suggest next steps for action and to share existing best practices.

1.2. Conceptual overview of approach to the CIRA

The CIRA comprises of the following steps (see Figure 1-1) which are discussed further in Sections 2 to 8 of this report:

Step 1 Defining critical infrastructure (CI) for the Çukurova CIRA
Step 2 Overview of the energy and transport & logistics sectors in Çukurova
Step 3 Identifying CI in Çukurova's energy and transport & logistics sectors
Step 4 Undertaking a natural hazard risk assessment

Step 5	Analysing current approaches to CI planning & management
Step 6	Providing recommendations for improving the resilience of CI
Step 7	Identifying sources of funding to build climate resilience into Critical Infrastructure Energy and Transport & Logistics assets.

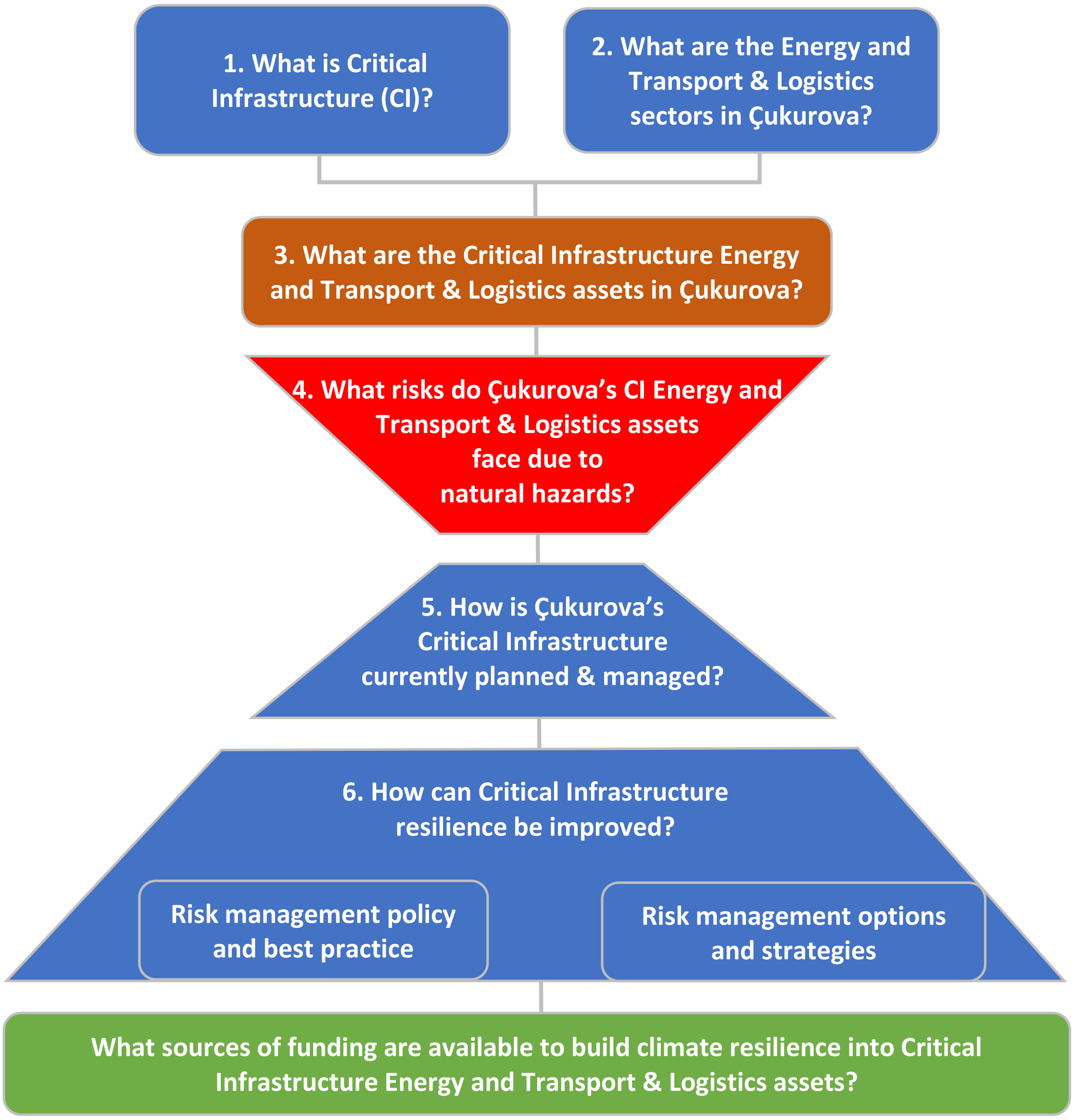


Figure 1-1: Conceptual approach to the CIRA. (Source: Report authors).

2. Defining Critical Infrastructure (CI) for the Çukurova CIRA

2.1. Introduction

The CIRA requires an agreed definition and criteria for identifying 'critical infrastructure'. A review was undertaken of approaches used by several governments and supra-national government organisations for:

- Defining critical infrastructure (Section 2.2);
- Criteria used to rank infrastructure, to determine what is deemed as 'critical' (Section 2.3).

The results of the review are presented in Annex A1. A short summary, together with recommendations for the definitions and criteria to be applied in the Çukurova Region, are presented respectively in the following sub-sections. These are subsequently used to identify a list of critical infrastructures that are assessed in the CIRA (see Section 4).

Summary of key points

- According to Turkey's Disaster and Emergency Management Presidency, AFAD, 'critical infrastructure' is defined as the *'Combination of networks, assets, systems and structures which can have serious impacts on health, security, and economy of citizens due to adverse impacts on environment, society order and public services that occur as a result of partial or complete loss of functionality of such networks, assets, systems and structures.'*
- Across many jurisdictions globally, Infrastructure 'criticality' is categorised according to the impacts that its loss of function would have on:
  - Essential services,
  - The economy,
  - Life

  - with interdependency / cascading impact being considered within these three criteria.

2.2. Definitions of Critical Infrastructure

The definitions used by the OECD, NATO, UNISDR, EU, UK, USA, Australia, Mexico and Turkey are summarized in Table 2-1, along with the drivers for action to protect critical infrastructure. The definitions have many common elements, including references to:

- Loss/destruction or disruption of essential functions or services,
- Consequences of the above for health, safety, security, economy, society.

Given that Turkey's Disaster and Emergency Management Presidency, AFAD, has provided a definition of CI, and that this definition is comprehensive when compared to other definitions, the AFAD definition is used in the Çukurova CIRA.

Table 2-1: Summary of definitions of critical infrastructure. (Source: Report authors).

Jurisdiction	Definition
Organisation for Economic Co-operation and Development (OECD)	*'Those interconnected information systems and networks, the disruption or destruction of which would have a serious impact on the health, safety, security, or economic well-being of citizens, or on the effective functioning of government or the economy.'*
North Atlantic Treaty Organization (NATO)	*'Physical or virtual systems and assets under the jurisdiction of a State that are so vital that their incapacitation or destruction may debilitate a State's security, economy, public health or safety, or the environment.'*

UN Office for Disaster Risk Reduction (UNISDR)		*'The primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency.'*
Jurisdiction	**Drivers**	**Definition**
EU (Official Journal of the European Union (OJEC))	Terrorism, all hazards	*'An asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions'*
UK (Cabinet Office)	Flooding, natural hazards	*'Those infrastructure assets (physical or electronic) that are vital to the continued delivery and integrity of the essential services upon which the UK relies, the loss or compromise of which would lead to severe economic or social consequences or to loss of life'.*
USA (Department of Homeland Security (DHS))	Terrorism, natural hazards	*'Systems and assets, whether physical or virtual, considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof'.*
Australia (Australian, State and Territory governments)	Terrorism, all hazards	*"Those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of the nation or affect Australia's ability to conduct national defence and ensure national security."*
Mexico (Secretariat of Public Security (SSP))	Terrorism, natural hazards, all hazards	*'Those assets, services and networks that are indispensable to the support and maintenance of the well-being of the Mexican population.'*
Turkey (Afet ve Acil Durum Yönetimi Başkanlığı (AFAD)	Terrorism, all hazards	*'Combination of networks, assets, systems and structures which can have serious impacts on health, security, and economy of citizens due to adverse impacts on environment, society order and public services that occur as a result of partial or complete loss of functionality of such networks, assets, systems and structures.'*

2.3. Criteria for identifying Critical Infrastructure

The criteria for identifying CI given by the EC, UK, Germany, USA and Turkey are summarized in Table 2-2. There are three criteria for the consequence of impact which are common across most of the jurisdictions, namely:

1. **Impacts on essential services,**
2. **Economic impact (sometimes including environmental effects),**
3. **Impacts on life.**

As further detailed in Annex A1.3, the factors that are applied to the above three criteria to distinguish between different degrees of impact (and hence to classify critical infrastructure) typically include:

- Severity of the impact,
- Extent of the impact, for instance in terms of geographical extent or population impacted,
- Duration.

Table 2-2: Summary of impact criteria for identifying critical infrastructure. (Source: Report authors).

	Impact criteria						
Jurisdiction	**Essential services**	**Economic**	**Life**	**Interdependency / cascading impact**	**Mass evacuation length of time**	**National security**	**Environment**
EU (OJEC)	✓ (1)	✓ (2)	✓ (3)	(✓) (4)			(✓) (5)
UK (Cabinet Office)	✓	✓	✓	(✓) (6)			
Germany (BBK)	✓	✓	✓ (7)	(✓) (8)			
USA (DHS)		✓	✓ (9)	(✓) (10)	✓	✓	
Turkey (AFAD)	✓ (11)	✓	✓ (11)	✓			✓

Notes:

(1) OJEC refers to 'Public effects' - assessed in terms of the impact on public confidence, physical suffering and disruption of daily life, including the loss of essential services.
(2) OJEC's reference to 'economic effects' includes environmental effects and cascading effects
(3) OJEC refers to 'casualties' including fatalities and injuries
(4) OJEC states that 'cascading effects should be counted where it can be demonstrated that they can be reasonably calculated' as part of the 'economic effects' criterion
(5) OJEC includes environmental impacts under the 'economic impacts' criterion
(6) The Cabinet Office states that the loss of Category 5 assets 'would have national long-term effects and may impact across a number of sectors'
(7) BBK refers to 'mortality'
(8) BBK states that 'interdependencies and cascading effects leading to different impact entry-points must be evaluated'
(9) DHS refers to 'fatalities'
(10) DHS states that consequences of disruption to critical infrastructure should include 'impacts that might cascade to other infrastructure assets.'
(11) AFAD refers to 'physical impact' and 'public impact'

Interdependency / cascading impact is not typically stated as a stand-alone impact criterion but is described as an issue to consider when evaluating the other criteria. The exception to this is Turkey (AFAD) where interdependency is listed alongside the other criteria. Figure 2-1 shows interdependencies between different types of infrastructure; interdependencies and cascading impacts can also occur between the infrastructure sector and other economic sectors.

For the UK, information is publicly available on the approach to categorisation of the nation's critical infrastructure as follows:

'Infrastructure is categorised according to its value or "criticality" and the impact of its loss. This categorisation is done using the Government "Criticality Scale", which assigns categories for different degrees of severity of impact. [1]

Table 2-3 provides broad descriptions of the types of infrastructure that would be categorized at the different levels in the UK. For example, Category 5 indicates infrastructure which would have the most severe impact when it is disrupted, whereas Category 0 indicates infrastructure whose loss would be minimal when considered in the national context. Critical infrastructure is defined as infrastructure which falls into Categories 3, 4 or 5.[2]

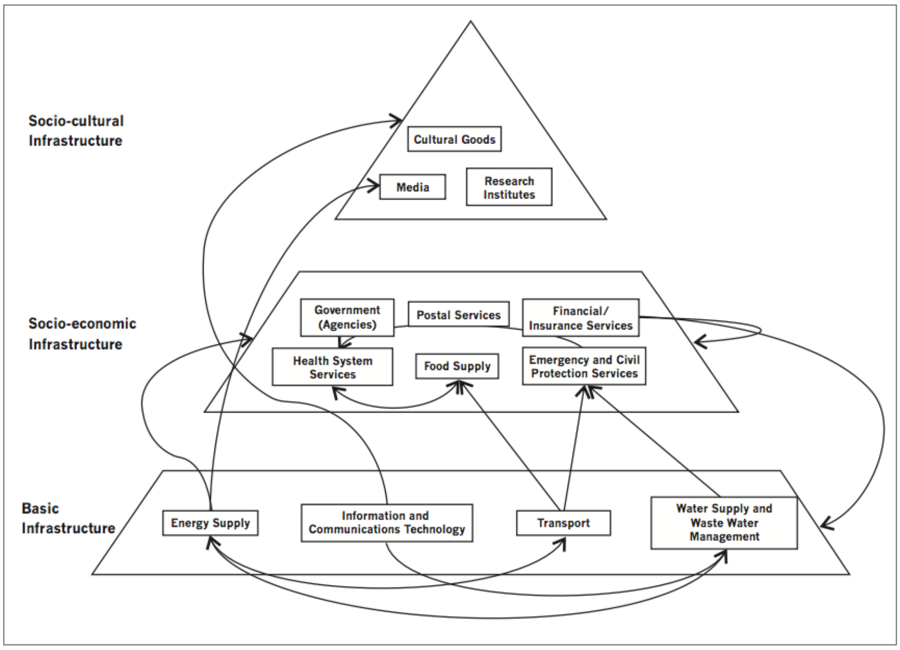


Figure 2-1: Interdependencies of infrastructure. (Source: Lauwe and Riegel, 2008[3]).

Table 2-3: UK Cabinet Office categorisation of infrastructure criticality and criticality scale. (Source: UK Cabinet Office, 2010[4]).

Criticality Scale	Description
Category 5	This is infrastructure the loss of which would have a catastrophic impact on the UK. These assets will be of unique national importance whose loss would have national long-term effects and may impact across a number of sectors. Relatively few are expected to meet the Category 5 criteria.
Category 4	Infrastructure of the highest importance to the sectors should fall within this category. The impact of the loss of these assets on essential services would be severe and may impact provision of essential services across the UK or to millions of citizens
Category 3	Infrastructure of substantial importance to the sectors and the delivery of essential services, the loss of which could affect a large geographic region or many hundreds of thousands of people
Category 2	Infrastructure whose loss would have a significant impact on the delivery of essential services leading to loss, or disruption, of service to tens of thousands of people or affecting whole counties or equivalents
Category 1	Infrastructure whose loss could cause moderate disruption to service delivery, mostly likely on a localized basis and affecting thousands of citizens
Category 0	Infrastructure the impact of the loss of which would be minor (on a national scale)

For the jurisdictions reviewed in this section, precise thresholds are not publicly available (through an internet search) on how each jurisdiction ranks its critical infrastructure against these criteria, and this information is typically described as 'classified'. A common theme from the jurisdictions studied is that there should only be a small number of infrastructures that achieve the highest ranking. With this limitation in mind, the criteria for identifying CI as set out in this section are applied to Çukurova Region in Section 4.

3. Energy and transport & logistics sectors in Çukurova

3.1. Introduction

This section provides a description of the energy and transport / logistics sectors in Çukurova Region, which in combination with the definitions and criteria of criticality (Section 2) can be used to identify Critical Infrastructure in the Çukurova Region (Section 4).

Summary of key points

- Turkey sits between major energy producing countries in the Middle East and Central Asia, and European countries where energy demand is high. This provides opportunities for Turkey to ensure its own energy supply security and to play a significant role with regards to regional energy security.
- The country also plays a central role in enabling Europe to access growing markets in the Middle East, the Caucasus and Asia via its transport and logistics networks.
- National energy demand has grown, and is projected to continue to grow rapidly, driven by industrialization and urbanization.
- The Tenth National Development Plan (2014-2018) stresses the importance of reducing import dependency in the energy sector through increased utilization of domestic resources. It also aims to transform the transport and logistics sector, with the aim of making Turkey a regional hub in logistics.
- Turkey is embracing an ambitious agenda of large-scale infrastructure projects in energy and transportation, with a strong emphasis on Public Private Partnership (PPP) models to attract private sector resources to infrastructure investments.
- Çukurova Region is noted in the Tenth National Development Plan as a critical hub for energy and transport/logistics, both within Turkey and transnationally. The region already includes key infrastructure facilities, with more large infrastructure investments in energy and transport/logistics under development.
- Çukurova Development Agency, ÇKA, established in 2006, was one of the first two regional development agencies in Turkey. Its main purpose is to foster economic and social development in Çukurova Region, and to increase the region's competitiveness.

The scope of the energy and transport and logistics sectors in the Çukurova Region covered in this analysis includes the following:

- Power generation
- Power transmission and distribution
- Oil and natural gas distribution facilities and infrastructure
- Road networks
- Railway networks
- Viaducts / bridges
- Airports and seaport infrastructure and facilities
- Seaport infrastructure and facilities
- Logistic hubs and warehouses.

Section 3.2 provides an overview of the drivers which influence the energy and transport / logistics sectors in Çukurova Region at various scales (international, national and regional). Annexes A2.1 and A2.2 describe the energy and transport / logistics sectors in Çukurova Region in detail, including:

- An overview of the current situation, i.e. existing infrastructure,

- Projections for the future development of the sector,
- A description of sector stakeholders.

3.2. Drivers affecting the energy and transport & logistics sectors in Çukurova Region

3.2.1. Overview

The region of Çukurova is of particular importance in Turkey's development and growth agenda. It is a critical hub for energy and transport/logistics, connecting Europe, Central Asia and the Mediterranean Basin, and is the closest sea gateway for natural resources-rich Near East and prosperous inner Anatolia. The Turkish government is aiming to make the region, and in particular the cities of Adana and Mersin, an alternative pole for urban development, commerce and tourism, since the Marmara region is already over-populated. The Tenth National Development Plan indicates the intention to have Ceyhan as an energy hub and ensure the area develops as a significant logistic centre to support the integration of Turkey within the EU Trans-European Transport Network. Accordingly, there are plans for several large infrastructure investments in energy and transport/logistics, including Akkuyu Nuclear Power Plant, Çukurova Airport, Ceyhan Energy Specialization Zone, Tufanbeyli Thermal Power Plant, Yenice Logistics Center and the Mediterranean Highway.

3.2.2. International sectoral drivers

Turkey has experienced adverse circumstances over the past three years, including four national elections, wars across the southern border, domestic tensions in the Eastern regions, trade restrictions with Russia and the inflow of millions of refugees from Syria since 2011. According to the United Nations Refugee Agency, as of early March 2016, more than 2.7 million registered Syrian immigrants resided in Turkey. Furthermore, a series of recent terrorist attacks has affected general confidence. Despite these negative factors, Turkey's economic growth has proved 'remarkably vigorous' according to the OECD, at 4% in 2015 and 4.8% in the first quarter of 2016[5].

3.2.2.1. Energy

Turkey sits between major energy producing countries in the Middle East and Central Asia, and European countries where demand for energy is high. It is geographically located in close proximity to more than 75% of the world's proven oil and gas reserves, making it a natural transit country for maritime and pipeline transportation of gas and oil[6]. This unique location provides opportunities for Turkey to ensure its own energy supply security and to play a significant role with regards to regional energy security.

Regional energy cooperation is one of the most important subjects of Turkey-EU relations, and Turkey joined the Energy Community with an observer status in 2006. (The Energy Community, founded in 2005, aims to have an integrated energy market supporting competition between EU members and non-EU members of South East Europe as well as other neighbouring countries.) Energy relations between Turkey and EU constitute a "positive agenda item",[i] and there have been two Turkey-EU High-Level Energy Dialogues in 2015 and 2016[7].

As a manifestation of this close cooperation, power transmission system linkages between Turkey and the EU have been established. The Turkish Electricity Transmission Company (TEİAŞ) and the European Network of Transmission System Operators for Electricity (ENTSO-E) signed a long-term agreement on 15 April 2015, providing permanent physical integration of the Turkish and EU electricity markets. Furthermore, to help create an integrated EU energy market, the European Commission has drawn up a list of key energy infrastructure projects known as projects of common interest (PCIs). PCIs benefit from accelerated planning and permit granting and access to financial support from the EU Connecting

[i] The European Commission in its Enlargement Strategy published on 12 October 2011 proposed to develop a "Positive Agenda" between Turkey and the EU. The Commission mentioned a broad range of areas as the main elements of the Agenda, including energy.

Europe Facility (CEF) from 2014-2020. Turkey is part of a PCI Cluster called the 'Priority Southern Gas Corridor' for the transportation of natural gas from the Caspian Region, crossing Azerbaijan, Georgia and Turkey and reaching EU markets in Greece and Italy. Turkey's elements of this PCI Cluster include the 'Trans Anatolia Natural Gas Pipeline' (TANAP) and a gas interconnector between Turkey and Bulgaria[8].

Looking to the future, the global energy sector is in a constant state of flux, with changes in the world regions showing strong demand growth, new reserves being exploited, intensifying international policy drivers for renewables, and large fluctuations in prices of energy commodities. In a global energy market, these drivers will also affect Turkey's energy sector going forward.

The International Energy Agency's (IEA) World Energy Outlook[9] and BP Statistical Review[10] identify the following drivers as being most significant for the energy sector globally:

- China's role in driving global energy trends is changing as it enters a much less energy-intensive phase in its development. In 2015, China's energy consumption grew at its slowest rate in almost 20 years, though it remained the world's largest growth market for energy.
- The coverage of mandatory energy efficiency regulation worldwide has expanded to more than a quarter of global consumption. Renewables contributed almost half of the world's new power generation capacity in 2014.
- The Paris Agreement, reached at COP21 in late 2015, is aimed at limiting the global temperature increase to well below 2°C and pursuing efforts to limit the increase to 1.5°C above pre-industrial levels. It entered into force on 4 November 2016. This give new impetus to the move towards a lower-carbon and more efficient energy system.
- The supply of energy in recent years is being driven by various factors, such as technological advances that have increased the availability of different fuels. The US shale revolution has unlocked huge oil and gas resources. At the same time, rapid technological gains have supported strong growth in renewable energy, led by wind and solar power.
- Oil and gas prices are subject to geopolitics between major producing countries. For instance, oil prices in late 2016 more than halved from their high of $115 a barrel in mid-2014, as geopolitics in the Middle East between Saudi Arabia and Iran worsened the global glut, with both countries upping their production.

According to scenario planning by the IEA, energy use worldwide is set to grow by one-third to 2040 in the IEA's central scenario, driven primarily by India, China, Africa, the Middle East and Southeast Asia (Figure 3-1). China is projected to remain the world's largest producer and consumer of coal, and [ii]by the 2030s it is expected to overtake the United States as the largest consumer of oil, and to have a larger gas market than the European Union. By 2040, India's energy demand is projected to be similar to the United States, though demand per capita is expected to remain 40% below the world average. However, demographic and structural economic trends, combined with greater efficiency, are projected to reduce total consumption in OECD countries from the peak reached in 2007.

From the point of view of Turkey-EU energy trade, the IEA's scenario analysis indicates that the economic benefits Turkey enjoys as a transit country for oil and gas to the EU could be reduced: due to energy efficiency improvements, energy demand in the EU is projected to decline more rapidly than anywhere else in the world, by 15% over the period to 2040[9].

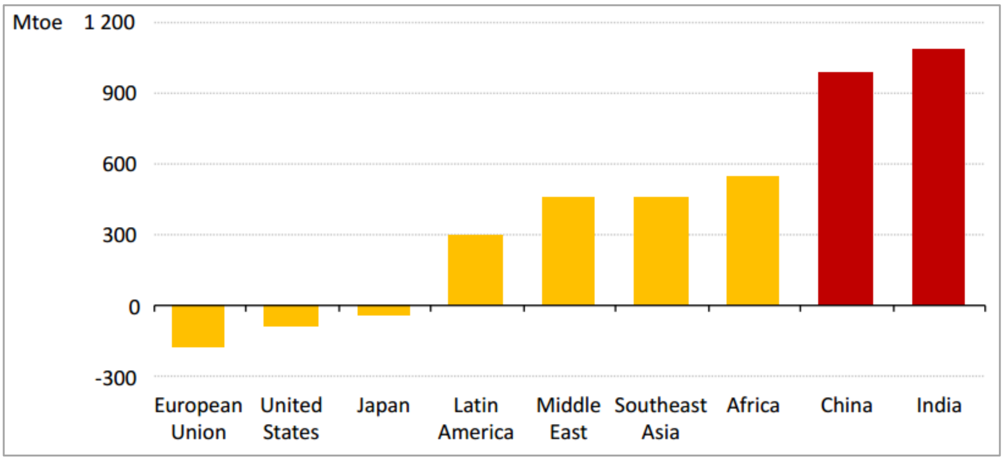


Figure 3-1: Projected changes in energy demand in selected regions, 2014-2040, under the International Energy Agency's central scenario. (Source: IEA, 2015[9]).

3.2.2.2. Transport and logistics

According to the Investment Support and Promotion Agency of Turkey (ISPA), the country's strategic location provides access within a four-hour flight radius to multiple markets with a combined population of 1.6 billion people, a combined GDP of USD 27 trillion, and more than USD 8 trillion of foreign trade, corresponding to around half of total global trade[11].

Turkey's share in world exports has increased since 2011, though, according to the OECD, this reflected strong growth of its trade partners rather than market share gains (Figure 3-2).

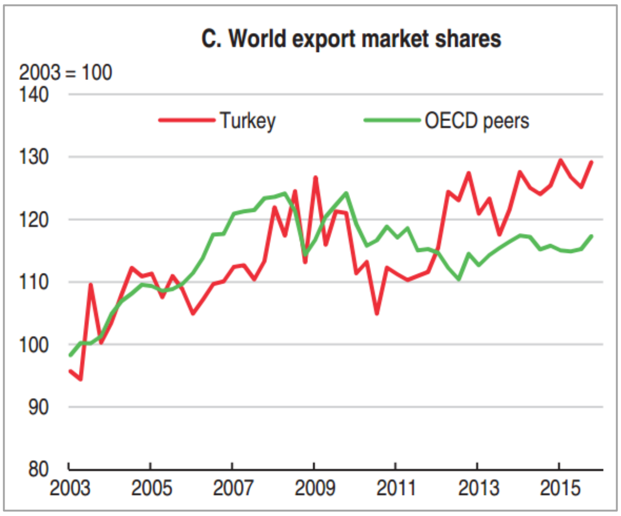


Figure 3-2: World export market shares for Turkey and its OECD peers. (Source: OECD, 2016[12]).

International export destinations of most importance for Çukurova Region

Based on export statistics, it can be seen that the majority of export products from Çukurova Region are sold to the Middle East (50%) with Iraq accounting for 28.3% of total regional exports in 2015 (Figure 3-3). Europe accounts for 27% of the export revenues of the region, and Russia and FSU States, 16%. Therefore, the economic performance of these world regions, together with the strength of Turkey's trade relationships with them, can have deep effects on the transport and logistics sector in Çukurova. This was demonstrated in 2015, when sharp contractions in regional markets such as Iraq and Russia (including a Russian embargo on Turkish exports), along with weak growth in the EU market, meant that Turkey's total exports remained weak[12].

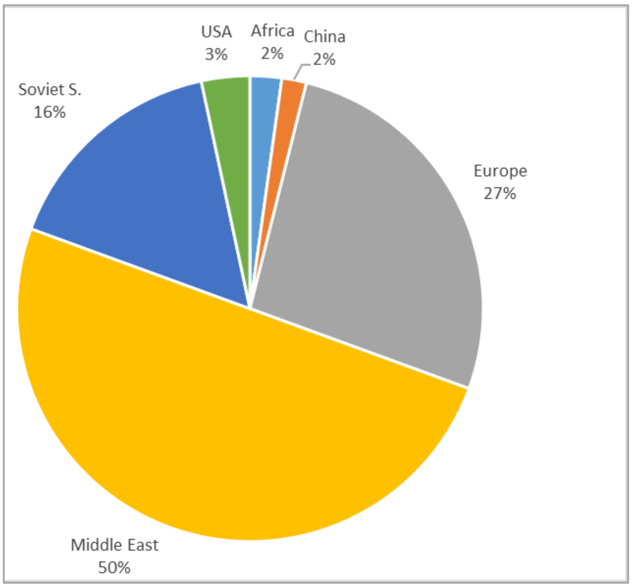


Figure 3-3: Global destinations for export products from Çukurova Region (2015). (Source: Report authors based on OECD data[12]).

Transport and logistics between Turkey and the EU

Today, Turkey plays a central role in providing opportunities for Europe to access growing markets in the Middle East, the Caucasus and Asia via its transport and logistics networks. From the year 2000, Turkey was involved in an interregional programme, TRACECA (Transport Corridor Europe–Caucasus–Asia), financed by the European Union, aimed at connecting the EU and the 14 member states of the Eastern European, Caucasian and Central Asian region[13]. The total length of TRACECA road network developed in Turkey is approximately 8,241 kilometers, and ten ports connect TRACECA roads to Europe and the Balkans with more than eleven maritime routes. Additionally, there are twelve airports in Turkey that make connections with TRACECA[14].

Since January 2014, the European Union has a new Trans-European Network-Transport (TEN-T) policy, which aims to achieve better accessibility of all parts of the EU to European and global markets, and puts a strong focus on infrastructure of topmost strategic importance, including connections to other key economic areas of the world. To ensure full implementation of this all-encompassing infrastructure plan, two strong EU instruments were introduced as integral parts of the policy, namely the Connecting Europe Facility and the 'core network corridors' as a coordination tool, helping to identify project pipelines and ensuring full core network completion by 2030. A Transport Infrastructure Needs Assessment (TINA) study was undertaken in Turkey from 2006-2008, which provided specific findings for extending the TEN-T to Turkey. The TINA study defined a multimodal network (core network) and prioritized potential network improvement projects in Turkey. The comprehensive TEN-T network for Turkey consists of 15,200 km of road network, 7,610 km of railways, 14 ports and 20 airports[13].

3.2.3. National sectoral drivers and dynamics

In order to maintain a strong GDP and employment growth, Turkey's overall investment strategy aims at further improvements in investment, both in terms of quality and quantity. Towards this end, Turkey is embracing an ambitious agenda of large-scale infrastructure projects in energy, transportation and health, with an emphasis on Public Private Partnership (PPP) models as means to attract private sector resources to infrastructure investments.

3.2.3.1. Energy

Growing domestic energy demand

Over the past decade, energy demand in Turkey has grown along with economic and social development, driven by industrialization and urbanization. This situation together with population growth expectations shows great potential for further growth in energy demand. According to the IEA, Turkey's total primary energy consumption rose considerably between 1973 and 2011, from 24.4 million tons of oil equivalent (Mtoe) to 114.1 Mtoe, at a compound annual growth rate (CAGR) of 4%. Turkey's share of global energy consumption increased from 2.5% to 5.2% during the same period. The IEA forecasted that Turkey's energy consumption would continue to grow at a CAGR of around 4.5% between 2015 and 2030. The Ministry of Energy and Natural Resources (MENR) estimated that the total primary energy demand would reach 218 Mtoe by 2023 from the current (2016) level of 125 Mtoe. Currently, primary energy demand is met by natural gas (35%), coal (28.5%), oil (27%), hydro (7%), and other renewables (2.5%).

Considering electricity specifically, the Turkish electricity market is one of the fastest growing in the world, with a CAGR of 5.8% over the period 2002 to 2013. The Turkish Electricity Transmission Company (TEİAŞ) estimated that national electricity demand will increase by 6 to 7% annually till 2023.

High dependence on imported fuels

The limits of Turkey's domestic energy sources in the face of its growing energy demand have led to dependency on energy imports. Currently, Turkey imports nearly 99% of the natural gas it consumes (of which 55.3% is imported from Russia, followed by Iran (16.2%), Azerbaijan (12.7%), Algeria (8.1%) and Nigeria (2.6%)). It also imports 89% of its oil supplies (from Iraq (45.6%), Iran (22.4%), Russia (12.4%), Saudi Arabia (9.6%), Colombia (3.5%), Kazakhstan (2.6%) and Nigeria (2.1%)). At present, only around 25% of total energy demand is being met by domestic resources[15].

Strategic focus on domestic energy security and becoming a regional energy hub

Turkey's high dependency on a limited number of countries for oil and gas supplies, coupled with the high share of natural gas in power generation, is perceived as a risk factor for supply security. Furthermore, as energy imports make up almost one quarter of total imports, price and supply developments in global energy markets affect Turkey's economic growth and its current account deficit[16].

Thus, Turkey's Tenth Development Plan (2014-2018) stresses the importance of establishing alternative policies to reduce import dependency in the energy sector. It emphasises increased utilization of domestic resources (especially lignite) for energy supply, along with nuclear power generation and increasing the share of renewables in power generation. On the demand side, it prioritizes improved energy efficiency to smooth electricity peak load, and developing electricity trade with neighbouring countries. It also notes that projects for transportation of oil and natural gas from the Middle East and the Caspian region to Europe would contribute to improving Turkey's supply security and would also "*transform its geopolitical capabilities into an advantage*."

Following the lead of the Tenth National Development Plan, the MENR Strategic Plan for the period 2015-2019 sets out the ambition for the country to realize its own energy security[17]. With this in mind, it aims to:

- diversify energy supply routes and source countries,
- increase the share of coal and renewables, and include nuclear power in the energy mix,
- take significant steps to increase energy efficiency,
- contribute to Europe's energy security.

Turkey's energy strategy also has a vision for the country to become a regional energy trade hub. Growing national consumption has already helped initiate development of pipelines to bring natural gas into the country, and while it has little natural gas left for export, new supplies have been contracted and new pipelines are under construction that will increase both Turkey's imports and exports of natural gas[18], making Turkey an important transit country for maritime and pipeline natural gas transportation. Turkey is also a major transit point for oil as it links the oil-rich east to high consuming regions in Europe. Growing volumes of Caspian oil are being sent to Black Sea ports and then to Western markets by tanker via the Turkish Straits. Pipelines carrying Caspian oil and Iraqi oil also cross Turkey and connect to Ceyhan oil terminal in Çukurova Region[18].

Privatization of the power sector

In line with the government's overall investment strategy, a striking feature of Turkey's power sector in recent years has been the rapid (and accelerating) decrease in the share of the state in power generation. As of the first quarter of 2016, the share of power produced by the private sector reached 83.8%, up from 40.2% in 2002[19]. The share of total installed power by the private sector also follows a similar trend.

3.2.3.2. Transport and logistics

Çukurova Region is prioritized in national plans as an emerging socio-economic development region in addition to Marmara (mainly the metropolis of Istanbul and its vicinity) and Aegean regions. In order to realize this ambition, the geostrategic location of the region will benefit from enhanced logistics and transport networks to boost economy and trade.

Dynamics of logistics performance

Turkey ranked 34 out of 160 countries in the World Bank's Logistics Performance Index (LPI) in 2016, with an overall LPI score of 3.42 out of 5 (Figure 3-4). The LPI ranks countries on six dimensions of trade:

- Efficiency of customs and border management clearance ('Customs'),
- Quality of trade and transport infrastructure ('Infrastructure'),
- Ease of arranging competitively priced shipments ('Ease of arranging shipments'),
- Competence and quality of logistics services—trucking, forwarding, and customs brokerage ('Competence of logistics services'),
- Ability to track and trace consignments ('Tracking and tracing'), and
- Frequency with which shipments reach consignees within scheduled or expected delivery times ('Timeliness').

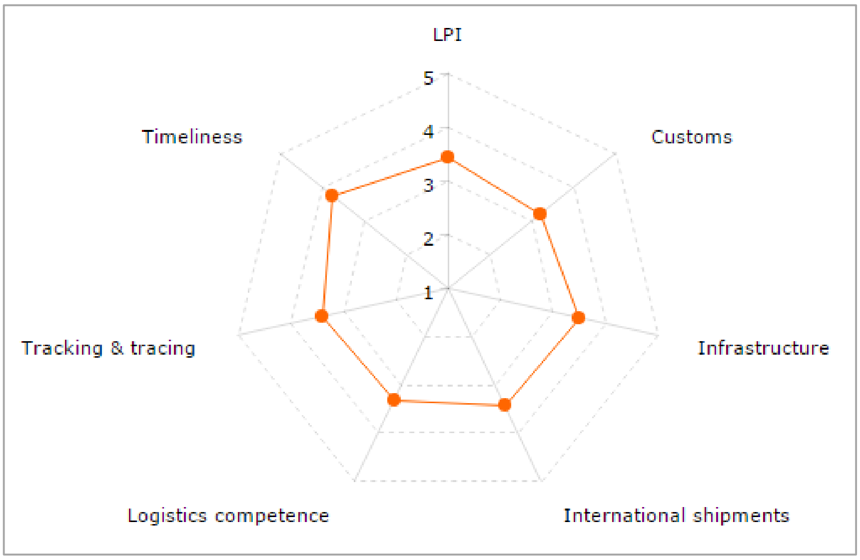


Figure 3-4: Turkey's Logistics Performance Index (LPI) scorecard (2016). (Source: World Bank data[20]).

According to the index, in 2016 Turkey performed better than 3 out of 4 BRIC countries (namely Brazil, Russia and India), and it scored well above the average of upper middle-income countries (average score = 2.73). However, its overall LPI score and rank have declined since 2012 (Figure 3-5), with four of the six LPI indicators ('Infrastructure', 'Logistics Competence', 'Tracking and tracing' and 'Timeliness') showing downward movement over the period.

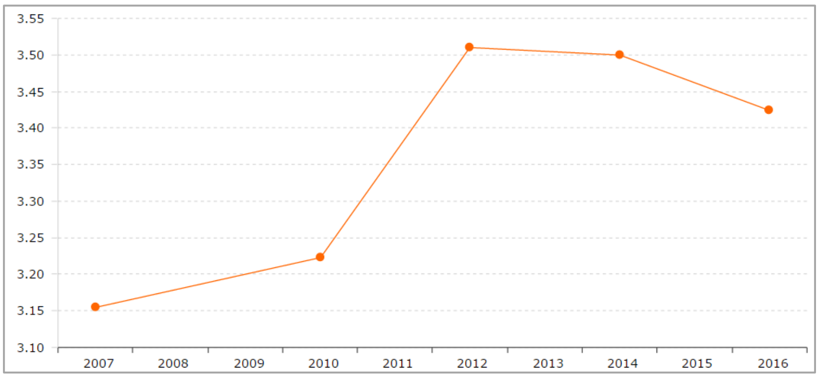


Figure 3-5: Trends in Turkey's overall LPI score (2007 – 2016). (Source: World Bank data [20]).

Turkey also scored well on other logistics indices compared to other countries. The Agility Emerging Markets Logistics Index scores markets in three broad categories: market size and growth attractiveness; market compatibility and connectedness. According to this index, Turkey was ranked 10th in logistics out of 45 emerging markets in 2016, though its index score for 2016 (5.95/10) showed a slight decline compared to 2015 (6.06/10).

Strategic focus on becoming a regional hub in logistics

One of the priority transformation programmes in the Tenth Development Plan is the transport and logistics sector, with the aim of making Turkey a regional hub in logistics. The plan aims at increasing the contribution of transport and logistics infrastructure to Turkey's growth potential in order to achieve export, growth and sustainable development objectives. As such, it targets provision of effective, productive, economic, environmentally-friendly and secure freight and passenger transport services. It puts an emphasis on combined (intermodal) transport applications in freight transport, increasing the share of railway and maritime transportation. The plan states that priority will be given to transport routes which facilitate access to neighbouring countries and new markets, especially to projects connecting to the EU transport network (TEN-T). An Action Plan (2014-2018) has been prepared to support these objectives, and a Logistics Coordination Council has been established. The Plan aims to design a Port Authority Model, and to revise the Coastal Structures Master Plan to implement port capacities in an effective manner in view of the rising foreign trade volume of Turkey.

In line with the Tenth Development Plan, the National Transportation Master Plan (2015-2018) aims to facilitate the development of a sustainable, safe, secure, accessible, inclusive, fast and technologically innovative transport sector, and transport infrastructure that will support competitive logistics, and increase the welfare of Turkish citizens and the competitiveness of the economy. It includes major transportation infrastructure investments, including PPP transportation projects.

Privatization of the rail sector

The Tenth National Development Plan states that restructuring of Türkiye Cumhuriyeti Devlet Demiryolları (TCDD / Turkish State Railways) will be completed, and rail freight and passenger transport will be opened to private operators, within the framework of the Turkish Rail Transport Liberalization Law. Following this, renovation and maintenance of TCDD’s rail network will be carried out by the private sector, thus reducing the financial burden of TCDD on public finances.

3.2.4. Regional sectoral drivers and characteristics

Located at the crossroads of Anatolia and Middle East, Çukurova has always been a focal point for investment opportunities. According to ÇKA, foreign trade volume was USD 6.4 billion in 2015 (USD 3.1 billion of exports and USD 3.3 billion of imports). Adana and Mersin together constitute one of the largest, most significant and most promising economic hubs of Turkey, thanks to their strategic location on historic trade routes and their proximity to significant markets.

Compared to the 25 other Turkish regions, the role of Çukurova Region in Turkey’s economy has been steady or slightly decreasing over the years 2004-2011 (Table 3-1). There are additional indicators for the region’s weakening impact: It is important to note that the Çukurova Region “gross value added per capita” index (which measures the contribution of the region to the Turkish economy) has decreased to a score of 78 (out of 100) in 2011 ($7,232) from 80 in 2004 ($4,065). The total public investment made in the region was only 1.7% of the total public investments in 2014.

Table 3-1: Contribution of Çukurova region to Turkey’s economy. (Source: Turkish Statistical Institute, 2017)[21]

	Çukurova Region as % of Turkey	
Indicator	**2004**	**2011**
Total gross value added	4.1%	4.0%
Gross value added in the agricultural sector	6.6% (2nd)	6.5% (3rd)
Gross value added in the industrial/manufacturing sector	3.3% (8th)	3.0% (8th)
Gross value added in the services sector	4.0%	4.0%

3.2.4.1. Çukurova Regional Development Agency (ÇKA)

Regional development policies in Turkey were transformed from centralization to decentralization within the process of gaining membership to the EU. Emerging from this process, the development agencies were established by an initiative of the Ministry of Development in 2006-2009 within 26 NUTS Level 2 regions in Turkey. The Ministry has an ongoing coordination role for development agencies, and is responsible for their legislation.

ÇKA was established in 2006, making it one of the first two regional development agencies in Turkey (along with Izmir). The main purpose of ÇKA is to foster economic and social development in Çukurova Region, and to increase the region's competitiveness. Its goals, in common with those of other development agencies, are shown in Figure 3-6.

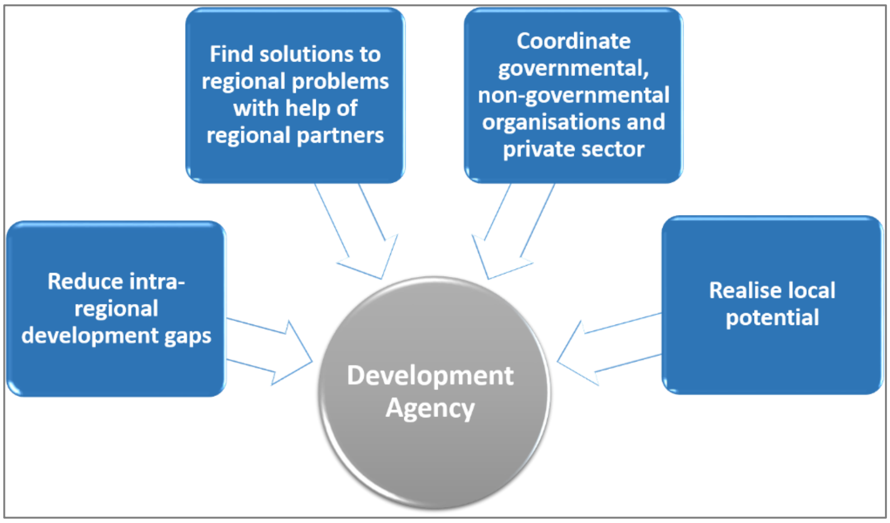


Figure 3-6: Goals of regional development agencies. (Source: ÇKA, 2016) [22]

ÇKA sets the regional vision and strategies and supports their implementation. To do this, it leads the elaboration of 5 and 10-year regional development plans and has its own investment funding to assist local actors in implementing the development plan. The 10-year Çukurova Regional Strategic Plan for 2014-2023 complements higher policy documents such as the Tenth Development Plan and the Regional Development National Strategy. It presents the vision, goals and plans for future sector developments (see Box 3-1). According to the plan, two of the priorities are to become an energy production and distribution center, and to transform the region's strategic location into logistical advantages.

Box 3-1: Vision for Çukurova Region (2014-2023, 10 year Regional Strategic Plan)

"To be a leader in the Eastern Mediterranean region converting its strategic location and rich resources into value"

Strategic Goals:

1. Attract regional and international investment, become a prominent production base and attract more economic activity:
    a. become an energy production and distribution center
    b. transform the region's strategic location into logistical advantages
    c. improve the competitiveness of the manufacturing industry
    d. increase the added value derived from agriculture
    e. realize the tourism potential of the region
    f. improve R & D capacity; improve the innovation and entrepreneurial environment
2. Decrease regional development disparities,
3. Solve social problems,
4. Improve human capital,
5. Ensure green growth and environmental sustainability,
6. Have attractive metropolises with high quality of urban life.

More specifically, the objectives for development of the energy and transport/logistics sectors in the region, according to the Çukurova Regional Strategic Plan, the Tenth National Development Plan and relevant sectoral strategy plans are as follows:

Energy

1. To become an energy production and distribution center.
2. To increase renewable energy production capacity in the region.
3. To establish alternative policies to reduce import dependency in energy in order to have positive impact on growth and account deficit due to imported energy sources.
4. In electricity transmission, investments will be realized in a way that protects the security of the electricity system.
5. To create adequate emergency supply stocks for oil and natural gas.
6. To extend the natural gas transmission and distribution networks throughout the country.
7. Construction of the first unit of Akkuyu NPP will be substantially completed during the Plan period.
8. Domestic coal resources will be used for electricity generation by private sector.
9. Efforts will be pursued for transforming Ceyhan into one of the main distribution points in international oil markets and one of the important centers in oil price formation.
10. Turkey will be actively involved in gas trade and transmission to Europe, necessary infrastructure will be created to increase the capacity of electricity trade with neighboring countries.
11. To prepare a detailed roadmap for establishment of Ceyhan integrated energy specialized zone.
12. To complete planned investments at Ceyhan Specialized Energy Industry Zone.
13. To position Ceyhan as the second largest energy terminal.
14. Implementation of an integrated security system to enhance protection of BOTAŞ assets (pipelines, stations and systems) in the framework of critical energy infrastructure project (due end 2018).
15. Modernization of crude oil pipelines.
16. Preparation of a master plan for transforming BOTAŞ facilities into integrated energy centers to increase energy export (due end 2016).

Transport / logistics

1. As an important logistics hub in the Eastern Mediterranean, to be part of the Trans-European Transportation Network (TEN-T), to support and ensure the realization of projects that will strengthen links with the Middle East and the Mediterranean Region.
2. Especially with the emphasis on the rail and maritime freight transport, to improve port hinterland connections and to become logistics centers that can support intermodal transport.
3. To have Çukurova region as the logistics center of Turkey and the Eastern Mediterranean.
4. To realize a significant contribution to the logistics industry due to the fact that Mersin Port is included in the Marine Highway Project of the EU Transport Network Expansion Plan.
5. Complete construction of the Kars-Tbilisi-Baku Railway Line, which will enable transportation of the transit railway loads from/to Mersin Port to/from the Middle East and Central Asia.
6. Complete construction of Çukurova Airport and Logistics Village.
7. Construct Mersin-Silifke (Taşucu) Highway (98 km).
8. Construct Southern Adana Highway.

Further information on the region’s characteristics related to the energy and transport & logistics sectors is provided in Annex A2.

4. Identifying Critical Infrastructure in the energy and transport & logistics sectors in Çukurova Region

4.1. Introduction

Summary of key points

- Specific critical infrastructure facilities have not yet been formally identified in Çukurova Region.
- The identification of critical infrastructure for the Çukurova CIRA therefore utilises a practical method which draws on AFAD's definition of critical infrastructure. The method allows the economic impact and geographical extent of loss of essential services provided by infrastructure to be estimated.
- By applying this method, some existing infrastructure facilities in Çukurova Region can be classified as 'critical' and are taken through the risk assessment, namely:
    - Sanibey Yedigoze Hydropower Plant
    - İsken Sugözü Thermal Power Plant
    - Yumurtalik-Kırıkkale Oil Pipeline
    - Mersin International Port
    - Seyhan Viaduct on E-90.
- Some new infrastructure under development can also be classified as 'critical' using this method, but as less information is available on these projects, they are not covered in the risk assessment.

Based on the review presented in Section 2, the following three criteria are considered most relevant to identifying critical infrastructure in Çukurova Region:

- **Impacts on essential services,**
- **Economic impact,**
- **Impacts on life.**

- with **interdependency / cascading impact** being considered within these three criteria.

Given the lack of availability of public information on the precise thresholds used to rank critical infrastructure in the jurisdictions reviewed in Section 2, it is more practical for the CIRA to derive thresholds based on recent major hazardous events that have been experienced in Turkey. Relevant attributes of recent events are summarised in Table 4-1.

Table 4-1: Recent natural hazards experienced in Turkey which can be used to define impact thresholds. (Source: Report authors).

	Impacts on essential services	Economic impact	Impacts on life
Event	National blackout (31 March 2015)	Marmara earthquake (1999)	Mersin floods (29 Dec 2016)
Impact	Loss of power across Turkey for several hours, (within 6.5 hours, power had been restored to 80% of the grid; some provinces were without power for 9 hours).[23] (Economic losses due to lost load are	4.5-6.5% of GDP[25]	Five lives lost. Economic losses to agricultural production and infrastructure damage, estimated[26] at more than USD 35 million[iii].

[iii] Using currency exchange rates TRY / USD as of December 2016

	estimated to be in excess of USD 1 billion[24])		

The following approach can be used to develop the categorization of critical infrastructure for Çukurova Region:

- As the CIRA is assessing regional, national and transnational impacts, the highest category (Category 5) for Çukurova Region is a **transnational** impact for the 'geographical extent' of 'impact on essential services'.
- Because their impacts were national (not transnational), the following events were used as benchmarks for Category 4 impacts:
    - The national blackout of March 31st, 2015 for 'impact on essential services',
    - The Marmara earthquake for 'economic impact'.
- For 'impact on life', in line with typical risk assessment approaches, 'single or multiple fatalities' are assigned the highest impact category (Category 5)[27].
- Other impact descriptions were derived relative to the above impacts.

The resulting categorisation for Çukurova Region is presented in Table 4-2. Given that only infrastructure in Categories 3 to 5 is considered 'critical' (following the UK example presented in Section 2.3), the thresholds for Categories 0 to 2 are not developed in Table 4-2.

Table 4-2: Approach to categorisation of infrastructure criticality for Çukurova Region. (Source: Report authors).

Criticality Scale	Description		
	Impacts on essential services	**Economic impact (impact on Turkey's GDP, %)**	**Impacts on life**
Category 5	**Geographical extent:** Transnational This is infrastructure the loss of which would have a catastrophic impact. The loss of these assets would have transnational long-term effects on delivery of essential services.	>10% impact on GDP	The loss of these assets may impact quality of life for millions of Turkish citizens and citizens in other countries or may lead to single or multiple fatalities.
Category 4	**Geographical extent:** National Infrastructure of the highest importance should fall within this category. The impact of the loss of these assets on essential services would be severe and may impact provision of essential services nationwide.	>5% to 10% impact on GDP	The loss of these assets may impact quality of life for millions of Turkish citizens or may lead to major or multiple Injuries, permanent injury or disability.
Category 3	**Geographical extent:** Regional Infrastructure of substantial importance to the delivery of essential services, the loss of which could affect a whole region.	>1% to 5% impact on GDP	The impact of the loss of these assets may impact quality of life for hundreds of thousands of citizens or may lead to serious injury.

4.2. Application for the Çukurova Region Critical Infrastructure Risk Assessment

The approach described above can be used to provide a robust categorisation of critical infrastructure in Çukurova. However, the analysis required to identify the appropriate category for each of the region's energy and transport & logistics assets would require significant research time and effort, beyond the scope of the CIRA. Therefore, a more practical method has been applied for the CIRA, which utilizes two of the main comparators identified above, namely:

1. A high-level estimation of 'economic impact' associated with loss of the service provided by critical infrastructure, expressed as a percentage of Turkey's GDP, and
2. Geographical extent of 'impacts on essential services'.

4.2.1. High level estimate of economic impact associated with loss of service

4.2.1.1. Energy sector

In TR62 (Adana, Mersin) region, the share of services, industry and agriculture sectors are 64.2%, 21% and 14.7% of Gross Value Added (GVA) respectively (2011 data). The TR62 region contributes 4% of GVA to Turkey as a whole (4% for services, 3% for industry and 6.5% for agriculture sectors), ranking the region 7th nationally at NUTS2 level[28]. Comparison of TR62 region and national figures shows that the impact and value loss associated with failure in energy supply will be higher in Çukurova Region compared to the national average.

Access to relevant resources for an activity is essential to achieve economic efficiency. In the absence of relevant resources, the market will search for alternative resources (if available) which will be more expensive. For the case of electricity cut or failure in natural gas supply, the relative cost of interruption of the service will depend on the sectors affected, as well as the season and hour of the day. However, a very simple calculation of cost of electricity not supplied (ENS) or failure in natural gas (NG) supply can be undertaken using GDP data. This approach provides aggregated data across all sectors of an economy and direct losses; however indirect losses cannot be calculated with this approach.

Table 4-3 provides data on GDP per MWh of electricity consumed, and GDP per m^3 of natural gas used, for Turkey as a whole. These ratios can then be applied to estimate the impact of interruptions to supplies of electricity and natural gas on GDP (see Table 4-4).

Table 4-3: Electricity and natural gas dependency of GDP in Turkey. (Source: Report authors; data from EPDK, TEIAS and TUIK)[29],[30],[31]

	2015	2014	2013	2012	2011
GDP (USD billions, 2015 prices)	719.6	799.4	823.0	786.3	774.0
Annual Electricity Consumption (GWh)	216,233	207,375	198,045	194,923	186,100
Annual Natural Gas Consumption (Mm^3)	47,999	48,717	45,918	45,242	43,697
GDP/GWh (USD/GWh)	3.3	3.9	4.2	4.0	4.2
GDP/m^3 (USD/m^3)	15	16	18	17	18

Some of the main electricity generation and natural gas assets in TR62 region are listed in Table 4-4, together with their capacity. Using the ratios provided in Table 4-3, the loss of GDP (%) for Turkey as a whole is also shown in Table 4-4, assuming that the services provided by these assets is interrupted for 3 months. It should be noted that these GDP losses are calculated assuming that there is no substitution for the assets. In general, the service provided by most of the renewable power generation assets in Çukurova can be easily replaced, due to their relatively small size compared to the size of the grid-connected power plant. However, large base load plants (thermal power plants or dam-type hydropower plants) are more important, though they can usually be substituted with other plants in less than 24 hours. Although each of these large base load assets cannot individually be classified as 'critical', groups of plants located close together or those supplying electricity to a certain region can be classified as 'critical' due to their cumulative impact on the grid or region.

Table 4-4: Impact on Turkey's GDP of loss of service from selected energy assets in Çukurova Region. (Source: Report authors).

Energy Asset	Capacity (GWh [power plants] or billion m^3 [natural gas storage])	% GDP loss if service cannot be replaced for 3 months*	GDP loss (million USD) per day of lost service (downtime)
Sanibey Yedigöze Hydropower Plant	672	0.078	6.1
Iskenderun Thermal Power Plant	9,183	1.1	84
Akkuyu Nuclear PP**	35,000	4.1	315
Tarsus Underground Natural Gas Storage**	5.2	2.7	210

*Based on 2016 GDP.
**Not yet operational.

On the basis of a simple comparison between the classification of economic impact given in Table 4-2 and the GDP impacts listed in Table 4-4, it could be judged that Akkuyu NPP, Tarsus Underground Natural Gas Storage and Iskenderun Coal Power Plant would be Category 3 assets if their service was lost for 3 months. However, considering the total size of the power plants connected to the national grid, it is difficult to justify the assertion that power generation assets or electricity cannot be substituted for this period. Hence, GDP losses would almost certainly be lower. Furthermore, Akkuyu NPP is not expected to be fully operational until 2022, by which time the overall grid capacity in Turkey will also have increased significantly. The economic impact of 3 months' supply interruption from Akkuyu NPP would therefore be lower, in parallel with its contribution to overall electricity generation. Nevertheless, the impact of disruption of Akkuyu NPP on essential services would be felt nationally and even transnationally, which implies that it would be a Category 5 asset. This is discussed further in the next section.

Underground natural gas storage facilities are planned to be operational by 2020. Compared to power generation assets, it is impossible to replace those facilities as there is no substitute for them. Any interruption in those assets would will be felt at national level and would directly impact GDP in terms of gas supply, electricity generation and the efficiency of the economy.

Çukurova Region also serves as an outlet for Caspian and Iraq oil to markets. While the Kirkuk-Ceyhan pipeline is the only outlet from Northern Iraq, BTC carries mainly Azerbaijan oil and small amounts of oil from Kazakhstan and Turkmenistan. Oil from Ceyhan is exported to more than 20 countries.[32] During the first half of 2016, most of the oil transported through Ceyhan stayed in the Mediterranean, while the rest headed to Europe, North America and Asia (Figure 4-1).

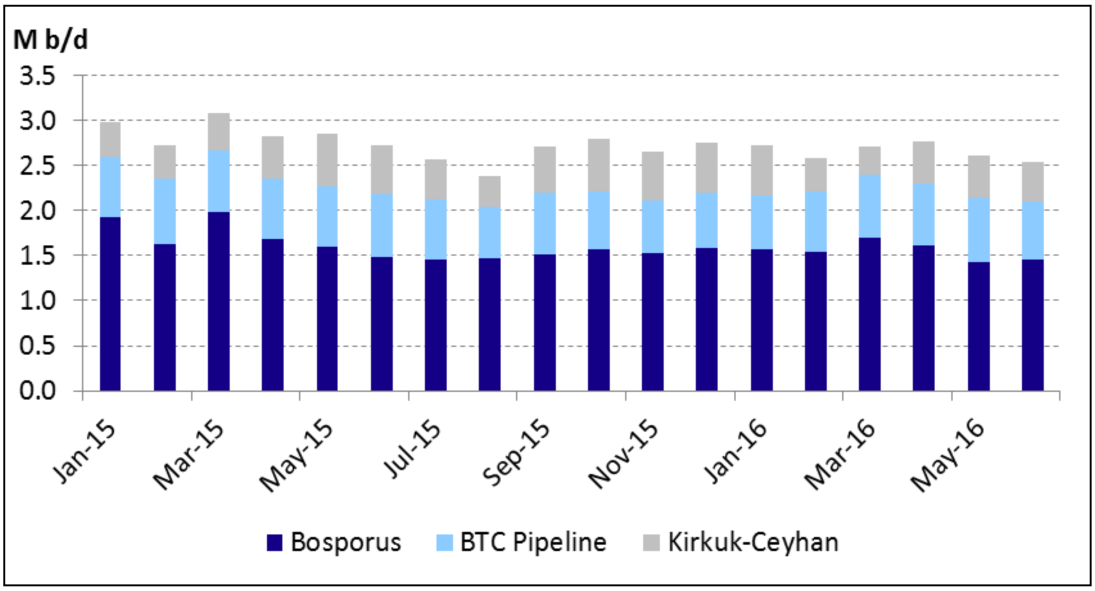


Figure 4-1: Recent oil shipments from Turkey (Source: Poten&Partners, 2016) [33]

The domestic pipeline between Ceyhan and Kırıkkale Refinery was built in 1986 to supply 100% of the crude oil demand of Kırıkkale Refinery. The capacity of the pipeline is 5M tons/year which can be increased up to 10Mt/year. Kırıkkale refinery provides for the petrol and diesel demand of central Anatolia, eastern Black Sea and eastern Mediterranean regions.

While disruption of the BTC and Kirkuk pipelines affect the Caspian region (mainly Azerbaijan) and Iraq on the supply side, on the demand side they can cause fluctuations in Mediterranean countries, followed by Asian, European and North American markets. As most of the oil is exported, the direct impact of any disruption on Turkey's GDP will be limited. However, due to their transboundary impacts, they can be classified as Category 5 assets. The impact of any disruption to the Yumurtalik-Kırıkkale pipeline will be limited to national boundaries on the demand side but would exceed national boundaries on the supply side. The criticality of Yumurtalik-Kırıkkale pipeline arises mainly from the impact on Kırıkkale refinery which relies on this pipeline for crude oil supply. As the impact of any disruption on the supply side will be limited, this asset can be classified as Category 4, as its disruption would cause significant impact on fuel supply for a significant part of Turkey.

In terms of natural gas pipelines, existing pipelines in the Çukurova region serve regional demand. Therefore, the direct impact of any disruption / loss of these assets will be mainly limited to the region. However, potential new pipelines, which will connect the recently discovered east Mediterranean gas reserves to Europe, are potential critical assets, if realized, due to their transboundary importance.

4.2.1.2. Transport and logistics sector

For the transport and logistic sector, calculations of economic losses associated with disruption can be complex and data intensive, involving consideration of a wide range of direct and indirect impacts. High-level initial estimates of the GDP impacts associated with loss of service from Mersin International Port (MIP) and the Seyhan Viaduct on the E-90 have been undertaken by experts for this study, and are summarised in Table 4-5 and Table 4-6 respectively.

Mersin International Port has a capacity of 1.8 million TEUs/year (Twenty-foot equivalent units/year). Disruption or shut down of MIP for 12 months would have a local/regional impact in terms of losses felt by direct and indirect employees and lost tax revenues, amounting to an estimated USD 1.45

billion (0.20% GDP). Closure of MIP would disrupt services in other ports as well as all carriers, having both national and transnational impacts. It would affect customers, consolidators, suppliers, retailers and banks. Disruption of service in MIP would result in cancellation of liner services and corresponding shipments to/from Europe, Asia, USA and Nordic countries. The top maritime destinations for exported goods from Çukurova region include Russia, Germany, Italy, Spain, France, Cyprus, China, Libya, Egypt, Sudan, and Morocco with total value of USD 1.7 billion in 2015. Among these export items, grains and seeds, fresh produce, textile products, chemicals, automotive parts and steel make up the 75% of the total export value. In addition, USD 2.3 billion worth of imported goods supply chain would be disrupted. The supply chain network disruption effect (40% loss of good will on exports and imports) is estimated at 0.22% of the GDP. Overall, the national economic impact is estimated at 1.1% of Turkey's GDP. This scale of economic impact places MIP into CI Category 3; however, as shown in Section 4.2.2, the disruption would be felt transnationally, which implies that MIP is a Category 5 CI.

Table 4-5: High level estimate of GDP impact of loss of service for Mersin International Port. (Source: Report authors).

	Item	Units	Year 2015 data	Percent of GDP
	GDP of Turkey	USD billion	719.6	100%
	GDP of Turkey	TRL billion	1,948	100%
	GDP of Turkey from transport	TRL billion	4.1	0.21%
GDP impacts due to loss of service for 12 months				
Direct Loss	Operating revenue (30 June 2016 data)	USD million	271	**0.038%**
Direct Loss	Construction revenue	USD million	2.2	**0.0003%**
Direct Loss	Finance and other income	USD million	4.0	**0.001%**
Indirect L1	Cost of investment (30%) on Total Assets	USD million	289	**0.040%**
Indirect L1	Value of lost imports	USD million	2,267	**0.32%**
Indirect L1	Value of lost exports	USD million	1,713	**0.24%**
Indirect L1	Inventory cost due to rerouting delays	USD million	995	**0.14%**
Indirect L2	Supply chain network disruption effect (40% loss of good will on export and imports)	USD million	1,592	**0.22%**
Indirect L2	Direct employment impact (1,412 employees)	USD million	85	**0.012%**
Indirect L3	Indirect employment impact (20,000 people)	USD million	600	**0.084%**
Indirect L4	Tax impact (18% of the above direct and indirect losses)	USD million	766	**0.11%**
Total estimated GDP impact due to loss of service for 12 months				**1.1%**
Estimated GDP loss per day of downtime				**21 million USD**

Seyhan Viaduct on the E-90 carries an average of 36,232 vehicles/day. If it is shut down, there will be direct revenue losses from tolls and bus passenger tickets. Transport through Mersin Industrial Zone, Adana Sakirpasa Airport, and traffic to Iskenderun, Gaziantep and Syria, Iraq will be rerouted. The increase in freight transportation costs will impact on the industries that are dependent on road transportation. Lost labour hours due to traffic delays will also be experienced. There will also be impacts on the performance of other carriers and ports, along with suppliers, retailers and customers etc. The supply chain network disruption effect (25% loss of value from exports and imports) is estimated to be the most significant impact, at USD 1.9 billion, or 0.22% of GDP. Overall, the national economic impact is estimated at 0.25% of Turkey's GDP. This scale of economic impact places the Seyhan Viaduct below CI Category 3. However, the effects of disruption would be felt regionally, which implies that it is a Category 3 CI.

Table 4-6: High level estimate of GDP impact of loss of service for Seyhan Viaduct on E-90. (Source: Report authors).

	Item	Units	Year 2015 data	Percent of GDP
	GDP of Turkey	USD billion	719.6	100%
	GDP of Turkey	TRL billion	1,948	100%
	GDP of Turkey from transport	TRL billion	4.1	0.21%
GDP impacts due to loss of service for 12 months				
Direct Loss	Revenue loss from tolls (Note A)	TRL million	37.9	0.002%
Direct Loss	Revenue loss from passenger tickets on buses	TRL million	7.9	0.0004%
Direct Cost	Repair/reconstruction cost (Note B)	TRL million	3.9	0.0002%
Indirect L1	Accident costs (Note C)	TRL million	134	0.007%
Indirect L3	Value of added travel time (lost labour at minimum wage) (Note D)	TRL million	153	0.008%
Indirect L1	Value of extra gasoline (Note D)	TRL million	59	0.003%
Indirect L2	Vehicle depreciation (10%)	TRL million	139	0.007%
Indirect L4	Effect of supply chain network disruption (Note E)	USD billion	1.59	0.22%
Total estimated GDP impact due to loss of service for 12 months				**0.25%**
Estimated GDP loss per day of downtime				**5.1 million USD**

Notes:

A Based on data for tolls from Ministry of Transportation - General Directorate of Highways

B Based on data from the Adana Metropolitan Municipality Procurement and Tender Department (October 13, 2016), for the value of the tender for the construction of "the concrete and reinforced concrete bridges over the Seyhan River which will provide the connection of the Adana Ili Çukurova - Sarıçam - Yüreğir Provinces"

C Based on data in General Directorate of Highways: Traffic Safety Project (2001). Methods and values for appraisal of traffic safety improvements.[34]

D Alternative route due to disruptions results in extra 25 minutes and 10 km for each vehicle.

E High-level estimation undertaken for this study, based on an assumed 25% network disruption effect to exports and imports to TR62 region (Adana and Mersin) associated with loss of service for Seyhan Viaduct.

4.2.2. Geographical extent of impact of loss of service

4.2.2.1. Energy sector

Assets such as Akkuyu Nuclear PP and underground natural gas storage facilities are not yet operational in Çukurova Region. However, once operational, very large facilities like Akkuyu NPP will be very important for the stability of the national electricity grid and even transnational electricity networks. Plants of those size cannot be substituted easily. Similarly, underground natural gas storage facilities planned in the region will be critical nationwide due to the dependency of the Turkish electricity generation mix on natural gas. As of 2015, nearly half of the electricity in Turkey was generated using natural gas, and existing storage capacity is only around 4% of annual consumption. Therefore, natural gas supply is even more critical for Turkey, especially in harsh winter conditions. Failure in supply has a cascading effect on electricity supply and economic activity (see Box A4-1.[35])

Box 4-1: On February 12th, 2012, harsh weather conditions coupled with infrastructure and supply side problems led to a shortage of natural gas in Turkey. The market operator announced emergency conditions and cut the gas supply to gas-fired power plants and prioritized residential heating. As a result, average electricity prices increased from 125TL/MWh to a record 2,000TL/MWh at the beginning of February due to critical natural gas shortages. This resulted in a loss of 11,320 MW of power capacity, causing blackouts in many regions, shut-downs of many industrial facilities and financial losses for many electricity market actors.

4.2.2.2. Transport and logistics sector

For transport and logistic assets, the geographical extent of their disruption can be very wide, depending on the type of asset. For assets without ready alternatives, like Mersin International Port or Çukurova International Airport, the geographical extent will be transnational for both imports and exports. In that sense, both facilities can be classified as Category 5 assets. In case of failure of service of these assets, alternatives can be utilized within a few weeks. However, this will have a direct impact on the effectiveness of economic sectors and may cause loss of market in some sectors such as agriculture, which is the main exporting sector in Çukurova. Major access roads and railways can also be critical, considering that Middle Eastern countries constitute half of the export market for the region (see Figure 4-2) and that most of the exports to those countries use road or railway transportation.

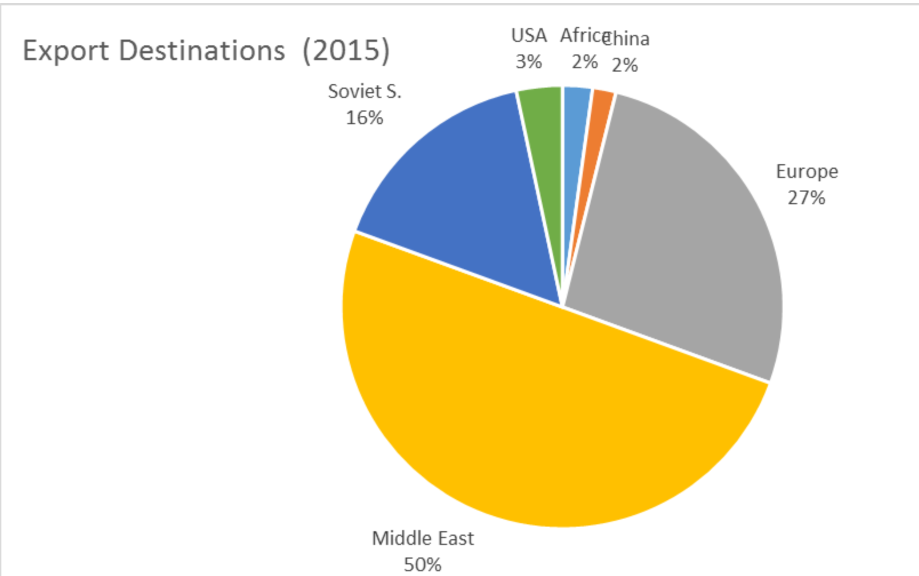


Figure 4-2: Global destinations for export products from Çukurova Region. (Source: Report authors based on OECD data[12]).

4.3. Summary of CI identified for Çukurova Region

The identification of critical infrastructure for the Çukurova CIRA utilises a practical method which considers the economic impact and geographical extent of loss of essential services.

High-level estimates of economic impact have been undertaken for energy assets; however, the scale of the impact is contingent on the length of time that the service disruption persists, and on whether substitutes are available. On a GDP basis, only the largest power generation assets in Çukurova could be considered as critical infrastructure, in the unlikely event that they were out of service for 3 months and that substitutes were not available. However, the geographical extent of disruption to Akkuyu NPP would be felt nationally, due to its importance for the stability of the electricity grid and its disruption could also affect transnational electricity networks. Underground natural gas storage projects at Tarsus appear to be critical infrastructure because there are no substitutes for them, and because of their downstream impacts on power generation. BTC pipeline and Kirkuk pipeline can be classified as Category 5 assets due to their transboundary impacts, whereas the Yumurtalik-Kırıkkale pipeline can be classified as Category 4, as its disruption would affect fuel supply for a significant part of Turkey.

For transport and logistics, high-level assessments of the economic impact associated with loss of service have been undertaken for Mersin International Port and the Seyhan Viaduct on the E-90. In terms of economic impact, MIP emerges as a Category 3 CI asset, but only if it was out of service for 1 year. However, the criticality of transport and logistics assets becomes more significant when the geographical extent of their disruption is considered. Assets such as Mersin International Port and Çukurova International Airport emerge as Category 5, due to their transnational significance for imports and exports, as do major access roads or railways serving Middle Eastern countries. Seyhan Viaduct is classified as a Category 3 CI asset, due to the regional impacts of its disruption.

In summary, some existing infrastructure facilities in Çukurova Region, together with new infrastructure under development, can be classified as 'critical'. For new infrastructure under development, less information is available as a basis for the risk assessment. Therefore, only existing infrastructure was taken forward for further analysis. The critical infrastructure facilities that were taken through the risk assessment are listed in Table 4-7. The locations of the critical infrastructures are shown in Figure 4-3.

Table 4-7: Selected critical infrastructure in Çukurova Region. (Source: Report authors).

Energy Infrastructure	Transport & Logistics Infrastructure
Sanibey Yedigoze Hydropower Plant	Mersin International Port
İsken Sugözü Thermal Power Plant	Seyhan Viaduct on E-90
Yumurtalik-Kırıkkale Oil Pipeline	

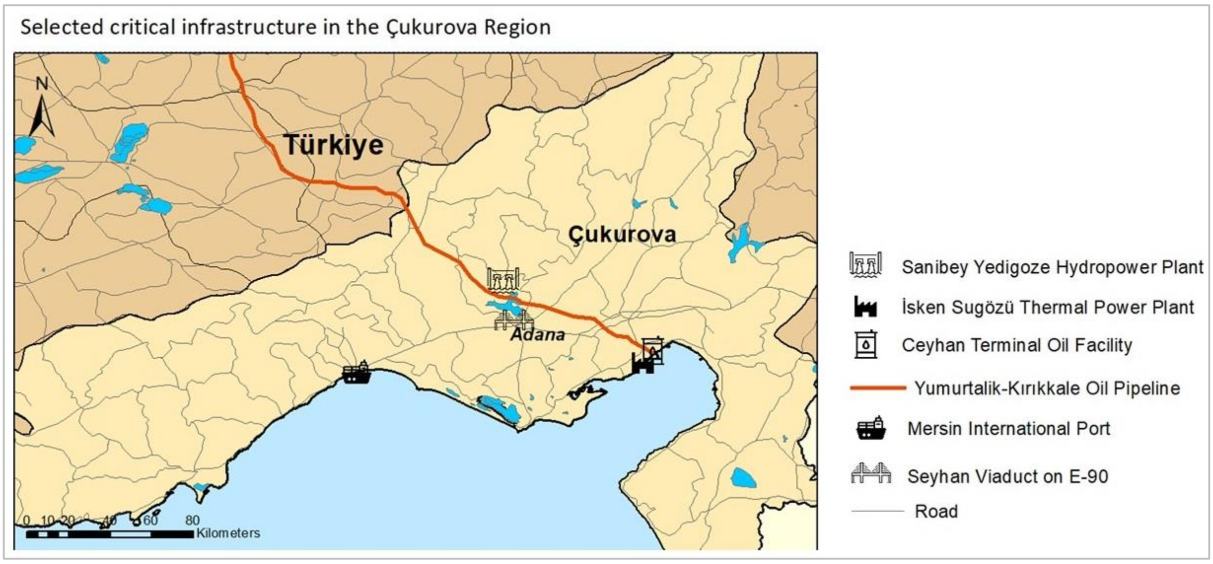


Figure 4-3: Location of the critical infrastructure analysed in the risk assessment. (Source: Report authors).

5. Natural hazard risk assessment

5.1. Introduction

Summary of key points

- A 7-step risk assessment procedure is used to undertake a high-level analysis of how natural hazards could damage/disrupt the selected critical infrastructure, and the wider consequences that the disruption can cause.
- The risk assessment considers geological and climatological hazards for the present day, 2030s and 2050s, taking account of how climatological hazards may change due to man-made climate change.
- The assessment uses RiskAPP©, a web based platform specifically developed to perform risk assessments on complex systems exposed to catastrophes.
- According to the risk assessment findings, the hazardous events estimated to cause the greatest economic risk are coastal floods today and in the 2050s. If a 1:100 year event were to strike the coast of Çukurova today, the total economic impact from disruption at İsken Sugözü Thermal Power Plant and Mersin International Port could be 2.1 billion USD.
- Heatwave in the 2050s emerges as the second most important hazardous event overall in terms of economic risk.
- Though the effects of earthquakes can be devastating when they occur, they appear to pose lower economic risk than climate hazards, due to their relatively lower probability of occurrence and because critical infrastructure is designed to withstand them.
- Risks to the essential services provided by several of the assets are mitigated to some extent by the availability of alternative assets which can substitute for the service in the event that it is disrupted.
- There is a broad spectrum in terms of the geographical extent and cascading impacts of disruption across the CI assets:
    - Disruption to Sanibey Yedigöze Hydropower Plant would only be felt locally, as the service it provides can be easily replaced due to its relatively small size.
- At the other end of the scale, disruption at Mersin International Port could have transnational impacts, due to its importance in the global supply chain. The cascading impacts would be felt by other ports and carriers, as well as by producers and customers of goods imported and exported via the port.

This section presents the methodology and results of the risk assessment for the selected CI in Çukurova Region. The main aims of the risk assessment are summarised in Box 5-1.

Box 5-1: Aims of the risk assessment

The risk assessment aims to provide information on:

1. The impact on essential services due to **damage or disruption** to the infrastructure that leads to reduced asset performance.
2. The **duration of the disruption,** the length in time of unavailability of the critical infrastructure.
3. High-level estimates of the **economic impact** arising from loss of the essential service
4. The **geographical extent** of the impact i.e. whether it is felt regionally, nationally or transnationally
5. **'Cascading effects'** where disruption to the infrastructure can lead to a chain of events elsewhere.

The risk assessment aims to provide information on:

1. The impact on essential services due to **damage or disruption** to the infrastructure that leads to reduced asset performance.
2. The **duration of the disruption,** the length in time of unavailability of the critical infrastructure.
3. High-level estimates of the **economic impact** arising from loss of the essential service
4. The **geographical extent** of the impact i.e. whether it is felt regionally, nationally or transnationally
5. **'Cascading effects'** where disruption to the infrastructure can lead to a chain of events elsewhere.

The floods experience in Mersin in December 2016 provide a stark reminder of the region's exposure to the kinds of natural hazards that are becoming more frequent due to climate change, and serve to demonstrate the value of improved understanding of the risks (see Box 5-2).

Box 5-2: Impacts of the Mersin floods of December 2016

Beginning on 20 December 2016, Mersin experienced a period of almost 10 days of continuously heavy rainfall. This culminated in exceptionally heavy rain for around 10 hours on 28-29 December, and severe flooding on 29 December, especially in coastal areas. Five people were swept away and died during the floods and there was intense disruption to social and economic activities. Whereas the present-day average total December precipitation for Mersin is around 130 mm[36], AFAD reported 140 mm rainfall in just 10 hours, higher than the 127 mm rainfall reported in 2001[37].

The flood caused economic losses in agriculture and trade and infrastructure damage. The cost impact of the flood on agricultural production was estimated as 116 million TL (in excess of 25 million USD), due to more than 136,000m^2 of agricultural land being flooded. The flood also caused damage to roads and urban infrastructure, and triggered diseases in the city[38]. Damage to water and sewerage infrastructure has been estimated at 5 million TL, whereas the cost of flood to highways and railways has been estimated as 3 million TL and 1 million TL respectively[39]. The flood also affected Mersin International Port and connecting roads, causing disruption to port operations and lower throughput[40]. According to port stakeholders, the flood led to operations at the port being disrupted for around 12 hours.

Figure 5-1 Flooding of container storage areas at Mersin International Port during the floods of December 2016. (Source: Report authors).

The remainder of this Section is structured as follows:

- **Section 5.2** presents the 7-step risk assessment methodology, explaining the approach used to conduct the risk assessment in Çukurova, and a description of the primary tool used to conduct the risk assessment, RiskAPP©.
- **Sections 5.3 to 5.7** present the application of the 7-step methodology to each critical infrastructure, and the risk assessment results.
- **Section 5.8** summarises the main outcomes of the risk assessment.

5.2. Risk assessment methodology

A 7-step procedure has been developed to conduct the risk assessment, which is designed to be replicable in other regions of Turkey and elsewhere. Figure 5-2 shows the 7 steps, which are further elaborated in Annex A3.1 to Annex A3.6. Box 5-3 summarises the definitions of hazard, vulnerability, exposure and risk used in the risk assessment which are based on those adopted by the Intergovernmental Panel on Climate Change (IPCC).[41]

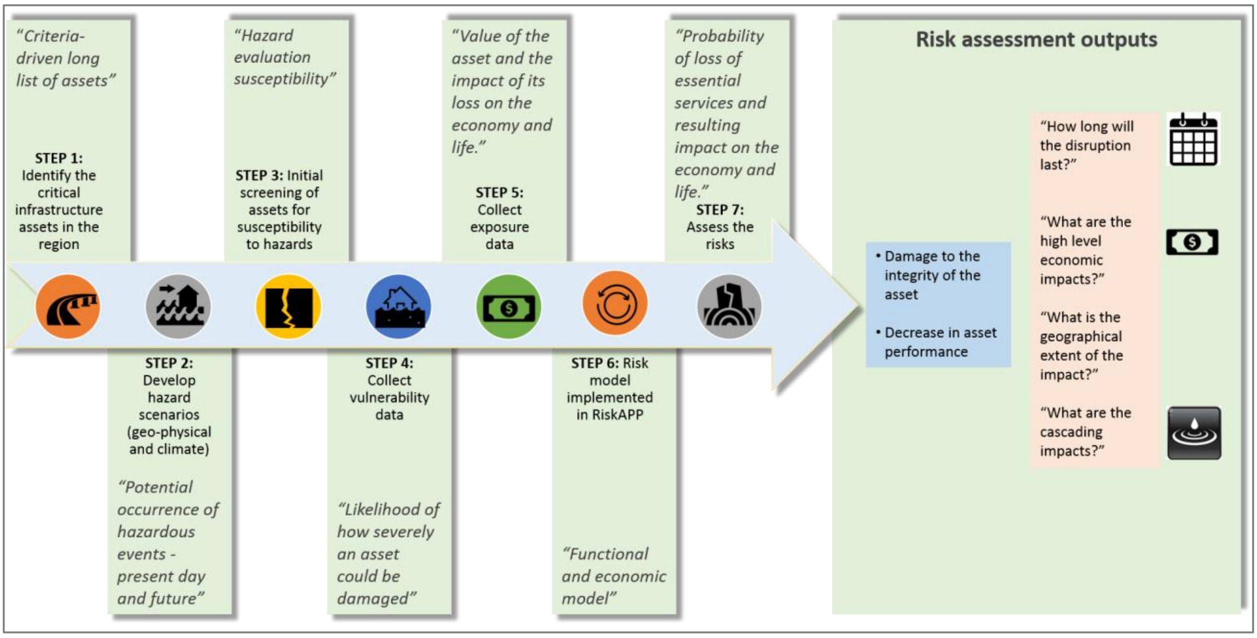


Figure 5-2: The 7 steps of the risk assessment methodology. (Source: Report authors).

Box 5-3: Definitions applied in the risk assessment

Hazard is defined by the IPCC as "*the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources*." **In this risk assessment, the level of hazard is given by the current and future frequency and magnitude of adverse climate and geophysical events.**

Vulnerability is defined by the IPCC as the "*The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt*." **In this risk assessment, vulnerability is given by the relationship between hazard events and the damage (or decrease in efficiency) this will cause expressed in percentage or category of damage to the CI.**

Exposure is defined by the IPCC as "*The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.*" **In this risk assessment, exposure is given by the economic impact and geographical extent of the cascading consequences if the CI is damaged.**

Risk is defined by the IPCC as the probability of occurrence of hazardous events or trends (associated with its magnitude) multiplied by the impacts (e.g. on the economy) if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. **In this risk assessment, Risk = Hazard x Vulnerability x Exposure.**

A summary of the current and future levels of hazards in Çukurova can be seen in Table 5-1 (see Annex A3.2 for further details on development of the hazard scenarios). For the future time periods, an upwards arrow indicates a likely increase in the hazard level (a double arrow indicates a strong increase). A dash or question mark indicates 'no change' or 'uncertain change' respectively.

Table 5-1: Summary of the current and future levels of hazard in Çukurova. (Source: Report authors).

Hazard		Summary of hazard level in Çukurova			
		Current		Future: 2030s	Future: 2050s
Geophysical hazards	Earthquake	Medium	In both Mersin and Adana there is a 10% chance of a potentially-damaging earthquake in the next 50 years.	-	-
	Landslide (earthquake induced)	Low	The landslide inventory report compiled by the General Directorate of Mineral Research and Exploration (MTA) states no records of earthquake triggered landslides (neither from historical or contemporary events) in Mersin and Adana provinces.	-	-
Climate hazards	Storm (extra tropical)	Medium	Probable maximum intensity peak wind speeds are in the range of 81-120km/h for 1 in 100-year return period events.	⬆	⬆
	Tornado	Low	Observed tornadoes in the region range up to F2 on the Fujita scale	?	?
	Hail	Low	Statistics for the whole of Turkey: • 42 severe hail cases, or 0.54 cases per 10,000 km² per year • 29 severe hail days, or 0.37 days per 10,000 km² per year.	?	?
	Flood (fluvial or pluvial)	Medium	Medium: 20% chance that potentially damaging and life-threatening floods will occur in the coming 10 years in Çukurova. 2-3 notable flood events over 1985-2011 in Çukurova.	⬆	⬆
	Heat waves	Medium	The low-lying coastal plain of the Çukurova region is amongst the higher heatwave hazard zones in Turkey. The intensity, length and number of heatwaves have increased since the 1960s across the country, including the Çukurova region	⬆	⬆⬆
	Flood (coastal)	High	Satellite data has been used to determine the 100-year wave height to be 6.1m (± 0.03m)	⬆	⬆
	Landslides (precipitation induced)	Low	Level of threat from landslides triggered by precipitation is relatively high in some localised regions of Çukurova, for example the mountainous border between Adana and Mersin provinces	?	?

The primary tool used to conduct the risk assessment is RiskAPP©; a web based platform specifically developed to perform risk assessments on complex systems exposed to catastrophes (see Figure 5-3). RiskAPP is used by major insurers and reinsurers to perform risk assessments by simulating the impact of hazards on often complex 'value chains'. These value chains can be made up of a single object e.g. a single piece of CI or multiple objects e.g. a company's supply chain. The output from RiskAPP is a set of potential damage scenarios which can be used to quantify the impact of scenarios of hazards (e.g. earthquakes) on downtime, loss of service and the economic consequences.

For the CIRA, the estimated daily economic impact of downtime for the asset is multiplied by the number of days of asset downtime under each scenario to estimate the economic impact of downtime per scenario. These economic impacts are then multiplied by the 'exceedance probability per year' to estimate the 'economic risk' per year for each scenario:

Downtime [days] x Daily economic impact of downtime = economic impact (GDP loss) [million USD] (Equation 1)

Economic risk per year [million USD] = economic impact (GDP loss) [million USD] x Exceedance probability per year (%) (Equation 2)

The calculations of economic impact has, of necessity, involved some simplifying assumptions, which should be noted. It has been assumed that the relative contribution of the CIs to the economy will be the same in the future as it is currently. This will over-estimate the importance of the impacts on the CIs, as additional capacity in both energy and transport and logistics will come into service in the coming decades. Secondly, future estimates of GDP impacts are undiscounted. As the CIRA aims to provide high-level estimates only, these simplifying assumptions are considered acceptable.

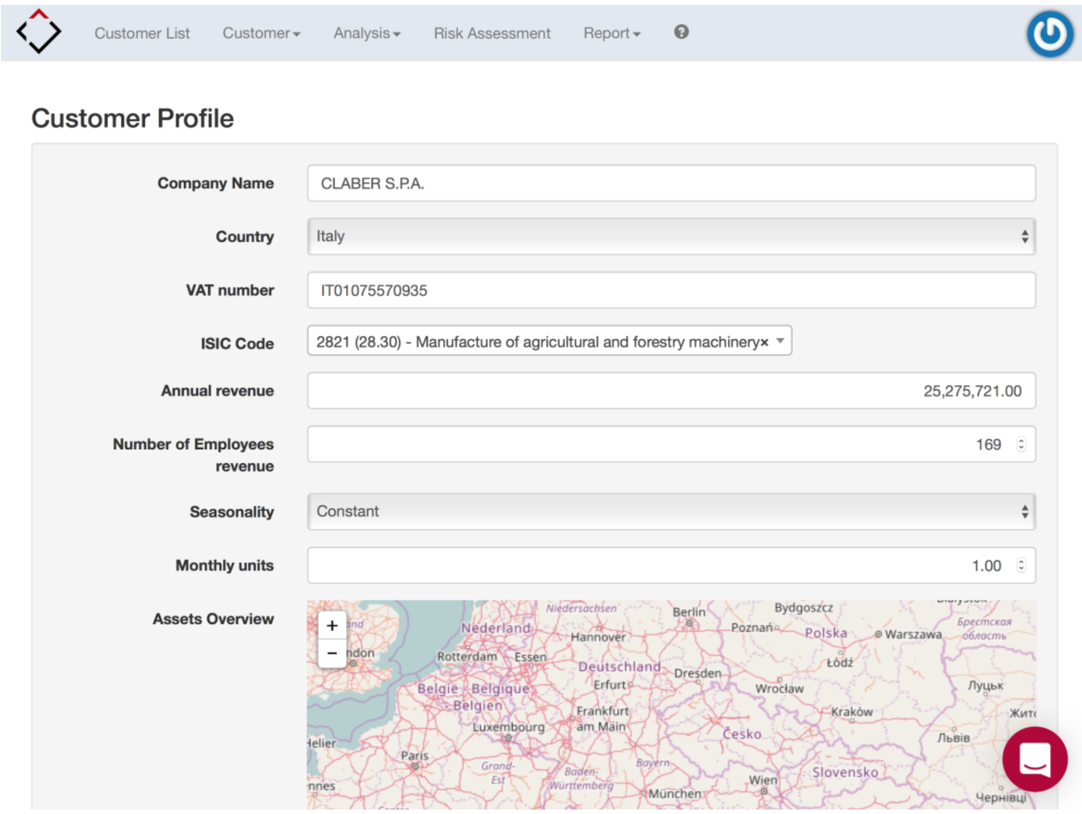


Figure 5-3: Example of the RiskAPP© user interface. (Source: Report authors).

The critical infrastructures that were analysed in the risk assessment, together with their capacity and the estimated GDP loss per day of downtime, are summarised in Table 5-2 and Table 5-3.

Table 5-2: Selected critical energy infrastructure in Çukurova Region analysed in the risk assessment. (Source: Report authors).

Energy Asset	Capacity (GWh [power plant] and barrels per day [pipeline])	Estimated GDP loss per day of downtime (million USD)*
Sanibey Yedigoze Hydropower Plant	672	6.1
İsken Sugözü Thermal Power Plant	9,183	84
Yumurtalik-Kırıkkale Oil Pipeline	141,000	11.6**
* GDP estimated as a proportion of 2015 total GDP for Turkey. Source: http://data.worldbank.org/country/turkey ** The figure for the oil pipeline includes: (1) loss of revenue for the refinery owners associated with disruption of oil supplies via the pipeline, assuming that disruption leads to lost refinery production (2) Loss of tax revenue to the government due to loss of sales of refined products. This figure therefore does not represent a full picture of GDP loss; rather it provides a partial view of the economic impact of pipeline disruption		

Table 5-3: Selected critical transport/logistic infrastructure in Çukurova Region analysed in the risk assessment. (Source: Report authors).

Transport & Logistics Asset	Capacity	Estimated GDP loss per day of downtime (million USD)*
Mersin International Port	1.8 million TEUs/year	21
Seyhan Viaduct on E-90	36,232 vehicles/day	5.1
* GDP estimated as a proportion of 2015 total GDP for Turkey. Source: http://data.worldbank.org/country/turkey		

5.3. Sanibey Yedigöze Hydroelectric Power Plant

Sanibey Yedigöze is a hydropower plant (HPP) on the Seyhan river with a dammed reservoir of 643 million m^3 feeding two vertical Francis turbines via a water drop of between 210m to 235m. The active flow rate is 300.48 m^3/h and the installed capacity is 2 x 158.5 MW, making Sanibey Yedigöze the largest HPP in Çukurova region. The investment cost for Yedigoze Dam is USD 600 million plus additional investment for irrigation infrastructure[42].

Further details of the hazards, vulnerability and exposure of this HPP as well as the operational model developed within RiskAPP RiskAPP are provided in Annex A3.9.

5.3.1. Risk assessment findings

The information on hazards, vulnerability and exposure are combined using the RiskAPP model to provide a measure of the damage and downtime each hazard scenario may cause at Sanibey Yedigöze HPP (Table 5-4). The estimated daily economic impact of downtime (USD 6.1m) is multiplied by the number of days of downtime under each scenario to estimate the economic impact of downtime per scenario (Table 5-4, column labelled 'Economic impact'). These economic impacts are then multiplied by the 'exceedance probability per year' to estimate the 'economic risk' per year for each scenario (Table 5-4, final column).

Table 5-4: Summary of the damage, downtime, economic impact and economic risk of each hazard scenario at Sanibey Yedigöze HPP. (Source: Report authors).

Scenario no.	Hazard	Intensity measure value	Unit	Exceedance Probability per year[iv]	Time period	Physical phenomena	Damage %	Downtime [days]	Economic impact (GDP loss) [million USD][v]	Economic risk per year [million USD][vi]
# 1	Earthquake	0.085 (D-soil)	g	2.33%	current	Peak ground acceleration	0	0	0	0
# 2	Earthquake	0.127 (D-soil)	g	1.39%	current	Peak ground acceleration	5	0	0	0
# 3	Earthquake	0.308 (D-soil)	g	0.21%	current	Peak ground acceleration	40	30*	184	0.39
# 4	Earthquake	0.472 (D-soil)	g	0.04%	current	Peak ground acceleration	40**	30	184	0.07
# 5	Flood	164	cm	4.00%	current	Water depth	10	7	43	1.72
# 6	Flood	233	cm	1.00%	current	Water depth	10	10	61	0.61
# 7	Flood***	281	cm	0.20%	current	Water depth	10	10	61	0.12
# 8	Storm	81 -120	km/h	1.00%	current	Wind speed	10	1	6	0.06
# 9	Storm	121-160	km/h	1.00%	2030s	Wind speed	15	5	31	0.31
# 10	Tornado	117-180 (F1)	km/h	0.33%	current	Wind speed	20	15	92	0.30
# 11	Tornado	181-253 (F2)	km/h	0.17%	current	Wind speed	25	15	92	0.16
# 12	Heat wave	27	°C	20.00%	current	Air temperature	0	0	0	0
# 13	Heat wave	35	°C	20.00%	2030s	Air temperature	5	0	0	0
# 14	Heat wave	40	°C	20.00%	2050s	Air temperature	10	5 at 90% output****	3.1	0.6

* The electrical equipment at the plant could take up to 30 days to repair[43] following 40% damage. (See Annex A3.8.1 for a description of the damaged elements[44].)
** The explanation for earthquakes of different intensity being shown here to causing the same level of damage is due to the fragility curve used for the computation. These curves have 5 damage states. Both earthquake scenarios shown here are within the same damage state.
*** This level of flooding would be insufficient to overtop the dam. Rather, the impact involves water being released from the dam to prevent overtopping, leading to flooding turbine halls, transformers and electric substation buildings.
**** Output is reduced by an estimated 10% over this period; not complete shut-down of plant.

5.3.2. Potential level of damage

5.3.2.1. Damage to the integrity of the asset

Sanibey Yedigöze HPP is exposed to storm, tornado, flood, heat wave and earthquake. Among all the hazardous events that can affect the HPP, earthquake is potentially the most damaging one. With a 0.04% yearly likelihood (i.e. a return period of 2475 years) a 0.472g event can damage 40% of the power plant (i.e. the substations, which increase the voltage of the electricity produced). Similarly, storms and tornadoes (scenarios # 8 to # 11) are estimated by the CI experts to lead to asset damage in the range of 10% to 25%, related to damage to the substations and transmission lines.

[iv] Assuming 1 year analysis period.
[v] Economic impacts for future time periods are undiscounted
[vi] Economic risks for future time periods are undiscounted

5.3.2.2. Decrease in asset performance

Relatively frequent hazards which cause limited damage to the integrity of the asset could, however, affect long-term asset performance (power output in this case). Of the hazard scenarios analysed in the risk assessment, heat waves are the most frequent events that can affect HPP performance, with an estimated annual frequency of 20%. Extreme heat can decrease the performance of the sub-stations as well as the associated transmission equipment. Extreme heat may cause disconnections and reduce the level of performance in energy transformation in the substations. Further, some components might not be operational when a high threshold temperature is reached. According to the CI experts, under current conditions, no loss of performance is expected. However, in the future, as climate change leads to more intense heatwaves, the impacts could become more severe, with a high-level estimate of 10% loss of output by the 2050s under extended heatwave conditions.

5.3.3. Duration of disruption

As shown in Table 5-4, under the scenarios investigated, the disruption (downtime) to Sanibey Yedigöze HPP is estimated to be in the range of zero to 30 days. The earthquake scenarios # 3 and # 4 show the greatest downtime - after a performance drop of 50%, the restoration process to recover back to 100% of energy production takes an estimated 30 days. This relatively lengthy period of disruption is a consequence of the potential need to carry out costly repairs following the earthquake. In fact, severe shaking can cause damage to the auxiliary components of the power plant, such as control rooms, switches, transformers, etc. Tornadoes, hitting the most vulnerable substations, can reduce performance for an estimated 15 days.

5.3.4. High level economic impact

The hazard that poses the greatest economic threat is earthquake, with scenarios # 3 and # 4 in Table 5-4 showing a potential GDP loss of USD 184m with 30 days of disruption, *if* a major earthquake was to occur. However, when the likelihood of the hazard is taken into account, (‘exceedance probability per year’ in Table 5-4), it can be seen that the economic risk is highest for flooding at the HPP (1.7 m USD per year; scenario #5; Table 5-4). This risk is primarily driven by flooding of the high-voltage sub-station.

The economic risk for floods with a 1% probability of occurring per year (scenarios #6) and extreme heatwaves in the 2050s are the second most significant at the HPP, at USD 0.6 m per year (undiscounted). It is the high probability (at 20% annually) which makes scenario # 14 a concern. In addition, the frequency of heatwaves is expected to increase due to climate change, therefore the 20% “Exceedance Probability per year” for the 2050s may be underestimated, suggesting that heatwaves may be even more of a threat.

5.3.5. Geographical extent of the impact

Sanibey Yedigöze HPP has an installed capacity of 317 MW. As shown in Table 5-5, this represents 14% of Çukurova region’s hydropower capacity and 7% of the region’s capacity across all generation types. Hence, if the plant is out of action, this represents a significant fall regionally. However, in general, the service provided by the renewable power generation assets in Çukurova can be easily replaced, due to their relatively small size compared to the size of the grid-connected power plant. The geographical extent of the impacts will be very localised and limited, with almost no cascading impacts, as generation capacity is much higher than consumption, and because the transmission system has back up routes to mitigate any eventual downtime.

Table 5-5: Contribution (%) of Sanibey Yedigöze HPP to Çukurova region's installed capacity (MW). (Source: EPDK[45]).

Source Type	Adana (MW)	Mersin (MW)	Total Regional Installed Capacity (MW)	Contribution of Sanibey Yedigöze HPP (% of regional total)
Hydroelectric	1,699.00	569.48	2,268.48	14%
All power plants	*3,541.50*	*020.32*	*4,561.82*	7%

5.3.6. Cascading impacts

As noted above, loss of production from Sanibey Yedigöze HPP would not have cascading impacts through the power system and into the wider economy. However, Mentaş HPP is located downstream of it, on the Seyhan River. There is potential for a cascading impact on Mentaş HPP, as downtime / disruption of Sanibey Yedigöze HPP might affect water management (although Mentaş is a relatively small HPP, with 49.5 MWe installed capacity). During an extended period of disruption, there may be consequences for other water users outside the energy sector. For example, during a prolonged heatwave, competition for increasingly scarce water supplies may lead to conflict and/or rationing.

5.4. İsken Sugözü Thermal Power Plant

İsken Sugözü Thermal Power Plant is a thermal power plant (TPP) located at Yumurtalık in Adana. The power plant has an installed capacity of 2 x 605 MW net with a steam generation of 524 kg/s each. Bituminous coal is used as fuel to heat the steam at 733 MVA (Mega-Volt-Ampere) per each generator. İsken Sugözü is the largest power plant in Çukurova and is responsible for meeting 4% of the total power demand in Turkey. It is cooled using sea water. Some 250 staff are responsible for the power plant operations, and the original investment to build the power plant was 1.5 Bn USD.

Further details of the hazards, vulnerability and exposure of this TPP as well as the operational model developed within RiskAPP are provided in Annex A3.10.

5.4.1. Risk assessment findings

The information on hazards, vulnerability and exposure are combined using the RiskAPP model to provide a measure of the damage and downtime each hazard scenario may cause at the TPP (Table 5-6). The estimated daily economic impact of downtime (USD 84m) is multiplied by the number of days of downtime under each scenario to estimate the economic impact of downtime per scenario (Table 5-6, column labelled 'Economic impact'). These economic impacts are the multiplied by the 'exceedance probability per year' to estimate the 'economic risk' per year for each scenario (Table 5-6, final column).

Table 5-6: Summary of the damage, downtime, economic impact and economic risk of each hazard scenario at İsken Sugözü TPP. (Source: Report authors).

Scenario no.	Hazard	Intensity measure value	Unit	Exceedance Probability per year[vii]	Time period	Physical phenomena	Damage %	Downtime [days]	Economic impact (GDP loss) [million USD][viii]	Economic risk per year [million USD][ix]
# 1	Earthquake	0.171	g	1.39%	Current	Ground shaking	Slight – 5%	0	0	0.0
# 2	Earthquake	0.375	g	0.21%	Current	Ground shaking	Moderate – 40%	30	2,520	5.3
# 3	Earthquake	0.641	g	0.04%	Current	Ground shaking	Extensive – 70%	60*	5,040	2.0
# 4	Landslides (earthquake)	None	-	-	Current	Debris	0%	0	0	-
# 5	Flash flood	4	m	-	Current	Water depth	< 10%	10	840	-
# 6	Storm	81-120	km/h	1.00%	Current	Wind speed	< 10%	5	420	4.2
# 7	Storm	121-160	km/h	1.00%	2030s/ 2050s	Wind speed	< 15 %	10	840	8.4
# 8	Tornadoes	117-180 (F1 Fujita scale)	km/h	0.33%	Current	Wind speed	< 10 %	0.5	42	0.1
# 9	Tornadoes	181-253 (F2 Fujita scale)	km/h	0.17%	Current	Wind speed	20%	15	1,260	2.1
# 10	Heatwaves	27	Celsius	20.00%	Current	Air temperature	0%	0	0	0.0
# 11	Heatwaves	35	Celsius	20.00%	2030s	Air temperature	5%	0	0	0.0
# 12	Heatwaves	40	Celsius	20.00%	2050s	Air temperature	10%	5** (at 90% output)	42	8.4
# 13	Coastal flood	6.1	m	1.00%	Current	Max wave height	< 10%	10	840	8.4
# 14	Coastal flood	6.2	m	1.00%	2030s	Max wave height	< 10%	10	840	8.4
# 15	Coastal flood	6.3	m	1.00%	2050s	Max wave height	< 10%	10	840	8.4
# 16	Coastal flood	10	m	1.00%	2050s	Max wave height	15%	15	1,260	12.6
# 17	Landslides (precipitation)	Occurrence	-	Low	Current	Debris	5%	20	1,680	-

* The electrical equipment at the plant could take up to 200 days to repair[46] following extensive (70%) damage. (See Annex A3.8.1 for a description of the damaged elements[47].) However, the downtime is capped at 60 days, because a replacement could come online before the plant was fully repaired.
** Output is reduced by an estimated 10% over this period; not complete shut-down of plant

[vii] Assuming 1 year analysis period.
[viii] Economic impacts for future time periods are undiscounted
[ix] Economic risks for future time periods are undiscounted

5.4.2. Potential level of damage

5.4.2.1. Damage to the integrity of the asset

İsken Sugözü TPP is exposed to earthquake, landslides, flash floods, storms, extra-tropical tornadoes, heat waves and coastal flooding. Among all the hazardous events that can affect the HPP, earthquake is the most damaging. With a 0.04% yearly likelihood (i.e. a return period of 2475 years) a 0.641g event can damage 70% of the power plant. A less rare earthquake with 0.21% yearly probability (approximately 1 in 50 year return period) can damage 40% of the plant. Coastal flood and tornadoes (scenario # 16, scenario # 9) are estimated by the CI experts to lead to asset damage in the range 15% to 20%.

5.4.2.2. Decrease in asset performance

Relatively frequent hazards which cause limited damage to the integrity of the asset could, however, affect long-term asset performance (i.e. power production). Of the hazard scenarios analysed in the risk assessment, heatwaves are the most frequent hazardous event that can affect the TPP, with an estimated 5 days of reduced output (output down by 10% in the 2050s time period, which takes account of climate change). A decrease in performance (output) can be caused by heatwaves affecting power plant equipment, including generators and transformers. Similarly, wind storms are relatively frequent and could limit performance at the plant by causing mild damage to coal loading or storage facilities. Since the TPP is located on the coast, a coastal flooding event caused by a wave could lead to: loss of coal stored in the open; damage to substations; and impacts of debris on TPP components.

5.4.3. Duration of disruption

As expected, the greater the level of damage caused by a hazard, the longer the period of disruption. Under the scenarios investigated, the disruption (downtime) to İsken Sugözü TPP is estimated to be in the range of zero to 200 days. The earthquake scenario # 3 shows the longest downtime, and an estimated 70% of power generation lost immediately after the event. However, while the restoration process to recover back to 100% of energy production could take up to an estimated 200 days, it is considered that a replacement could come online after a maximum of 60 days. A range of other hazard scenarios, including earthquake, flash flood, storm, tornado, coastal flood and landslide (precipitation-induced), lead to estimated disruption in the range of 10 to 30 days.

5.4.4. High level economic impact

The hazard that poses the greatest economic threat is earthquake, with scenario # 3 in Table 5-6 showing a potential GDP loss of USD 5 bn with 60 days of disruption, *if* a major earthquake was to occur. However, when the likelihood of the hazard is considered, ('exceedance probability per year' in Table 5-6, the economic risk is highest for 1:100 year coastal floods in the 2050s, at USD 12.6m per year (undiscounted). Less severe coastal floods and heatwaves are the equal second most important economic risks for the TPP, with USD 8.4m of computed risk.

5.4.5. Geographical extent of the impact

İsken Sugözü TPP has an installed capacity of 1,210 MW and annual power production of 9.183 GWh. Due to its size, the geographical extent of any impacts on İsken Sugözü TPP *could* be felt nationally, as it provides 4% of Turkey's power supply. However, substitution of its power production by other facilities is possible or likely, due to the highly-centralized power network in Turkey, in which case its impact would not be felt, except at the plant itself.

5.4.6. Cascading impacts

İsken Sugözü TPP provides approximately 9 billion kWh electrical energy to the grid annually (2015 data). The total electricity generated was equal to 118% of Adana city's total consumption and around 4% of Turkey's total electricity consumption. It is difficult to predict if a sudden failure of the TPP could start a chain of events, as happened during the national blackout of March 31st, 2015. However, a TEİAŞ representative consulted for this project stated that this was unlikely, due to the possibility of substituting the power plant with production from other power production facilities and thanks to the intrinsic resilience of the power network.

5.5. Yumurtalik-Kırıkkale Oil Pipeline Storage and Pumping Facilities

Yumurtalik-Kırıkkale Oil Pipeline is a 24” diameter pipeline with a total length of 457 km that transfers crude oil from Ceyhan (the terminal of the Iraq-Turkey pipeline systems) to the Central Anatolian Refinery (Figure 5-4). The pipeline infrastructure starts at Ceyhan, where it comprises of a set of storage tanks and 2 pumping stations. The pipeline route crosses the rough and rocky areas of the Toros Mountains, ending at the refinery. The API 5LS X-60 pipes have a wall thickness ranging from 6.35 to 11.92 mm. Construction of the pipeline begun in May 1983 and ended in February 1986. The pipeline was commissioned by BOTAŞ, Petroleum Pipelines Corporation. The capacity of the pipeline is 7.2 million tonnes/year, which converts into 51 million barrels of oil per year.

There is limited publicly-available information on the pipeline, and the exact location of the pipeline route is not publicly available. Furthermore, it appears that much of the pipeline is buried and is thus not exposed to many of the hazards. Therefore, the risk assessment focuses solely on one critical component of the pipeline infrastructure, namely the storage and pumping facilities at Ceyhan terminal.

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Figure 5-4: Location of Yumurtalik-Kırıkkale pipeline infrastructure (green storage facility and green line inside red square). (Source: Valeura Energy[48]).

Further details of the hazards, vulnerability and exposure of the oil pipeline storage and pumping facilities as well as the operational model developed within RiskAPP are provided in Annex A3.11.

5.5.1. Risk assessment findings

The information on hazards, vulnerability and exposure are combined using the RiskAPP model to provide a measure of the damage and downtime each hazard scenario may cause at the pipeline storage and pumping facilities at Ceyhan (Table 5-7). The estimated daily economic impact of downtime of the pipeline (USD 11.6 m) is multiplied by the number of days of downtime under each scenario to estimate the economic impact of downtime per scenario (Table 5-7, column labelled

'Economic impact'). These economic impacts are the multiplied by the 'exceedance probability per year' to estimate the 'economic risk' per year for each scenario (Table 5-7, final column).

Table 5-7: Summary of the damage, downtime, economic impact and economic risk of each hazard scenario at the Ceyhan storage and pumping facilities associated with the Yumurtalik-Kırıkkale pipeline. (Source: Report authors).

Scenario no.	Hazard	Intensity measure value	Unit	Exceedance Probability per year[x]	Time period	Physical phenomena	Damage %	Downtime [days]	Economic impact [million USD][xi]	Economic risk per year [million USD][xii]
# 1	Earthquake	0.171	g	1.39%	Current	Ground shaking	Slight – 5%	0	0	0.0
# 2	Earthquake	0.375	g	0.21%	Current	Ground shaking	Moderate – 40%	30	348	0.7
# 3	Earthquake	0.641	g	0.04%	Current	Ground shaking	Extensive – 70%	60	696	0.3
# 4	Landslides (earthquake induced)	None	-	-	Current	Debris	5%	20*	(232)*	-
# 5	Flash flood	4	m	-	Current	Water depth	<10%	2*	(23.2)*	-
# 6	Storm	81-120	km/h	1.00%	Current	Wind speed	<5%	1*	(11.6)*	(0.1)*
# 7	Storm	121-160	km/h	1.00%	2030/ 2050	Wind speed	<10 %	10*	(116)*	(1.2)*
# 8	Tornadoes	117-180 (F1 on the Fujita scale)	km/h	0.33%	Current	Wind speed	<10%	1*	(11.6)*	0.0
# 9	Tornadoes	181-253 (F2 on the Fujita scale)	km/h	0.17%	Current	Wind speed	20%	10*	(116)*	(0.2)*
# 10	Heatwaves	27	Celsius	20.00%	Current	Air temperature	0%	0	0	0.0
# 11	Heatwaves	35	Celsius	20.00%	2030	Air temperature	5%	0	0	0.0
# 12	Heatwaves	40	Celsius	20.00%	2050	Air temperature	10%	5*	(58)*	(11.6)*
# 13	Coastal flood	6.1	m	1.00%	Current	Max wave height	<10%	10*	(116)*	(1.2)*
# 14	Coastal flood	6.2	m	1.00%	2030	Max wave height	<10%	10*	(116)*	(1.2)*
# 15	Coastal flood	6.3	m	1.00%	2050	Max wave height	<10%	10*	(116)*	(1.2)*
# 16	Coastal flood	10	m	1.00%	2050	Max wave height	15%	15*	(174)*	(1.7)*
# 17	Landslides (precipitation induced)	Occurrence	-	Low	Current	Debris	5%	20*	(232)*	-

* As noted in Section 5.5.3, national legislation requires Turkish refineries to hold at least 20 days of product stocks. Therefore, events causing downtime of 20 days or less should not lead to disruption to the refinery. Hence, economic impacts / risks for these events are shown in brackets.

5.5.2. Potential level of damage

5.5.2.1. Damage to the integrity of the asset

The Ceyhan storage/pumping facility associated with the Yumurtalik-Kırıkkale pipeline is exposed to earthquake, landslides, flash floods, storms, tornadoes, heatwaves and coastal flooding. Scenario #3, leading to an estimated 70% damage to the asset is the most harmful of the possible events hitting the CI, though it has a low yearly occurrence probability, of 0.04% (2475 year return period).

[x] Assuming 1 year analysis period.
[xi] Economic impacts for future time periods are undiscounted
[xii] Economic risks for future time periods are undiscounted

Tornadoes and coastal flooding in the 2050s are also important hazardous events, leading to estimated damage of 15% to 20%.

5.5.2.1. Decrease in asset performance

Earthquake, as well as causing physical damage to the storage/pumping facilities, will also impact asset performance, since the damage leads to reduced capacity of the asset. An earthquake hitting the storage/pumping facilities can disrupt the pumps that inject the oil into the pipeline, and can cause significant damage to the storage tanks, because of shaking of the structures. A coastal flood could damage the pumping stations.

The damage to the asset causes interruption of its operations until repairs are made. Depending on the level of damage experienced, the interruption could be as long as 60 days.

5.5.2.2. Duration of disruption

The #3 scenario, very rare earthquake with 2475 years of return time (0.04% annual exceedance probability), has the worst consequence in terms of duration of the effects, with an estimated 60 days. This is followed by the #2 scenario earthquake with annual exceedance probability of 0.21% and an estimated downtime of 30 days. Landslide (either precipitation induced or earthquake induced) is estimated to lead to disruption lasting 20 days.

5.5.3. High level economic impact

The highest economic risk, at USD 0.7 m per year is associated with the rare earthquake (#2 scenario), with 0.21% yearly exceedance probability.

As a member of the International Energy Agency (IEA), Turkey is responsible for building a stock of oil, equivalent to its 90-day net imports. As a requirement of national legislation, Turkey has an industry-oriented oil stockholding system, imposing stockholding mandates on refineries, distributors and eligible consumers. Under the relevant acts, refineries and fuel distribution companies are obliged to hold at least 20 days of product stocks, based on the average daily sales of the previous year. This means any failure that can be fixed within this time period should not trigger a huge crisis. Hence, based on the risk assessment, only two of the earthquake scenarios (# 2 and # 3), which lead to estimated downtime of 30 days and 60 days respectively, could lead to a loss of production at the refinery.

5.5.4. Geographical extent of the impact

Long term (more than 20 days) disruption to the flow of crude oil along the Yumurtalik-Kırıkkale pipeline could affect operations at Kırıkkale refinery, which in turn partially serves the demands for refined fuels of end users in Ankara, Central Anatolia, Eastern Mediterranean and Eastern Black Sea regions.

5.5.5. Cascading impacts

In 2015, Kırıkkale Refinery reached full capacity, and processed 4.2 million tons of crude oil. The refinery’s capacity utilization rate stood at 87.1%. Its main products are LPG, gasoline, jet fuel, kerosene, diesel, fuel oil and bitumen. Approximately 4.1 million tons of petroleum products were produced in 2015; together with refinery transfers, 4.0 million tons of products were sold during the year. The refinery has Turkey’s largest road tanker filling capacity. Disruption to crude oil reaching the refinery which consequently affects refinery production could then have a cascading impact on the transportation sector (due to loss of diesel production) and, to a lesser extent, aviation (dependent on jet fuel production).

5.6. Mersin International Port

Mersin International Port (MIP) is one of the leading ports in Turkey and in the East Mediterranean region. The port has a total berths length of 3370 m, so it can simultaneously handle 8-9 vessels (vessels with length of 400 m). Mersin International Port (MIP) enjoys a favourable environment which possesses all the resources required for successful logistics functions: the port benefits from availability of a free trade zone, railway transportation infrastructure, a strong truck fleet in the region, and Adana Şakirpaşa Airport at 69 km distance.

Further details of the hazards, vulnerability and exposure of the port as well as the operational model developed within RiskAPP are provided in Annex A3.12.

5.6.1. Risk assessment findings

The information on hazards, vulnerability and exposure are combined using the RiskAPP model to provide a measure of the damage and downtime each hazard scenario may cause at the MIP (Table 5-8). The estimated daily economic impact of downtime (USD 21m) is multiplied by the number of days of downtime under each scenario to estimate the economic impact of downtime per scenario (Table 5-8, column labelled 'Economic impact'). These economic impacts are the multiplied by the 'exceedance probability per year' to estimate the 'economic risk' per year for each scenario (Table 5-8, final column).

Table 5-8: Summary of the damage, downtime, economic impact and economic risk of each hazard scenario at Mersin International Port MIP. (Source: Report authors).

Scenario no.	Hazard	Intensity measure value	Unit	Exceedance Probability per year[xiii]	Time period	Physical phenomena	Damage %	Downtime [days]	Economic impact (GDP loss) [million USD][xiv]	Economic risk per year [million USD][xv]
# 1	Storm	81 -120	km/h	1.00%	current	Wind speed	10	1	21	0.21
# 2	Storm	121-160	km/h	1.00%	2030s	Wind speed	15	15	315	3.15
# 3	Tornado	117-180 (F1)	km/h	0.33%	current	Wind speed	10	1	21	0.07
# 4	Tornado	181-253 (F2)	km/h	0.17%	current	Wind speed	50	30	630	1.07
# 5	Coastal Flood	6.1	m	1.00%	current	Max wave height	50	60	1260	12.60
# 6	Coastal Flood	6.2	m	1.00%	2030s	Max wave height	50	60	1260	12.60
# 7	Coastal Flood	6.3	m	1.00%	2050s	Max wave height	50	60	1260	12.60
# 8	Coastal Flood	10.0	m	1.00%	2050s	Max wave height	50	60	1260	12.60
# 9	Flood (Flash)	-	cm	-	current	Water depth	-	15	-	*
# 10	Heat wave	32	°C	20.00%	current	Air temperature	0	0	0	0
# 11	Heat wave	41	°C	20.00%	2030s	Air temperature	0	0	0	0
# 12	Heat wave	54	°C	20.00%	2050s	Air temperature	10	2	42	8.40
# 13	Earthquake	0.060 (D-soil)	g	2.33%	current	Peak ground acceleration	5	0	0	0
# 14	Earthquake	0.085 (D-soil)	g	1.39%	current	Peak ground acceleration	5	0	0	0
# 15	Earthquake	0.218 (D-soil)	g	0.21%	current	Peak ground acceleration	5	0	0	0

[xiii] Assuming 1 year analysis period.
[xiv] Economic impacts for future time periods are undiscounted
[xv] Economic risks for future time periods are undiscounted
* There is insufficient information to define the risk associated with this scenario

Scenario no.	Hazard	Intensity measure value	Unit	Exceedance Probability per year[xiii]	Time period	Physical phenomena	Damage %	Downtime [days]	Economic impact (GDP loss) [million USD][xiv]	Economic risk per year [million USD][xv]
# 16	Earthquake	0.350 (D-soil)	g	0.04%	current	Peak ground acceleration	10	5	105	0.04

5.6.2. Potential level of damage

5.6.2.1. Damage to the integrity of the asset

The MIP is exposed to storm, tornado, coastal flood, heat wave and earthquake. Among all the hazardous events that can affect the MIP, coastal flood is the most damaging one. A coastal flood with a 1.00% yearly likelihood (i.e. a return period of 100 years) is estimated to lead to damage to 50% of the port (cranes, waterfront structures). Storms in the 2030s (scenario # 2) are estimated by the CI experts to lead to asset damage of 15% of the port.

5.6.2.2. Decrease in asset performance

The most significant decreases in performance for Mersin International Port are associated with scenarios #5 to #8 whereby coastal flooding might lead to the port becoming inaccessible, with sea vessels and land-based transport (trucks) unable to enter the port. In addition, coastal flooding can prevent the rubber gantry cranes from operating, stopping operations related to container movements. Flooding can also affect storage areas, depending on their design and can also lead to wetting of the content of shipping containers stored at ground level.

Of the hazard scenarios analysed in the risk assessment, heat waves are the most likely hazardous event that can affect MIP, with an estimated annual frequency of 20%. High temperatures / extended heat waves can lead to changes in the performance (output) of the port, including downtime of cranes or reduction of speed of cargo handling due to extreme heat. According to the CI experts, under current conditions, no loss of performance is expected. However, in the future, as climate change intensifies, the impacts could become more severe, with a high-level estimate of 10% loss of performance by the 2050s under extended heatwave conditions.

5.6.3. Duration of disruption

As shown in Table 5-8, under the scenarios investigated, the disruption (downtime) to MIP is estimated to be in the range of zero to 60 days. The coastal flood scenarios #5 to #8 show the greatest downtime - after a performance drop of 50%, the restoration process to recover back to 100% of port activities takes an estimated 60 days. Under the scenarios investigated, wind storms and tornadoes hitting the port are estimated to reduce performance for between 15 - 30 days, due to damage to cranes and containers.

5.6.4. High level economic impact

The hazard that poses the greatest economic impact is coastal flood, with scenarios # 5, #6, #7, #8 in Table 5-8, showing a potential GDP loss of USD 1260m with 60 days of disruption *if* the events occur. Based on their 1.00% ‘exceedance probability per year’, the same scenarios have also the highest estimated economic risk, of USD 12.6 m per year (undiscounted).

5.6.5. Geographical extent of the impact

Due to the strategic location of Çukurova region, MIP is the central node in a network of ports including Iskenderun, Lattakia and Antalya, along with Beirut (Lebanon) and Limassol (Cyprus) which have the strongest links and could be considered the dependent ports in the Mersin network. So, the geographical extent of disruptive events at the port can be extensive, with cascading impacts within Turkey’s port network and overseas.

Disruption of services at Mersin International Port lasting for more than a few days would result in delay or cancellation of liner services and corresponding shipments from/to Europe, Asia, USA and Nordic countries. The top maritime destinations for exported goods from Çukurova region includes Russia, Germany, Italy, Spain, France, Cyprus, China, Libya, Egypt, Sudan, and Morocco, with a total value of USD 1.7 billion in 2015. Among these export items, grains and seeds, fresh produce, textile products, chemicals, automotive parts and steel make up the 75% of the total export value. In addition, the imported good supply chain, which was worth USD 2.3 billion in 2015, would be disrupted.

5.6.6. Cascading impacts

In general terms, the cascading impacts arising from transport disruption can be identified by considering three 'layers' of stakeholders, as shown in Figure 5-5. Hence, disruption of operations at MIP can have impacts on the 'logistics layer', i.e. affecting the performance of other ports and carriers, as noted above. Disruption at the port could also impact the producers and customers of goods imported and exported via the port, as well as consolidators, i.e. the 'supply chain transaction layer' shown in Figure 5-5. Finally, the cascading impacts could also affect the 'oversight layer', namely transportation authorities.

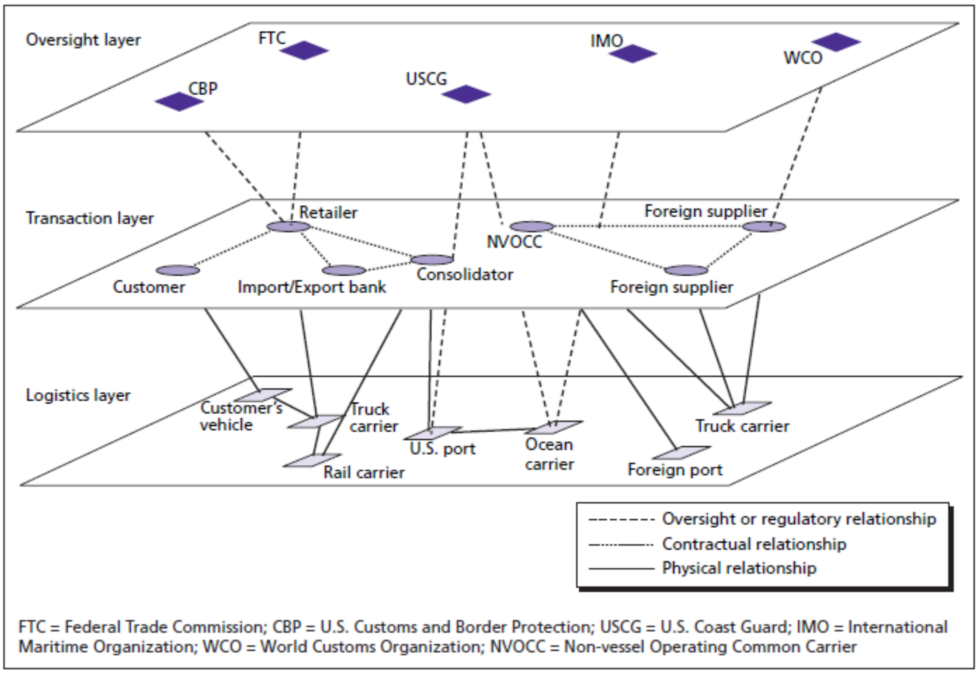


Figure 5-5: Schematic showing the cascading impacts of transport disruption through supply chains. (Source: RAND Corporation, 2005[49]).

5.7. Seyhan Viaduct across Seyhan River on E-90 European Highway

The Seyhan Viaduct is a two lane, 470 m long bridge over the Seyhan river in Adana, with a total height of 18.50m. It serves the E-90 (O-50) European highway, connecting the region to Syria, Iraq and Iran. It had a daily reported traffic of 36,232 vehicles in 2015. The E-90 is managed by the Ministry of Transportation; General Directorate of Highways (Karayollari Genel Mudurlugu).

Further details of the hazards, vulnerability and exposure of the viaduct as well as the operational model developed within RiskAPP are provided in Annex A3.13.

5.7.1. Risk assessment findings

The information on hazards, vulnerability and exposure are combined using the RiskAPP model to provide a measure of the damage and downtime each hazard scenario may cause to the Seyhan viaduct (Table 5-9). The estimated daily economic impact of downtime (USD 5.1m) is multiplied by the number of days of downtime under each scenario to estimate the economic impact of downtime per scenario (Table 5-9, column labelled 'Economic impact'). These economic impacts are the multiplied by the 'exceedance probability per year' to estimate the 'economic risk' per year for each scenario (Table 5-9, final column).

Table 5-9: Summary of the damage, downtime, economic impact and economic risk of each hazard scenario at Seyhan Viaduct on E-90 European Highway. (Source: Report authors).

Scenario no.	Hazard	Intensity measure value	Unit	Exceedance Probability per year[xvi]	Time period	Physical phenomena	Damage (% or category)	Downtime [days]	Economic impact (GDP loss) [million USD]	Economic risk per year [million USD]
# 1	Flood	0.0	cm	4.00%	Current	Water depth	0%	0	0	0.00
# 2	Flood	32	cm	1.00%	Current	Water depth	0%	0	0	0.00
# 3	Flood	217	cm	0.20%	Current	Water depth	25%	7	35.7	0.07
# 4	Earthquake	0.09	g	2.33%	Current	Peak ground acc	0%	0	0	0.00
# 5	Earthquake	0.13	g	1.39%	Current	Peak ground acc	Cosmetic repairs, asset is serviceable	15	76.5	1.06
# 6	Earthquake	0.31	g	0.21%	Current	Peak ground acc	Cosmetic repairs, asset is serviceable	15	76.5	0.16
# 7	Earthquake	0.46	g	0.04%	Current	Peak ground acc	Cosmetic repairs, asset is serviceable	15	76.5	0.03
# 8	Landslide (precipitation induced)	Occurrence	-	Low	Current	Debris	Very high	30	153	Not known[xvii]
# 9	Landslide (earthquake induced)	Occurrence	-	Low	Current	Debris	Very high	30	153	Not known

5.7.2. Potential level of damage

5.7.2.1. Damage to the integrity of the asset

The Seyhan Viaduct is exposed to earthquake, landslides and, to a lesser extent, flood hazards. The viaduct is correctly designed against seismic actions, and earthquakes with very high damage potential will not require the viaduct / bridge to be rebuilt; only cosmetic repairs will be needed. Landslides are reported to have a low frequency (with an index of 1 out of 5 on a global frequency scale), but a landslide can cause very high damage, and the resulting debris can also make the viaduct / bridge inaccessible. Flooding of the viaduct could potentially cause damage to the abutments and washing out the filling.

[xvi] Assuming 1 year analysis period.
[xvii] The economic risk cannot be calculated as the exceedance probability is not known for this hazard

5.7.2.2. Decrease in asset performance

For a viaduct / bridge, asset performance is directly connected to its integrity (as described above), because the operation of a bridge relies on its integrity. Since most of the hazards will impact the integrity of the bridge, due to strict regulations, the bridge could not be used again before it had been restored. A decrease in asset performance without physical damage is an unrealistic scenario.

5.7.3. Duration of disruption

The longest disruption to Seyhan Viaduct is expected to be triggered by landslides, with an estimated 30 days of disrupted operations. Disruption due to earthquakes is estimated at 15 days. Severe floods might trigger 7 days of disruption, mainly because of the debris transported by them.

5.7.4. High level economic impact

The hazards that pose the greatest economic threat are landslides and earthquakes, showing potential GDP losses of USD 153m and USD 73.5m respectively, *if* these events were to occur. As the exceedance probability for landslide occurrence is not quantified, the economic risk associated with this hazard cannot be calculated. However, for lower intensity (0.13g), less rare, earthquakes (scenario # 5), the economic risk is USD 1m per year.

5.7.5. Geographical extent of the impact

Any damage to the viaduct / bridge will have a significant impact on the traffic in downtown Adana. Since the viaduct / bridge is located on European road E-90 and the Adana-Sanliurfa highway, all transportation through Mersin Industrial Zone, Adana Sakirpasa Airport, and onwards to Iskenderun, Gaziantep and Syria, Iraq will be rerouted. If only isolated damage to the viaduct / bridge is considered, there will be alternative transportation routes and traffic will be diverted with some delays. However, if there are multiple damages at different parts of the road network, alternative routes might be very costly. In either case, Çukurova region will be significantly affected by any (short and long term) disruption of the viaduct / bridge operations. Due to the existence of multiple alternative routes, the impacts would only be felt regionally. It is not expected that there would be a significant impact at the national or transnational level.

5.7.6. Cascading impacts

Disruption of a viaduct / bridge on a major highway results in a broken link in the supply chain network. Since the links or arcs on the network constitute paths between origin and destination, broken links and resulting freight delays may have impact on activities at the origin and destination. The increase in freight transportation costs will impact the profitability and consequently competitiveness of the industries that are dependent on the road transportation. Not only the logistics sector, but all supply chains having operations in this region (major supply chains include Hugo Boss and Bossa in textiles; TemSA in automobile, etc), will feel the impact of a viaduct / bridge interruption as increased costs, reduced customer service levels and a potential 'bullwhip' effect at the other end of the supply chain.

Another dimension of the cascading impact relates to employment: Lost labour hours (due to traffic delays) would be a local or regional impact. Finally, with reference to Figure 5-5 in Section 5.6.6, any disruption of viaduct / bridge operations will have impact on the 'logistics layer' (i.e. affecting the performance of other carriers and ports), the 'supply chain transaction layer' (suppliers, retailers, customers etc), and the 'oversight layer' (transportation authorities).

5.8. Risk assessment summary & conclusions

This Section provides the findings of the high-level risk assessment of critical infrastructure in Çukurova Region. As already noted, the assessment has been based on publicly-available information about the critical infrastructure, and on current and future natural hazards. This information has been complemented with analysis by team members with expertise in the energy and transport & logistics sectors, and expertise related to geological and climate-related hazards. It is clear that more detailed information, particularly about the design of components of the critical infrastructure facilities and their economic importance, would enable a more thorough risk assessment to be performed.

5.8.1. Risk for individual assets

The results of the risk assessment using RiskAPP can be visualised using 'bubble plots' in order to identify the risks of greatest concern (both currently and potentially in the future). For example, Figure 5-6 summarises the estimated level of economic risk associated with a range of hazards at Sanibey Yedigöze Hydropower Plant. The horizontal axis provides a scale of "probability of occurrence" within the lifetime of the asset (assumed here to be 100 years). The vertical axis shows the cumulative damage associated with each hazardous event over the same period. Here, it can be seen that flooding and severe heatwaves (which are becoming more frequent and more severe due to climate change) may accumulatively create the most significant economic risks (see Table 5-4 in Section 5.3.1). Similarly, coastal flooding has the most significant impact for Mersin International Port (MIP) (Figure 5-7) due to the relatively high level of damage and downtime such an event could cause (see Table 5-8). Heatwaves represent the second most important risk at the port. For the sake of the following analyses, the lifespan of the asset is considered to be 100 years, which is typical for critical infrastructure.

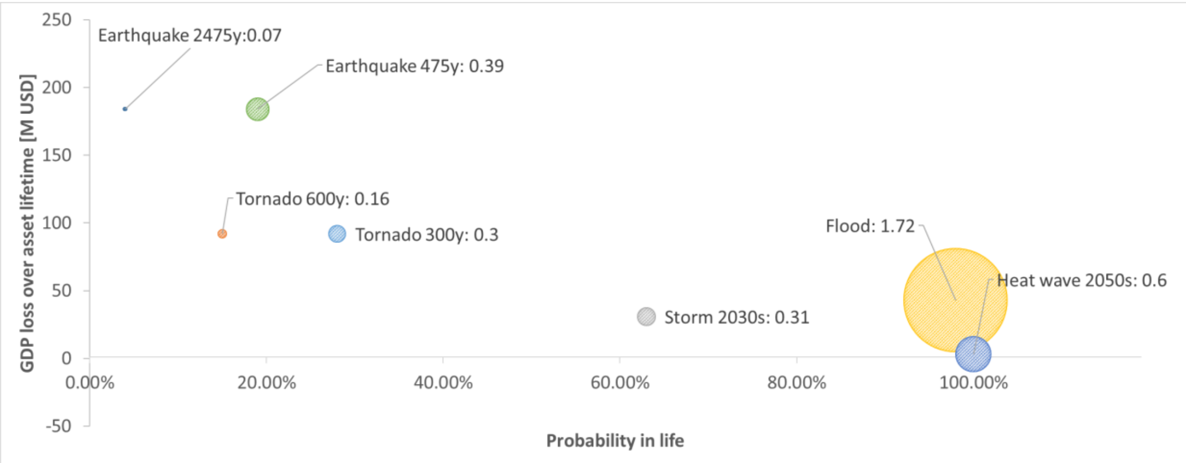


Figure 5-6: Economic risk at Sanibey Yedigöze Hydropower Plant for each hazard scenario. The scale on the y-axis refers to the cumulative GDP damage over the lifespan of the asset (assumed as 100 years) in USD millions. The size of the circle and the number represents the annual average expected economic risk in USD millions. (Source: Report authors).

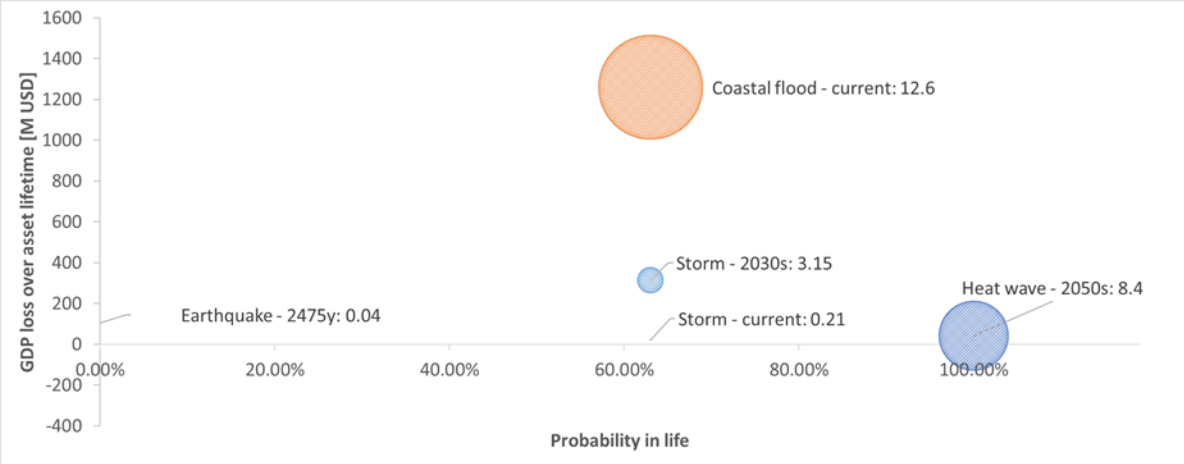


Figure 5-7: Economic risk at Mersin International Port for each hazard scenario. The scale on the y-axis refers to the cumulative GDP damage over the lifespan of the asset (assumed as 100 years) in USD millions. The size of the circle and the number represents the annual average expected economic risk in USD millions. (Source: Report authors).

5.8.2. Risks for multiple assets

The most important outcome of the risk assessment is the ability to visualise and assess risks across CI assets and hazards. Such information is vitally important for focussing resources and efforts to tackling the most pressing issues.

5.8.2.1. Risk summary across assets

Figure 5-8 shows the multiple dimensions of the risks facing CI in Çukurova. The horizontal axis shows the geographic extent of the impact and the vertical axis is the disruption time in days. The 3rd dimension is the size of the 'bubble' which is the economic risk. The same data are provided in Table 5-10.

The following overall conclusions can be drawn:

- The hazardous events estimated to cause the greatest economic risk are coastal floods today and in the 2050s. Coastal floods are the most important hazardous events (in terms of economic risk) for İsken Sugözü Thermal Power Plant and Mersin International Port.
- Heatwave in the 2050s emerges as the second most important hazardous event overall in terms of economic risk. It is the second most important hazard for İsken Sugözü Thermal Power Plant, Mersin International Port and Sanibey Yedigöze HPP.
- While earthquakes garner a lot of attention, they appear to pose lower economic risk than climate hazards, due to their relatively lower probability of occurrence and because critical infrastructure is designed to withstand them.
- The critical infrastructures facing the highest economic risks are İsken Sugözü Thermal Power Plant and Mersin International Port. This reflects the economic importance of these assets, as well as their higher hazard exposure.
- Risks to the essential services provided by several of the assets are mitigated to some extent by the availability of alternative assets which can substitute for the service in the event that it is disrupted:
    - For Sanibey Yedigöze Hydropower Plant and İsken Sugözü Thermal Power Plant, substitution of power production by other facilities is possible or likely, due to the highly centralized power network in Turkey.
    - In the event of damage to the Seyhan Viaduct on the E-90, traffic can be re-routed, though with some delays and additional costs.

- A useful risk management measure has been identified for Kırıkkale refinery, in the event of disruption to oil supplies via Yumurtalik-Kırıkkale Oil Pipeline: The refinery is required by legislation to have storage facilities capable of withstanding at least 20 days of disruption. This storage capacity allows it to cope with all but the most severe hazard scenarios.
- There is a broad spectrum in terms of the geographical extent and cascading impacts of disruption across the CI assets:
  - At one end of the scale, disruption to Sanibey Yedigöze Hydropower Plant would only be felt locally, as the service it provides can be easily replaced, due to its relatively small size compared to the size of the grid-connected power plant.
  - At the other end, disruption at Mersin International Port could have transnational impacts, owing to its importance in the global supply chain. The cascading impacts would be felt by other ports and carriers, as well as by producers and customers of goods imported and exported via the port.

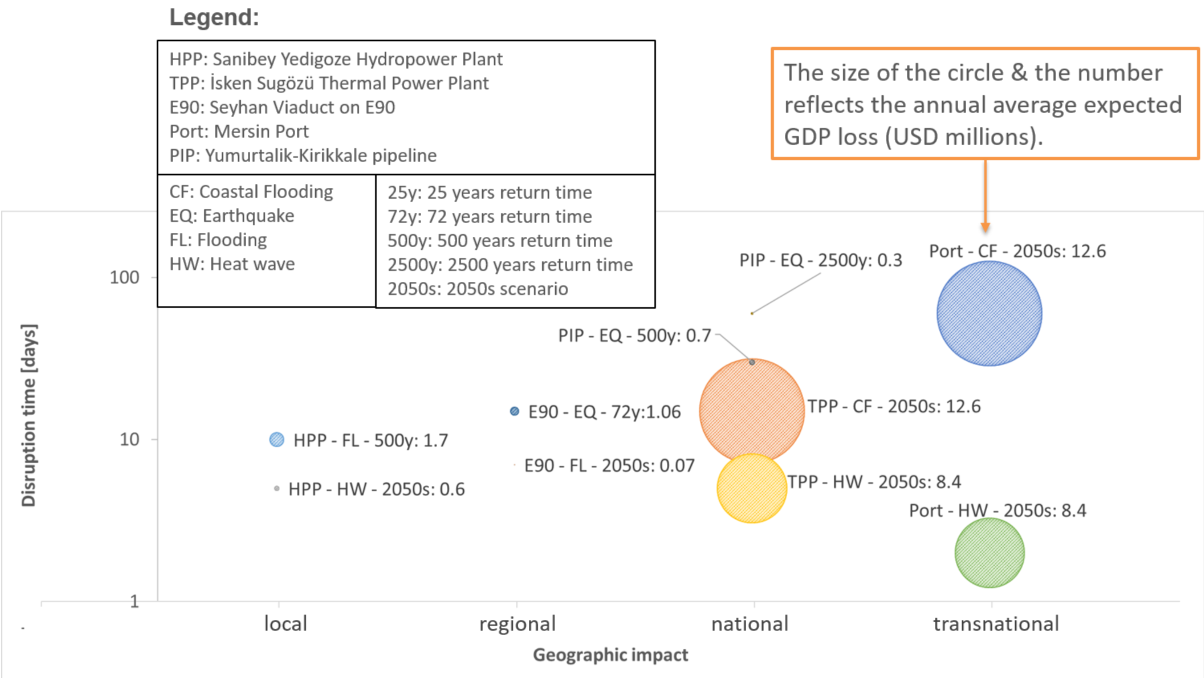


Figure 5-8: Multi-dimensions of risk facing the critical infrastructures. (Source: Report authors).

Table 5-10: Summary of risk assessment findings – top two economic risks per CI. (Source: Report authors).

CI	Hazard	Intensity measure value	Unit	Exceedance Probability per year[xviii]	Time period	Downtime [days]	Economic risk per year [million USD][xix]	Geographical extent
Sanibey Yedigöze HPP	Flood	164	cm	4.00%	current	7	1.72	Local
Sanibey Yedigöze HPP	Heat wave	40	ºC	20.00%	2050s	5 at 90% output*	0.6	Local
İsken Sugözü TPP	Coastal flood	10	m	1.00%	2050s	15	12.6	National
İsken Sugözü TPP	Heat wave	40	ºC	20.00%	2050s	5 at 90% output*	8.4	National
Yumurtalik-Kırıkkale pipeline	Earthquake	0.375	g	0.21%	Current	30	0.7	National
Yumurtalik-Kırıkkale pipeline	Earthquake	0.641	g	0.04%	Current	60	0.3	National
Mersin International Port	Coastal Flood	10.0	m	1.00%	2050s	60	12.6	Transnational
Mersin International Port	Heat wave	54	ºC	20.00%	2050s	2	8.4	Transnational
Seyhan Viaduct on E-90 European Highway	Earthquake	0.13	g	1.39%	Current	15	1.06	Regional
Seyhan Viaduct on E-90 European Highway	Earthquake	0.31	g	0.21%	Current	15	0.16	Regional
* Output is reduced by an estimated 10% over this period; not complete shut-down of plant								

xviii Assuming 1 year analysis period.
xix Economic risks for future time periods are undiscounted

5.8.2.2. Risk summary by hazard type or event

It is also possible to visualise the risks posed by hazard type or event for multiple assets across the region. This allows the total economic impact to be calculated for the region, if for example a specific coastal flood or heatwave event occurs. Not all scenarios can be regarded as a single event in this way. A coastal flood or heatwave is likely to affect multiple assets during the same event, whilst the impact of a tornado would be more localised. For hazards that affect a geographically wide area, it makes sense to sum all the consequences of a single event to give a total for the region.

Figure 5-9 shows the risk of losses and disruption time for a coastal flooding event affecting Mersin International Port and İsken Sugözü TPP. If a 1:100 year event (based on current hazard levels) were to strike the coast of Çukurova, the total impact for both assets could be 2.1 billion USD. In the future (by 2050s) a more extreme event could total 2.5 billion USD.

Figure 5-10 represents the consequences of a typical heatwave expected by the 2050s on Sanibey Yedigöze HPP, İsken Sugözü TPP and Mersin International Port. The total loss, in this 2050s scenario, would be 87 million USD. İsken Sugözü TPP and Mersin International Port are the assets most exposed to heatwave due to their contributions to GDP.

Figure 5-11 and Figure 5-12 summarise the impacts of tornado and earthquake scenarios respectively. Because earthquakes and tornadoes do not usually affect wide areas, it does not make sense to sum all the consequences of a single event to give a total for the region.

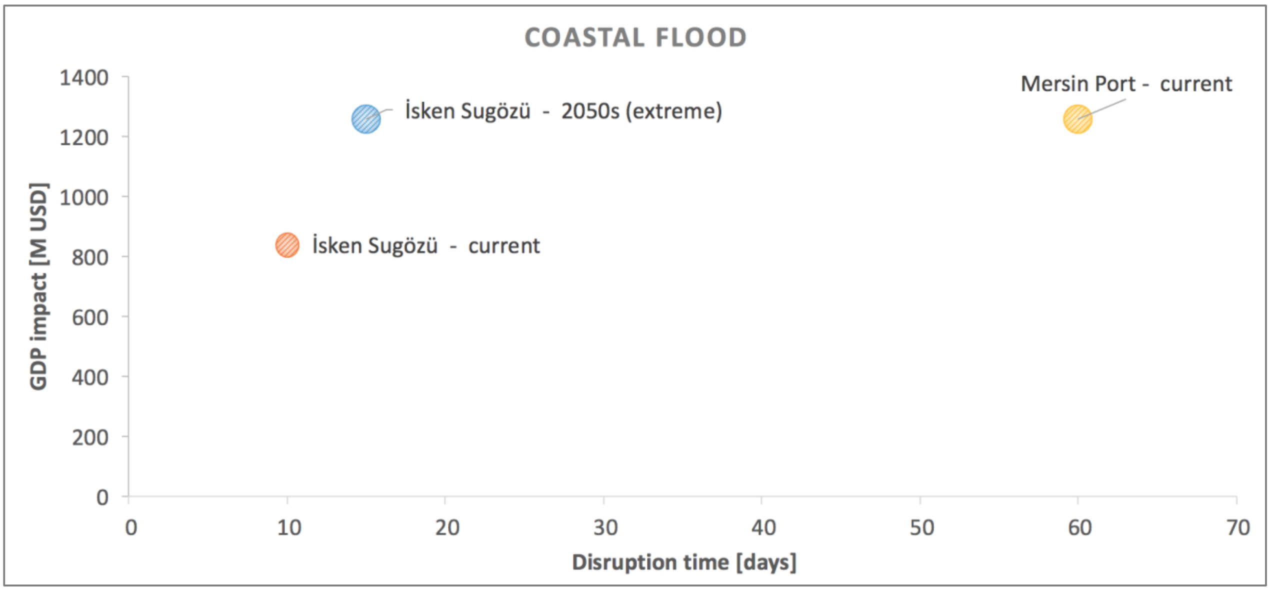


Figure 5-9: Coastal flood scenarios (current and future, 2050s) losses and risk summary (the size of the bubble represents the risk, multiplying the loss of GDP by the frequency of the event, i.e. rarer events have smaller bubble size even with a large impact on GDP). (Source: Report authors).

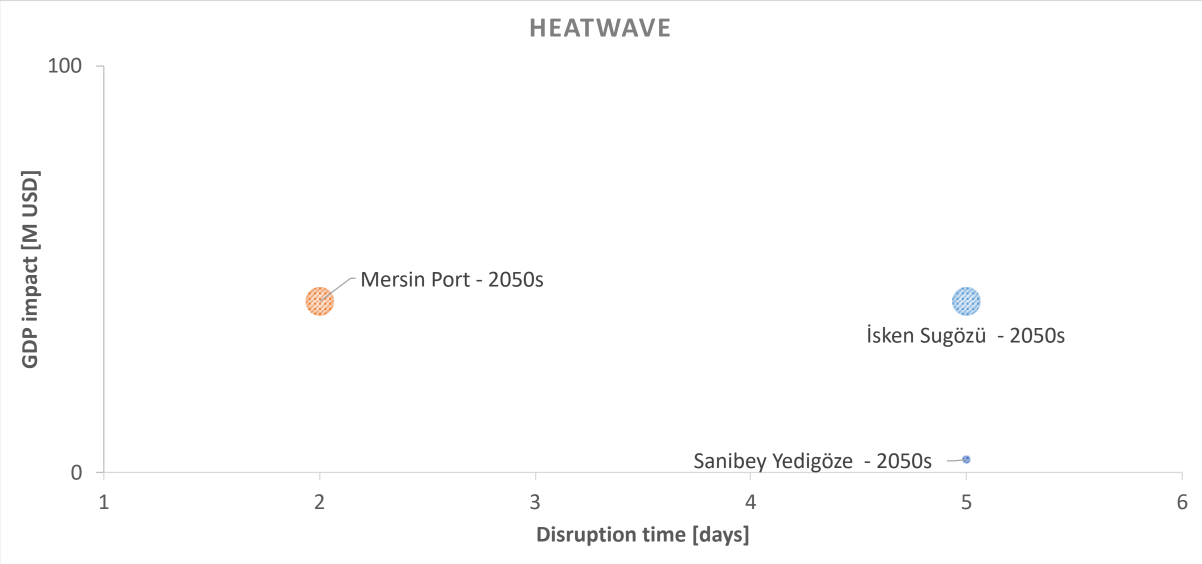


Figure 5-10: Heatwave scenario losses and risk summary (the size of the bubble represents the risk, multiplying the loss of GDP by the frequency of the event, i.e. rarer events have smaller bubble size even with a large impact on GDP). (Source: Report authors).

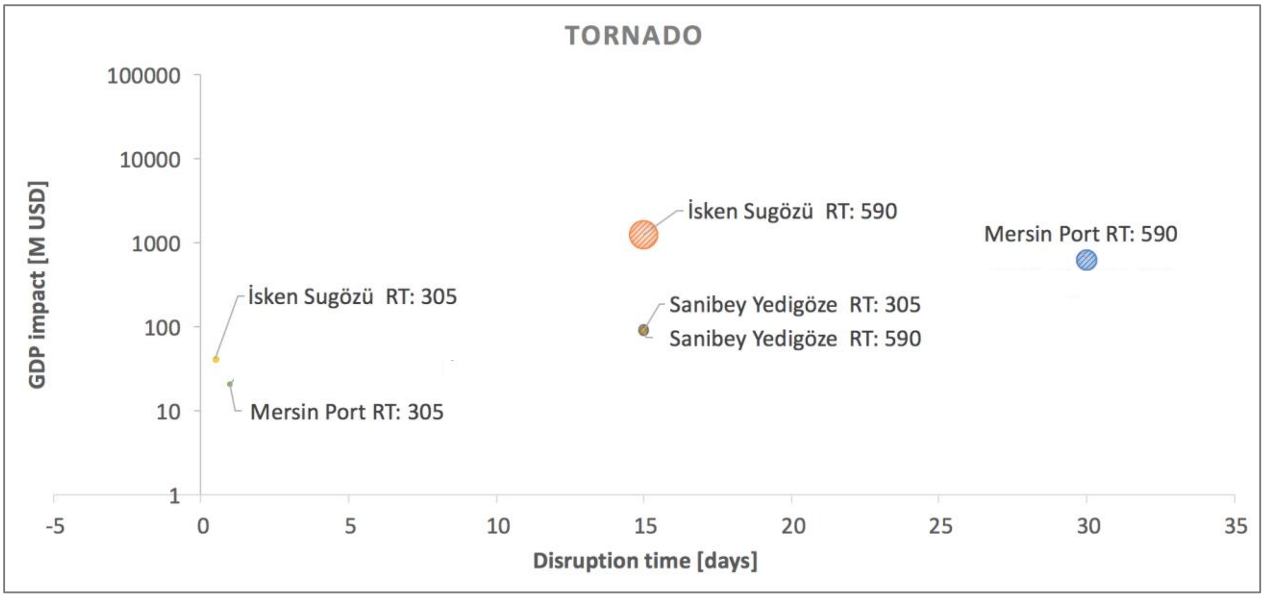


Figure 5-11: Tornado scenarios (305 yr and 590 yr return periods) losses and risk summary (the size of the bubble represents the risk, multiplying the loss of GDP by the frequency of the event, i.e. rarer events have smaller bubble size even with a large impact on GDP). (Source: Report authors).

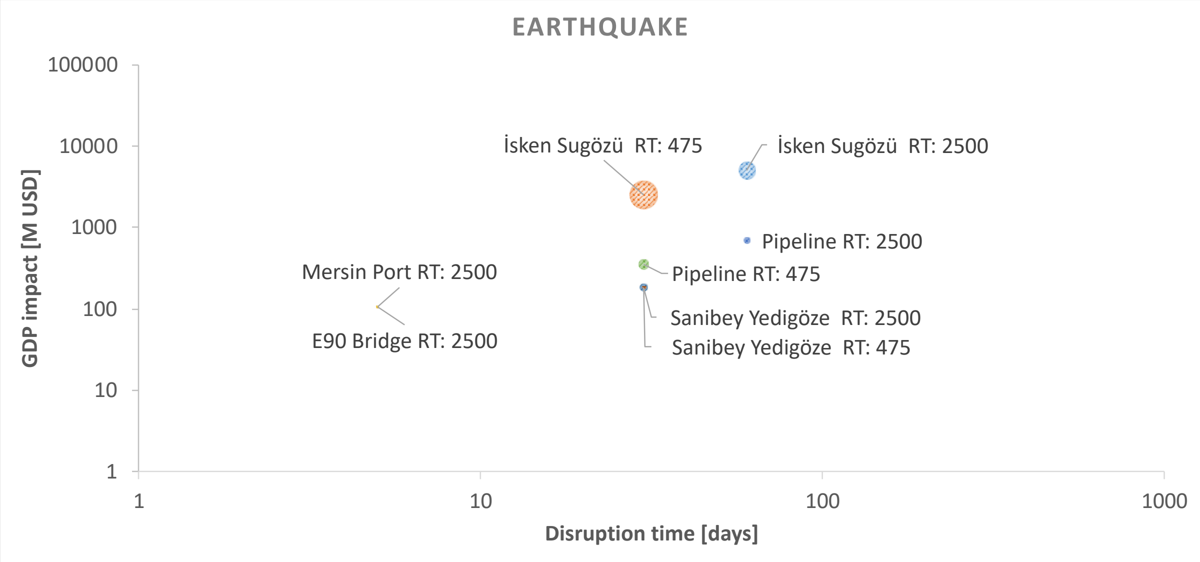


Figure 5-12: Earthquake scenarios (475 yr and 2500 yr return periods) losses and risk summary (the size of the bubble represents the risk, multiplying the loss of GDP by the frequency of the event, i.e. rarer events have smaller bubble size even with a large impact on GDP). (Source: Report authors).

5.8.3. Areas for future research and advancement of the risk assessment

This analysis represents a first iteration attempt to develop a replicable, high level risk assessment methodology in the Çukurova region. In future, there are a number of areas where the methodology and/or data behind the assessment could be advanced, for example:

1. More in-depth and complex functional models can be developed in RiskAPP©. In this instance, asset operators could facilitate in-situ assessments of the vulnerability of individual asset components, e.g. TPP turbine, inflow channel, outflows, conveyor belts, transformers and switches.
2. Further research on infrastructure design parameters and how these may evolve over time.
3. Greater understanding of levels of damage and downtime of specific CI asset components associated with hazard events.
4. A more comprehensive set of hazard scenarios can be used, representing specific infrastructure design parameters.
5. Additional stakeholder meetings for further detail on existing adaptive capacity, culture of risk and awareness on climate change (see Section 6.4).
6. Asset level studies to provide component level risk management recommendations.
7. A greater focus on the interaction of impacts between and beyond individual CI assets.

6. Current approaches to Critical Infrastructure planning & management

6.1. Introduction

Summary of key points

- With Turkey ranking ninth in the world in terms of earthquake-related casualties and fifth with regard to the total number of people affected, a coordinated approach to natural hazard management is crucial.
- The Republic of Turkey is a unitary state and has highly centralized political, governance and administrative structures. National planning objectives cascade down to the regional level through Regional Development Agencies (such as ÇKA) via their regional plans.
- RDAs can also drive a bottom-up approach for risk management requirements from the regional scale up towards the national scale via the Ministry of the Interior and the Ministry of Development.
- Within this context, integration of natural hazard risk assessment and resilience in national and regional planning processes which influence CI can help to ensure resilience of such infrastructure.
- The physical (spatial) planning system in Turkey has the objective to "*ensure guidance in terms of determining investment locations*". As such, physical plans can offer an effective tool for better integration of risks posed by natural hazards at various levels of planning.
- There is little evidence that climate risks are being explicitly considered in the development of critical infrastructure projects. Despite Turkey having a national climate change adaptation plan and strategy in Turkey, there is no requirement for infrastructure operators to assess climate change risks and implement adaptation action plans.
- A resilience requirement at the Project Development stage for new infrastructure investments would filter through to later project stages, effectively working the issue up the decision chain to project approval where national governing / regulatory bodies are heavily involved.
- For infrastructure investments in Turkey, risk assessments are included in Environmental Impact Assessment and Feasibility Studies. But despite meteorological and seismic hazards being considered in detail, risks from a changing climate are usually not addressed.

One of the main objectives of the CIRA is to highlight how the regional planning process can be improved, to guide ÇKA on ways to better integrate resilience. In order to develop effective recommendations, research and analysis has been conducted to:

- evaluate how decisions on development of critical infrastructures are made;
- identify ways to reach decision makers responsible for critical infrastructure;
- identify ways to influence decision-makers on improved risk management / resilience for climate and geological hazards.

The CIRA analyzed the decision-making processes used for infrastructure investment planning. This analysis involved review of public strategy and planning documents, and semi-structured interviews with selected members of the CIRA Advisory and Technical Committees. The analysis identified the steps and actors in the decision-making process, and types of tools/studies which are used to support the decision-making process (e.g. feasibility studies, environmental and social impact assessments). The decision-making processes are summarized in diagrams, and commonalities and differences between them are described. To further illuminate this, a SWOT[xx] analysis was conducted, focusing on

[xx] SWOT stands for Strengths, Weaknesses, Opportunities and Threats analysis

the region's current ability to achieve resilient energy and transport sectors. The SWOT was carried out by groups of participants (55 individuals) at the 1st CIRA risk assessment workshop, held in Adana, Turkey, in January 2017.

This Section presents the findings of this research and analysis, with the aim of supporting ÇKA in identifying 'hooks' in the decision-making processes and their supporting studies which provide entry points for risk assessment and management of geological and climate-related hazards. Figure 6-1 presents a conceptual overview of the framework and approach applied to the review and analysis, and comprises of three sections:

- **Section 6.2** focuses on national planning and regional planning in Turkey.
- **Section 6.3** focuses on the links between planning and critical infrastructure investment in the framework of the energy and transport / logistics sectors.
- **Section 6.4** focuses on the results of a SWOT and Adaptive Capacity assessment of organizations within the region, undertaken with stakeholders during the 1st CIRA risk assessment workshop (January 2017).

Additional materials are provided in Annex A4, which help to provide context specific to Çukurova Region to the discussion and findings.

6.2. Planning and risk assessment interactions in Turkey

6.2.1. Introduction

In order to assist ÇKA to improve the integration of resilience in the regional planning process, it is important to understand how planning works at the national and regional levels in Turkey, and how planning and risk assessment interact when it comes to making critical infrastructure investment decisions.

6.2.2. Development planning at the national (central) level in Turkey

The Republic of Turkey is a unitary state and a highly centralized country in relation to political, governance and administrative structures. Planning at the national level was formerly carried out by a central government institution, the **State Planning Organization** (founded in 1960) which was reorganized as the **Ministry of Development (MoD)** in June 2011 by Decree Law No. 641. The MoD plans and guides Turkey's development process through a macro approach and focuses on the coordination of policies and strategy development. With a vision of designing and leading the process of Turkish development in a holistic way, MoD focuses on coordination of strategic planning at all levels in collaboration with line ministries, affiliate institutions and higher councils (see Figure 6-2).

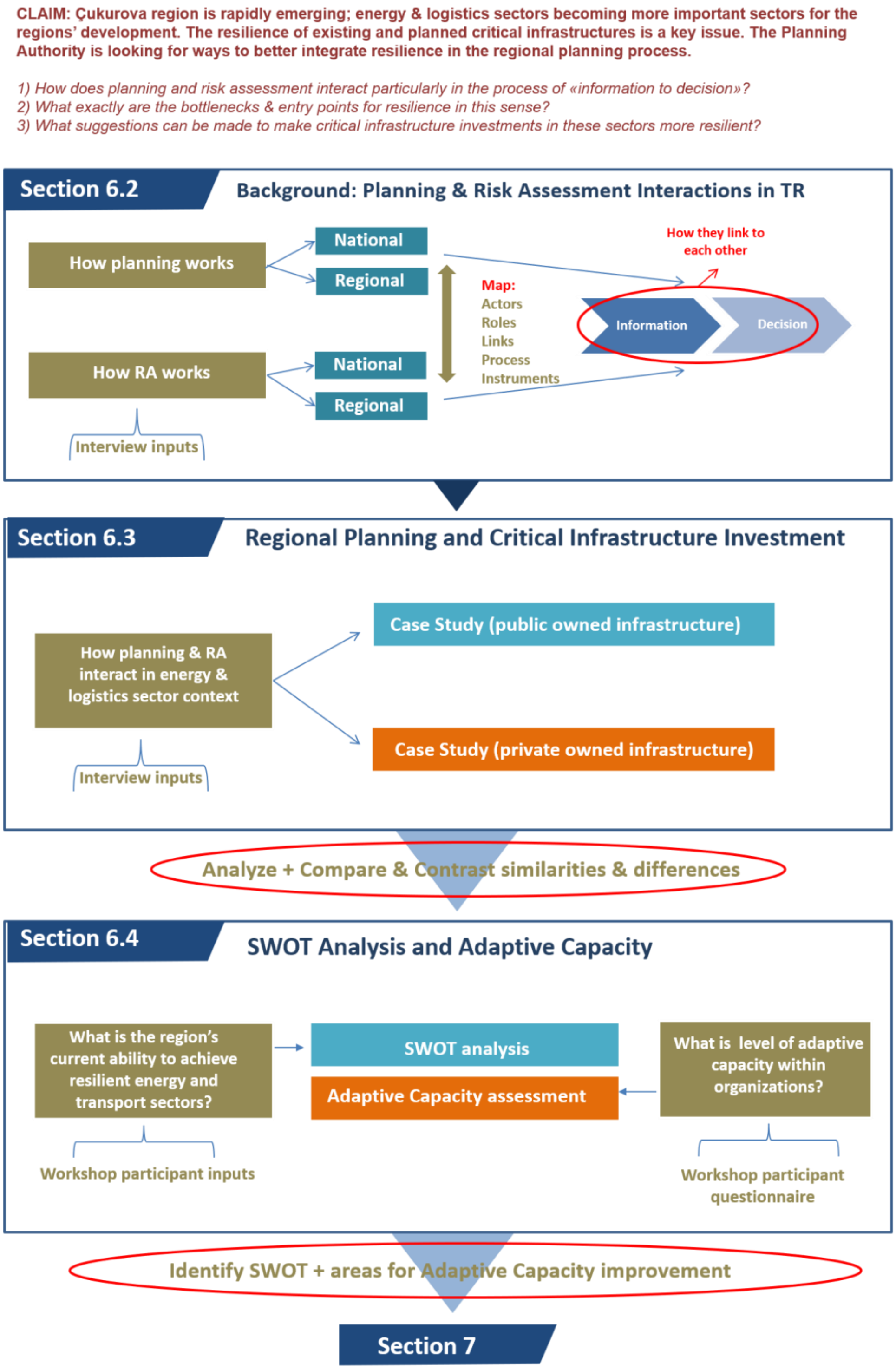


Figure 6-1: Conceptual framework of the analysis presented in this section. (Source: Report authors).

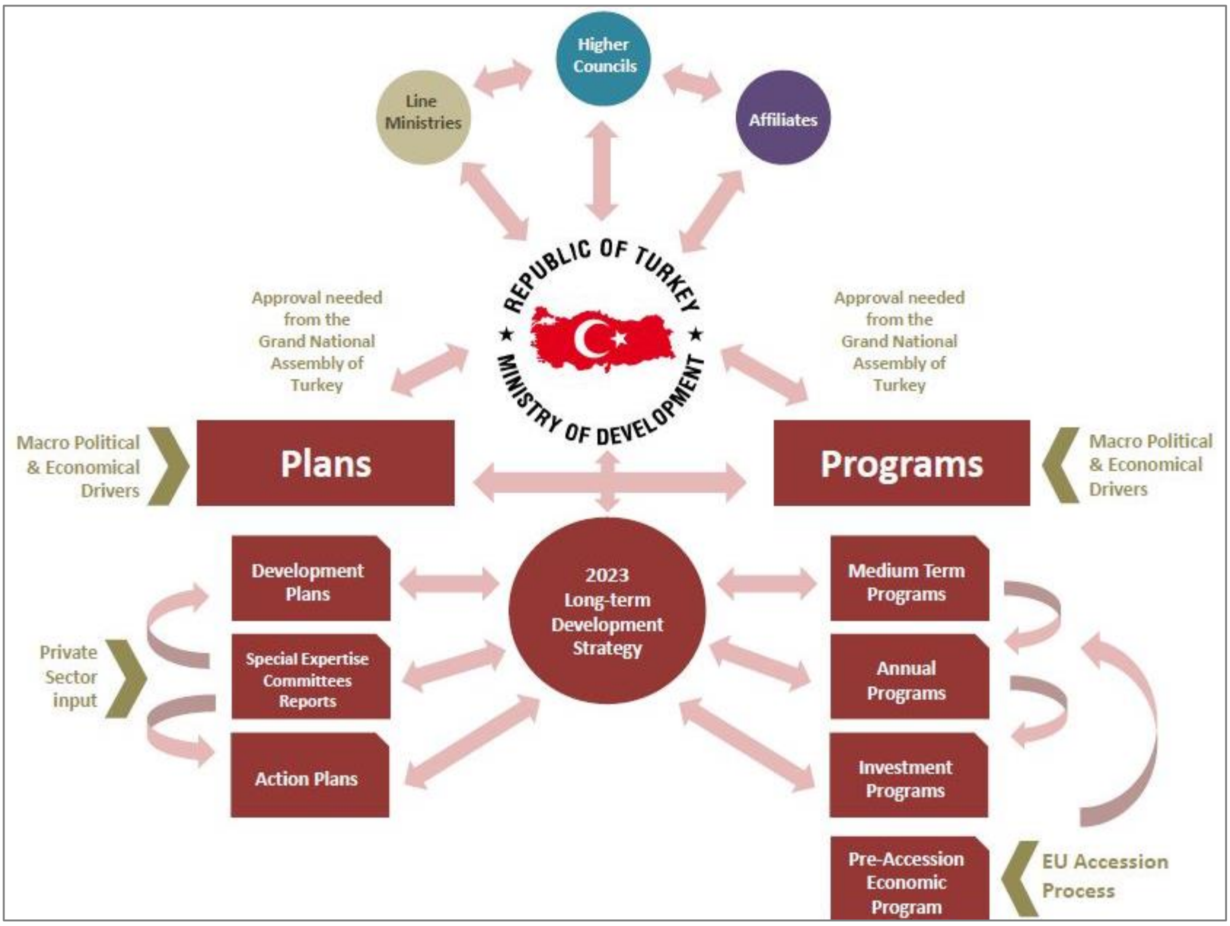


Figure 6-2: Landscape of strategic development planning at national level in Turkey (Source: Report authors)

The MoD:

- advises the government in determining Turkey's economic, social and cultural development policies;
- carries out studies aimed at guiding the public and private sectors to bring about new approaches in economic, social and cultural areas;
- prepares Turkey's main policy documents (including plans, programs and strategy documents) for the development process utilizing a holistic and strategic approach and pursuing participatory approaches;
- increases effectiveness of the implementation of main strategy and policy documents, particularly development plans and annual programs;
- administers the public investment process in line with development plans, annual programs and strategy documents of the country;
- provides for efficient and effective use of public resources allocated for public investments;
- develops policies and strategies to reform and improve the structure and functioning of public organizations as necessary for Turkey's economic and social development process;
- develops policies and strategies regarding regional development, to increase the level of institutionalization of local authorities; and
- guides and coordinates implementation of regional policies.

The timeline of the main characteristics and developments (see Table 6-1) which shaped the evolution of Turkey's development planning process (see Figure 6-3) show that a highly centralized planning process is under transformation particularly since the middle of last century. It is interesting to note that together with external factors (such as liberalization, globalization, and the EU accession process), over time Turkey has increasingly put more emphasis on strategic planning and regional development.

Table 6-1: Timeline of the main characteristics which have influenced Turkey's development planning process (Source: Report authors; adapted from Erkut and Sezgin, in Remier et al, 2014[50])

Periods	Main characteristics and developments
1923 – 1945	Nation state building period; developing a national economy
1945 – 1960	Starting from WWII up to the planned development period; mechanization in agriculture by Marshall aid
1960 – 1980	Planned development period; five-year development plans starting from 1963
1980 – 2000	Neoliberal economic principles and globalization; EU accession period
2000 - present	Europeanization, public administration reform; devolution of powers; privatization

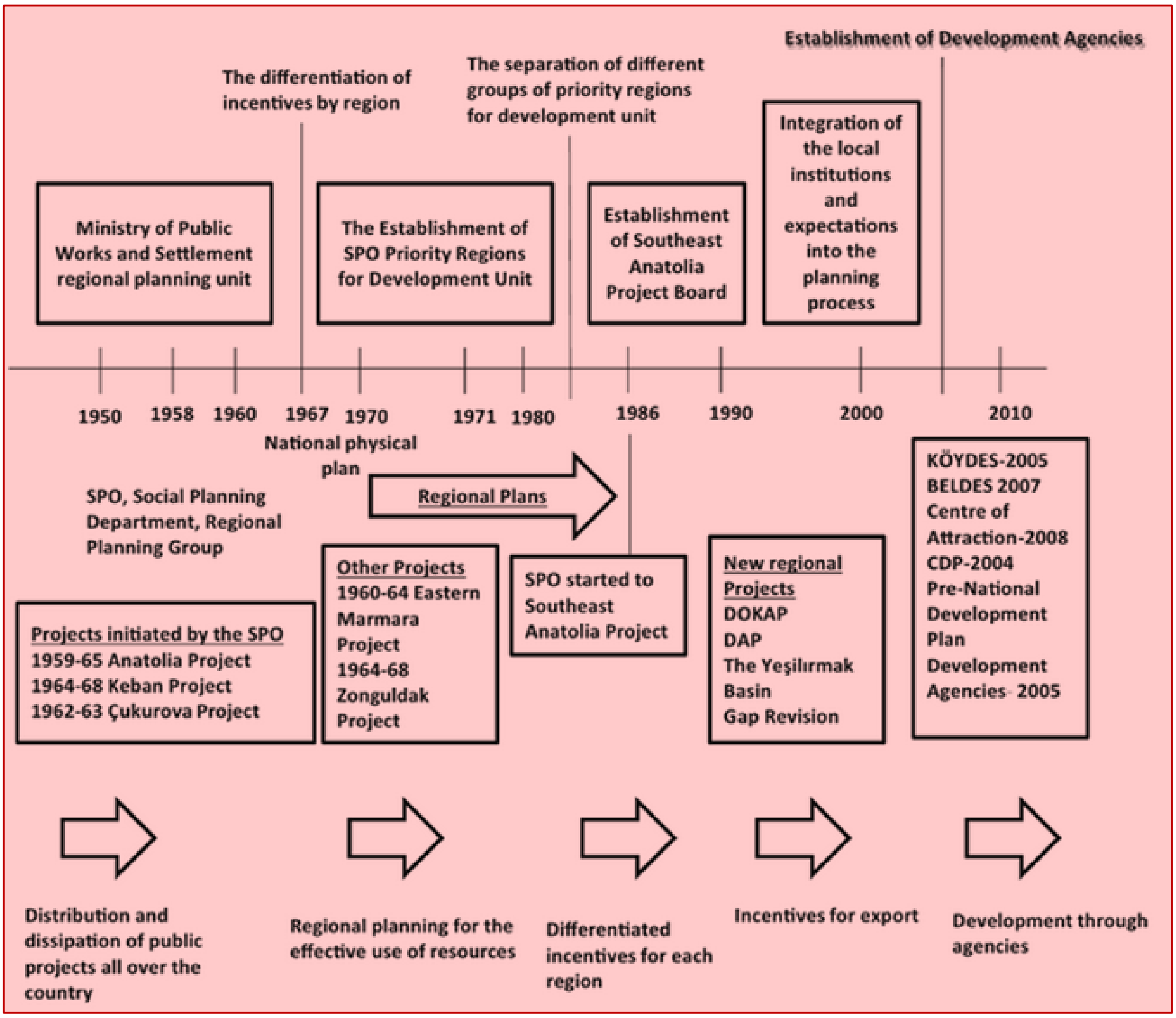


Figure 6-3: The process of institutionalization of the Regional Development Agencies in Turkey (Source: Turan, 2016[51]).

As previously mentioned, the MoD is responsible for drafting a number of high level strategic planning and policy documents which collectively provide clear directions for the country in all policy domains (Figure 6-4). Here it is useful to note the main differences between development plans and programs in Turkey. Development plans are the highest level planning tools which determine the framework of macro-economic, social and environmental development objectives of the country. Development plans provide direction to policies/strategies. In turn, policies give direction to plans and programs which are more specific in terms of targets, outcomes, and means of reaching them.

It is also important to note that national development plans are "guides" for public and private investments in Turkey. These guiding documents provide clear direction particularly for public investment decisions and operate at different timescales. They also provide strategic direction and incentives for public-private and private sector investments. Higher level, long-term policy documents are reflected into investment programs through medium and short term plans, programs and reports.

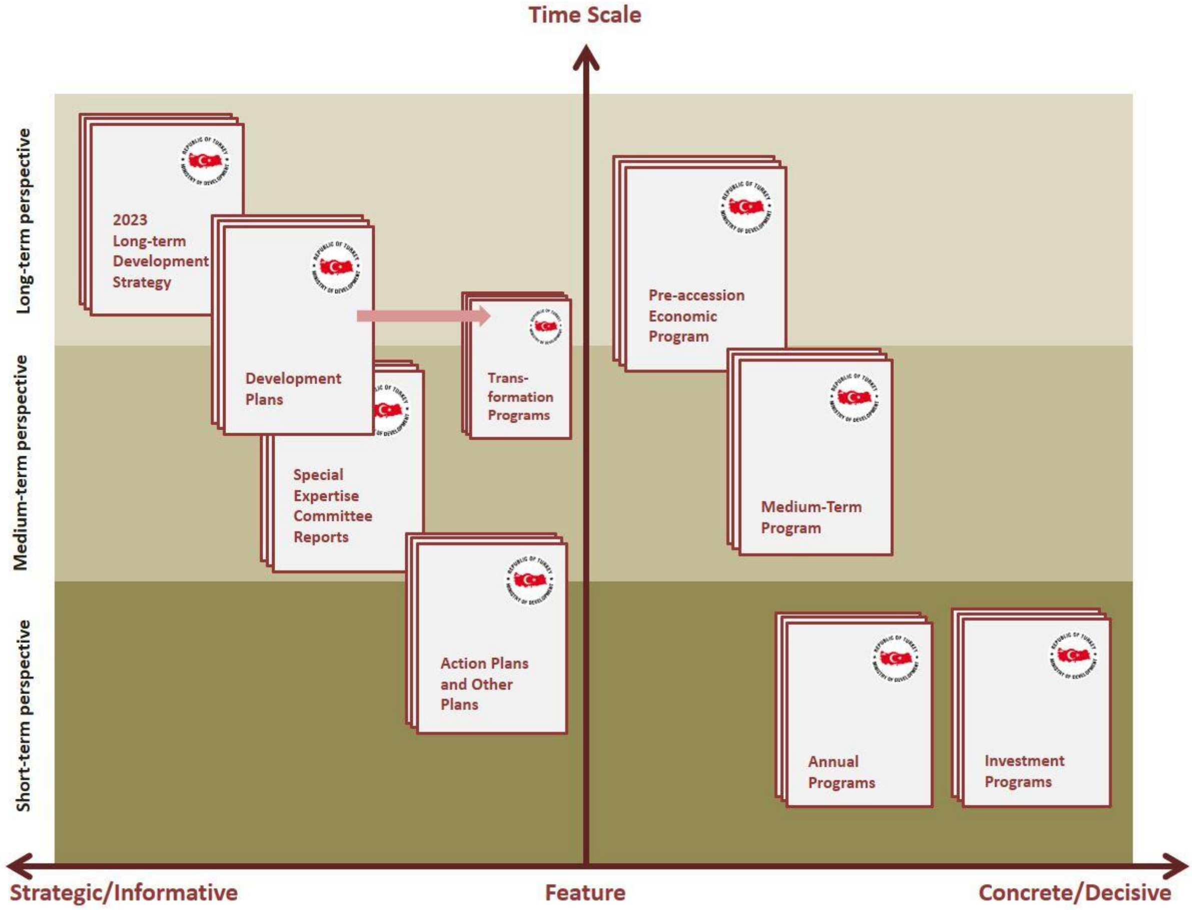


Figure 6-4: Guiding documents on national planning and investment decision making in Turkey (except spatial plans) (Source:Report Authors)

Among these documents, the **2023 Long-term Development Strategy** is at the highest level. The Strategy states the ultimate development target for Turkey to become one of the top ten economies in the world by 2023, the centennial of the Republic of Turkey. The document presents a number of objectives: by 2023, Turkey is to receive a larger share of the world output; quality of life is to be improved; Turkey is to have influence in decisions at the regional and global level and to make significant contributions to world science and civilization. Quantitative targets are also included, such as achieving a Gross Domestic Product (GDP) of 2 trillion USD; per capita income of 25,000 USD; exports of 500 billion USD; single digit inflation and interest rates; an unemployment rate of 5% and research & design (R&D) expenditure of 3% of GDP.

The MoD prepares multi-year **Development Plans** that are in line with the Long-term Development Strategy. In principle, these development plans are prepared with a participatory approach and with sectoral focus. **Special Expertise Committees (SECs)** are formed to provide economic, social and environmental perspectives and policy inputs. To date, the MoD has coordinated and drafted ten development plans, and the process for the eleventh starts in early 2017.

The latest development plan, the 10th Development Plan, was adopted by the **Grand National Assembly of Turkey (TBMM)** on July 2, 2013. The variety of SECs (66 in total) and participation of non-state actors (more than 3000 NGO, private sector, and academia representatives) emphasizes the efforts in making the planning process participatory and inclusive. The Plan placed the sustainable development concept at its core and outlined four main thematic areas, namely:

- Qualified people, strong society: human centered development,
- Innovative production, stable high growth: structural transformation in production and prosperity,
- Livable places, sustainable environment: sustainable urbanization & ruralization; reducing regional disparities,
- International cooperation for development: priorities and policies of Turkey's bilateral, regional, and multilateral relations.

In addition to these areas, the Plan also consists of 25 **Transformation Programs** that are designed in line with the 2023 Long-term Development Strategy. Overall aims are to reduce structural barriers impeding development, to contribute to the structural transformation process, and to enable coordination amongst state institutions. Some of the transformation programs that are related with the energy and transport / logistics sectors as well as investment planning processes are as follows:

- Transformation Program from Transportation to Logistics,
- Program for Reduction of Import Dependency,
- Domestic Resource Based Energy Production Program, and
- Energy Efficiency Improvement Program.

A relatively new policy document is the **Medium-Term Program (OVP)** which provides a more concrete roadmap for the country to steer public policies and resource allocation. The foundation of the OVP is laid down in Law No. 5018 within the framework of public financial management reforms. The OVP is prepared for 3 year terms and is revised every year depending on the outcomes of annual monitoring results of its implementation or any other urgent sudden onset development requirement.

Another high-level policy and planning document at the national level is the **Annual Program (AP)**. The AP is prepared in line with specific objectives and policies put forward by the Development Plans. The AP must be approved by the High Planning Council and the Council of Ministers.

In addition to the APs, **Investment Programs (IP)** are prepared, outlining allocations for public investments by sectors and central government institutions, state economic enterprises, institutions with revolving funds, social security institutions, the Provincial Bank (İl Bank), and institutions within the scope of privatization. These investment programs consider regional priorities. The public investment programs are prepared in accordance with Central Government Budget Law and upon decision of the Council of Ministers; it is published in the Official Gazette within 15 days from the date of entry into force of the Budget Law. Once published, these programs are clear roadmaps providing the following information on all public investments:

- Annual appropriations allocated for projects listed by sectors and institutions,
- Means of financing,
- Total amount of expenses in the previous years,
- Costs, locations, characteristics, and start/end dates of projects.

The MoD underlines that **the Pre-Accession Economic Program** should also be counted as a high-level policy and planning document as it summarizes structural reforms with respect to economic and social transformation of Turkey towards full membership of the European Union. Recalling that Turkey was given candidate status for the European Union in 1999, the country prepares and delivers the Pre-Accession Economic Program to the European Commission, in accordance with the EU accession criteria since 2001[xxi].

[xxi] For more detailed information on plans and programs, please see Annex A4.1 for relevant links and resources.

6.2.2.1. Disaster management

In relation to disaster management in Turkey, the Disaster and Emergency Management Presidency (AFAD) plays a central role. As AFAD emphasizes, Turkey ranks ninth in the world in terms of earthquake-related casualties and fifth with regard to the total number of people affected[52]. According to AFAD, the number of laws adopted prior to the 1940s was somewhat limited, until Turkey experienced catastrophic events such as the Erzincan earthquake in 1939. After that, Law no. 4623 on Measures to be Taken Before and After Earthquakes was published on 18 July 1944 and studies oriented to reduce losses from disasters in a practical sense started with this law in Turkey. Turkey's first Seismic Zones Map, Regulation on Building Codes for Seismic Zones, and Regulation on Buildings to be Built in Disaster Zones were issued in 1945. Law no. 4373 on Protection against Floods and Overflows was adopted on 14 January 1943. This identified, for the first time, measures to be taken against floods before disasters took place, and introduced new principles for works to be undertaken during disasters.

The Zoning Law of 1956 dealt with determination of disaster hazards when identifying settlement areas along with the technical liability system and building inspection matters. Law of 1958 established the Ministry of Development and Housing with the primary duties of taking necessary measures before and after disasters, planning the regions, cities and villages of the country, solving the problem of housing and settlement, and developing building materials and standards. Law no. 7269 on Precaution and Aid Against Disasters Affecting Common Life, dated 15 May 1959, introduced the concepts of disasters such as earthquake, flood, landslide, rock fall, avalanche, fire and storm. It also covered measures to be taken for the protection of lives and property before a disaster in settlement areas at risk, and laid the foundations of the General Directorate of Disaster Affairs. Law no. 7126 on Civil Defense, which came into effect in 1959, regulated the rescue and first aid actions that should be carried out during disasters, filling an important gap in this area and establishing the General Directorate of Civil Defense under the Ministry of Interior. Another important arrangement in the area of disaster management is the 1988 Regulation on Principles of Organizing and Planning Emergency Aid for Disasters. It regulated the establishment and duties of aid organizations to ensure planning of all state resources and forces before a disaster, and in case of a disaster, to ensure that state forces reach the disaster scene as fast as possible and provide victims with effective emergency assistance.

After another catastrophic disaster, the Marmara Earthquake in 1999, the country's disaster management structure was completely transformed in order to bridge the gap in coordination and capacity. The General Directorate of Emergency Management of Turkey was established in 2000, the building inspection system was fully changed, and insurance coverage became mandatory. Law no. 5902 was adopted in 2009 to eliminate the problem of coordination between agencies involved in the disaster management system. The Disaster and Emergency Management Presidency was also established together with Provincial Disaster and Emergency Directorates at the local level in provinces attached directly to the Governorates. The Law replaced the old crisis management approach with a new approach that gave priority to risk management.

More recently, the AFAD 2013 - 2017 Strategic Plan strives to:

- Ensure cooperation between all relevant national and international agencies and organizations for effective planning, management, support and coordination of necessary activities in line with specified standards,
- Promote disaster awareness and culture in the public by carrying out research, development and education activities,
- Ensure that protective and preventive measures are taken within the framework of the principle of the social state.

AFAD also envisages carrying out specific activities including:

- **Risk Reduction Activities:** "Determining the risks that may be caused by disaster hazards, determining the vulnerabilities of assets exposed to these risks, and developing models to eliminate or reduce the risk constitute the foundation of disaster risk management. All activities that will identify potential risks, mitigate the outcomes of possible disasters and prevent development of secondary hazards will be carried out within this scope."
- **Hazard and Risk Mapping:** "It will be ensured that hazard and risk maps that will form the basis for risk reduction activities and that will include multiple disaster hazards are prepared, updated and used in local and national plans."
- **Maintaining Disaster Risk Reduction Platform:** "The efficiency of the platform established for the purpose of increasing disaster sensitivity in the public, ensuring continuity in risk reduction works, ensuring conformity with plans, policies and programs at all levels of risk reduction and contributing to monitoring and assessment of implementation, will be increased."
- **UDSEP-2023 (National Earthquake Strategy and Action Plan of Turkey):** "Actions that will be carried out by AFAD will be effectively incorporated into the program, works carried out by other responsible organizations under UDSEP-2023 will be followed up, activities of UDSEP-2023 Monitoring and Evaluation Committee will be organized and followed up, and UDSEP-2023 will be promoted nationwide, ensuring that it is adopted by all segments of the society."

It is important to note that AFAD closely cooperates with State Hydraulic Works (DSİ), General Directorate of Mineral Research and Exploration (MTA) and Turkish State Meteorological Service (MGM) as providers of warning information / analysis regarding climate and seismic hazards.

The MTA Strategic Plan 2015 – 2019, Turkish State Meteorological Service Strategic Plan 2013 – 2017 and DSİ Strategic Plan 2015 – 2019 have interlinkages with each other as well as with AFAD priorities and objectives. An initial analysis of publicly available information and interviews reveal that there is a certain amount of interactions and dialogue between the most relevant actors and policies at the national level. Despite the lack of more detailed hazard assessments, such data are being prepared and will be ready for use in the short-medium term.

6.2.2.2. Climate change policy

While the MoD is more active in coordinating higher level planning, the Ministry of Urbanization coordinates climate change related policies in collaboration with other line ministries and a number of stakeholders.

On the development planning side, the foundations of Turkey's climate policies were laid with the 8th Five-year Development Plan published in 2001 which included the Climate Change Special Expertise Commission Report. As a result, follow-on national development plans (9th and 10th Development Plans) include climate related objectives. From an institutional angle, it is noteworthy that the Climate Change Coordination Board (CCCB) was also established (restructured in 2004 and 2013 and renamed as the Coordination Board on Climate Change and Air Management). The board is coordinated by MoEU and composed of all relevant ministries and a number of industry umbrella organization representatives. Most of the main climate policy documents of Turkey at national level have been published in the last decade. Among them, the most important ones are:

- National Climate Change Strategy (2010-2020),
- National Climate Change Action Plan (2011-2023),
- National Climate Change Adaptation Strategy and Action Plan (2011),
- National Legislation on Monitoring, Reporting and Verification (MRV) of Greenhouse Gas (GHG) emissions (2012, revised in 2014).

Other relevant documents include the Sustainable Development Report (2012), Strategy on Energy Efficiency (2012-2023), National Renewable Energy Action Plan (2013-2023) and National Smart Transportation Systems Strategy Document (2014-2023). There are also other high level documents which are presented to the United Nations Framework Convention on Climate Change (UNFCCC) such as the Intended Nationally Determined Contribution of Turkey which include updated climate objectives at national level.

Climate change adaptation entered the planning stage with the adoption of the 9th Five-year Development Plan. A number of supporting plans and strategies feed Turkey's adaptation strategy such as the Action Plan to Combat Desertification, Biodiversity Strategy and Action Plan, Forestation and Erosion Control Mobilization Action Plan and DG Forestry Strategic Plans. Relevant legislation directly and indirectly related to climate change adaptation is provided in Annex A4.2. It is important to note that separate branches were founded for climate change compliance, drought management and flood management under the Ministry of Forestry and Water Affairs - General Directorate of Water Management (GDWM) to determine the impact of climate change on water resources and to carry out compliance planning for managing possible impacts on river basins. The main fields of activity of these branches are to prepare sectoral compliance plans, drought management plans and flood management plans in river basins. River basin management plans are prepared by the Basin Management Branch and these plans consider suitable compliance measures and the impacts of climate change on water resources. The Climatology Branch, which operates under the Research Department of General Directorate of Meteorology (Ministry of Forestry and Water Affairs), also conducts climate change studies[53].

6.2.2.3. Summary of interactions between development, disaster and climate change policy

A summary of interactions between some key documents and actors is presented in Figure 6-5 where:

- Dashed line circles represent different policy domains (development, disaster, and climate) where development policy comprises and guides disaster and climate domains;
- Coordinating actors are represented by colored circles as follows: green: MoD, red: MoEU and dark blue: AFAD; and
- Smaller circles indicate prominent institutions generating and providing data, and their strategic plans.

Core development documents provide the main objectives regarding disaster and climate domains while sector- or theme-based documents interact or mention climate and disaster-related objectives. In general, documents in the same domain explicitly refer to each other, and they implicitly mention objectives related with the ones that fall within other domains. Annual programs and investment programs do mention and budget for particular activities that are mentioned in disaster and climate domains.

6.2.1. Regional development planning

As the MoD is striving for better regional development policy and planning, **26 Regional Development Agencies (RDAs)** were established in Turkey to work in coordination with the MoD (Annex A4.3). In addition to the RDAs, **Investment Support Offices (ISOs**) were established in all 81 provinces of the country. In July 2006, in order to promote and develop regional investment strategies, **the Investment Support and Promotion Agency of Turkey (ISPAT)** was established. ISPAT promotes investment opportunities in Turkey to the global business community and provides assistance to international investors who intend to invest in Turkey.

A brief history of RDAs helps to better understand what specific roles they have had and how they have formed in Turkey's context. The EU's regional policies have influenced all candidate countries including Turkey, despite its highly centralized governance structure. Particularly after the candidacy decision of the EU in 1999, reform process has accelerated and Turkey is aligning itself with the EU acquis on regional policy through the pre-accession strategy (Figure 6-6).

The NUTS classification was introduced in Turkey as of 2002, and the Law on the Establishment, Coordination and Duties of Development Agencies was legislated in 2006. Currently, in Turkey, there are 81 Level 1, 26 Level 2 and 12 Level 3 NUTS regions.

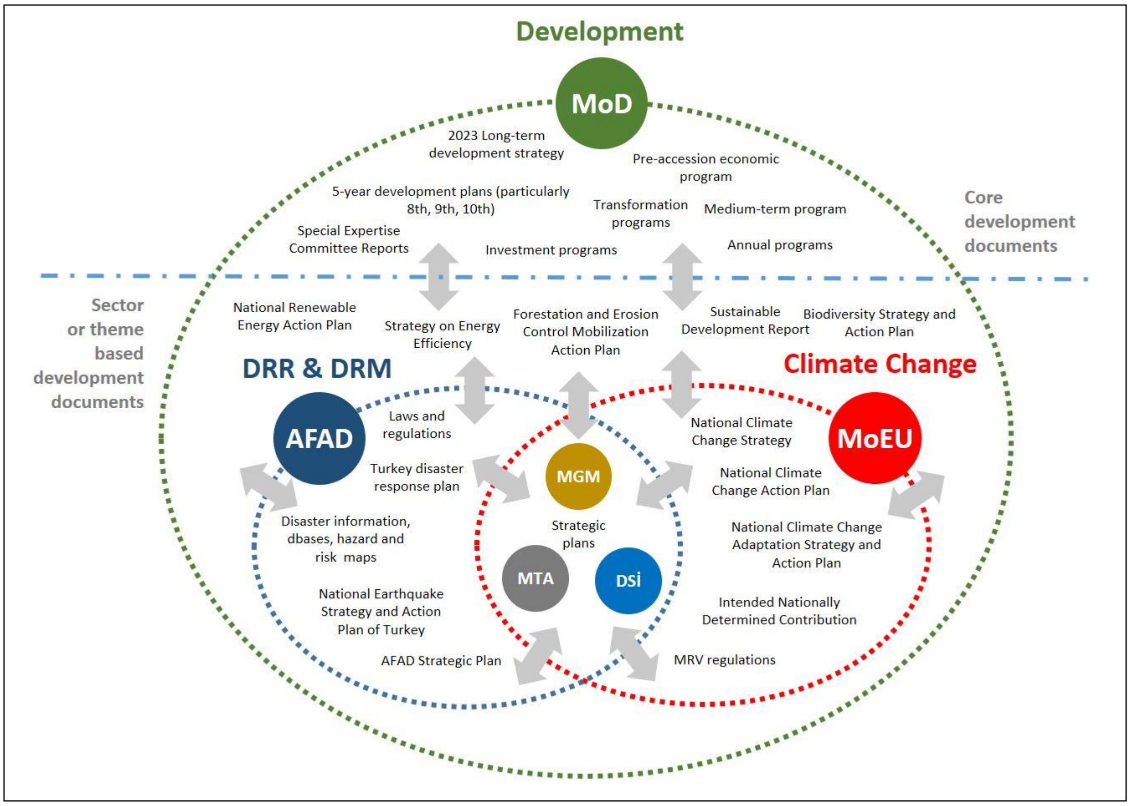


Figure 6-5: Interactions between development planning, climate change and disaster related policy actors and guides (Source:Report authors)

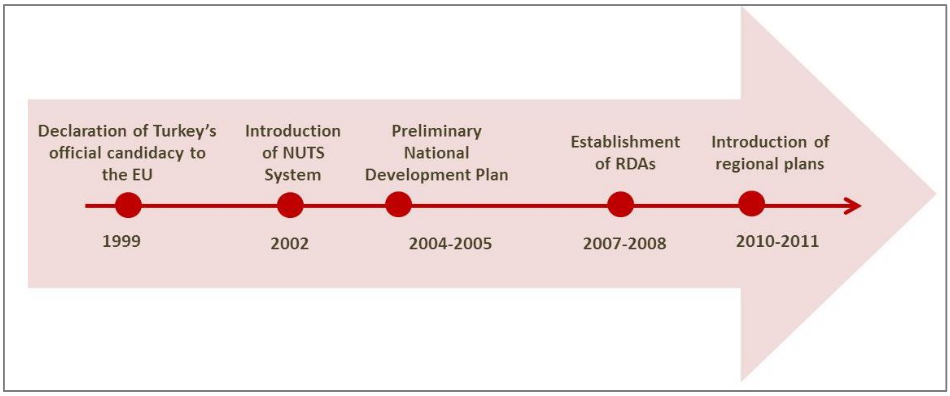


Figure 6-6: Milestones in Turkish Regional Policy: the EU Impact. (Source: Report authors; reconstructed from Sungur et al, 2013[54]).

Analyzing the development planning hierarchy in Turkey, it can be seen that in addition to the socio-economic plans (such as 5-year development plans), physical (or spatial) plans also play a critical role in the development planning and infrastructure investment process at the regional level (see Table 6-2).

Table 6-2: Physical (spatial) development planning hierarchy in Turkey (Source: Report authors; adapted from Say and Yücel, 2006[55])

Planning type		Frame - spatial scale	Scope
Socio-economic plans	National Development Plan (5-year Dev. Plans)	Written statements	Macro-economic targets; sectoral aims, objectives and policies; social development
Physical or spatial plans	Regional Plan	Region – 1/500000, 1/100000	Superior physical plans or high-level physical plans
	Master Plan	Metropolitan – 1/50000	
	Environmental Plan	Sub-region, province – 1/2000, 1/50000, 1/100000	Local physical plans or local development plans
	Master Plan	Urban – 1/2000, 1/5000	
	Implementation Plan	Urban – 1/1000	
	Tourism Development Plan	Sub-region – 1/1000, 1/5000	Special and thematic plans
	Reclamation Development Plan	Urban – 1/5000	
	Rural Development Plan	Rural - 1/1000	

Physical (or spatial) planning is among the responsibilities of MoEU and local authorities (such as municipalities) rather than the MoD. Strategic planning principles require that these plans reflect national and regional planning priorities and objectives.

In Turkey's context, the **Spatial Strategy Plan**:

- Aims to integrate national development policies and regional development strategies at the spatial level;
- Considers and evaluates the economic and social potentials, objectives and strategies of regional plans with regard to transport networks and physical thresholds;
- Determines spatial strategies that will make resources useful for the economy, protect and develop natural, historical and cultural values, orient transport system and urban, social and technical infrastructure;
- Establish the relationship between spatial policies and strategies regarding sectors, that is prepared by using schematic and graphic languages on maps with a scale of 1/250,000, 1/500,000 or higher covering the country and where necessary in regions, with sectoral and thematic maps and reports.

In 2014, the new "Regulation for the Preparation of Spatial Plans" covering the creation process of the plans came into effect. According to the MoEU, within the context of this law:

- the hierarchy of spatial plans was clarified and relations with other special plans were defined; the definitions of spatial strategy plan, integrated coast zones plan, action plan, urban design project, and long-term development plan were defined for the first time;
- principles regarding every plan are identified alongside the general planning procedures; tools that will ensure the publicity of and participation in plans were developed[xxii].

Box 6-1 provides details about specific plans.

[xxii] For more information, please kindly see: http://www.csb.gov.tr/gm/mpgm/

Box 6-1: Physical planning at the local and regional level in Turkey (Ülger and Yomralıoğlu, 2014[56])

> "In Turkey, the **Land Development Planning and Control Law** (Act. No. 3194 dated 1985) and **Regulation for the Preparation of Spatial Plans** (dated 2014) govern and identify all physical plans and public and private infrastructures to be constructed inside and outside municipal boundaries and adjacent areas. Plans shall be prepared as **Regional Plans** and **Land Development Plans** in terms of area coverage and purpose; and land development plans as **Master plans** and **Implementation Plans**. The local planning unit may be the municipality, a group of districts or a water basin. Where planning is initiated at the regional level, the implementing plan has to be carried out by municipalities. Alternatively, this may be the first level of planning, with its priorities drawn up by the local stakeholders. Local-level planning called **Master Plan** is about what shall be done where and when, and who will be responsible. Master Plan (scaled to 1:5000) is a holistic plan with a detailed explanatory report which is drawn on the base maps with cadastral drawings. **Implementation Plan** (scaled to 1:1000) also called as **Zoning Plan** is the plan which is drawn on approved base maps with cadastral drawings in accordance with the master plan, and contains in detail the building blocks of various zones, their density and order, roads and implementation phases to form the basis for land development implementation programs and other information. At the national level, implementation is usually a matter of government decisions on priorities. In planning at the regional level, implementation will often be achieved through a development plans, requiring considerably greater details of land development."

6.2.1.1. Regional development agencies

The organizational structure of a typical RDA in Turkey consists of a **Development Council**, an **Administrative Board** and a **Secretariat**. Composed of local public, private and civil sector representatives the Development Council acts as an advisor to the Administrative Board and coordinates regional stakeholders. The Administrative Board acts a decision-making organ and is chaired by the Governor. (As in the **Çukurova Development Agency**'s case) the Administrative Boards of metropolitan regions might consist of more private sector representatives than the Development Councils do. This underlines the focus on private sector-led development particularly in metropolitan areas. The Administrative Board approves annual programs, projects, budget and all supported activities. The Secretariat (which might also be named as the General Secretariat) acts an implementing organ and implements the decisions of the Administrative Board, drafts annual programs and budgets, provides technical and capacity support to regional stakeholders. In addition to these bodies, **Investment Support Offices** could be established to support investor needs at the region.

The RDAs in Turkey are accountable to **the Ministry of Interior** (legal issues) and to **the Ministry of Development** (planning and implementation issues). The RDAs are responsible for preparing regional plans and allocating resources for projects that will support regional development. They also carry out investment support activities and promote research that supports regional development. To do this, the RDAs utilize several mechanisms such as technical support, financial support through calls for proposals, guided proposals or direct operational grants. The duties and objectives of the RDAs defined by Law No. 5549 are further summarized in Annex A4.4.

Izmir, Adana and **Mersin** were chosen as pilot regions for the establishment of the very first RDAs in Turkey and therefore the **Çukurova Development Agency** can be considered a pioneer among other RDAs. While the founding law has institutionalized the region concept in Turkey, RDAs do not have public institution status as they are subject to private law in their fields of activity. With its "in-between" nature, the RDAs allow enhanced participation of private sector and civil society representatives in decision making process at a regional level. The RDAs address several problems such as the lack of coordination between national and local governments and lack of technical and administrative capacity to solve regional development issues.

Since the administrative system is based on provincial perspective in Turkey, the country is divided into provinces and sub-provinces. Article 126 the 1982 constitution allows establishment of a central administrative unit comprising more than one province for providing effective public services. This had been the legal basis for the establishment of all regional bodies including RDAs. Despite the adoption of Law No. 5549, the first RDAs including **Çukurova Development Agency** could only be established by Decree No. 2006/10550 in 2006. However, at the time, the main opposition party took a case to the Supreme Court to revoke the founding law, with the same concerns over national integrity and unity. The court rejected the case but similar concerns and perceptions still prevail. This was assumed to be one of the issues that could hinder RDAs' effectiveness and institutionalization in regional development governance[57].

The organizational structure of Çukurova Development Agency follows a typical governance structure (see Figure 6-7).

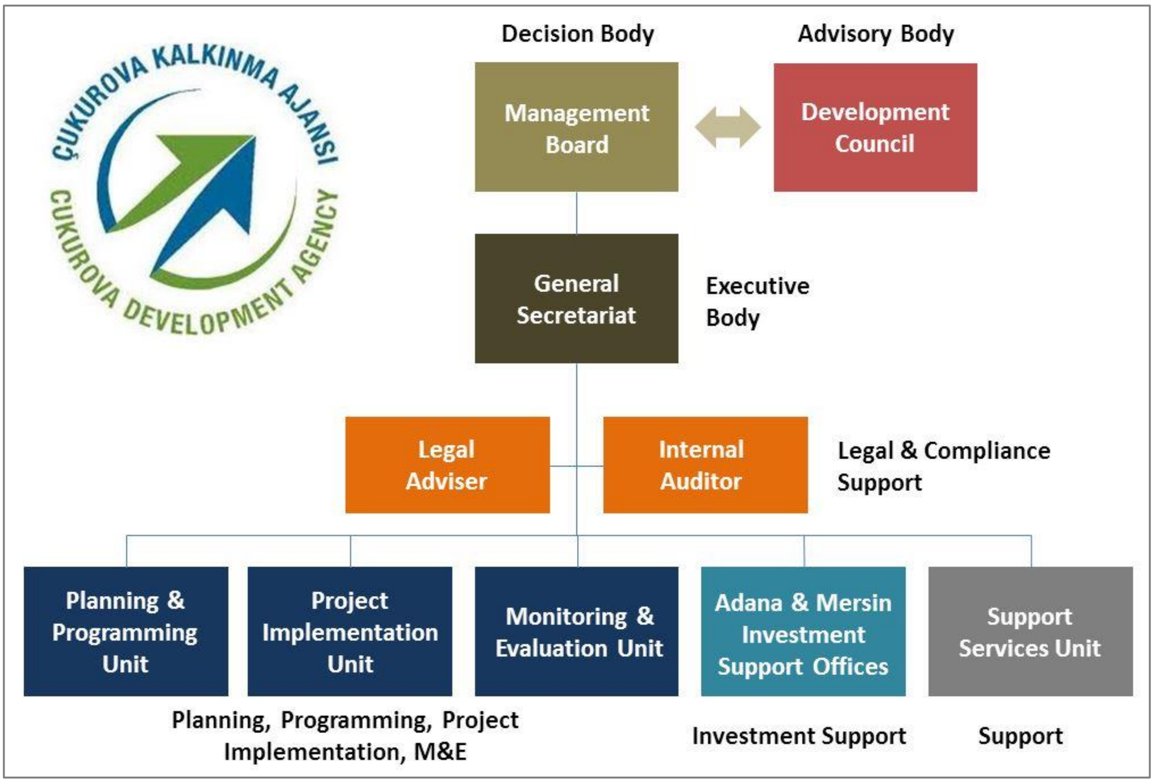


Figure 6-7: Organogram of the ÇKA. (Source: ÇKA, 2016[58]).

Consisting of public, private and non-governmental institution representatives, the Management Board is the decision body of ÇKA. The governors of Mersin & Adana act as the president of this body and usually on a rotating basis. The Development Council consists of 90 members and allows wider participation into steering and guidance process the council delivers. The Council chooses its own board, and the current board involves representatives from Mersin Municipality, Turkish Statistical Institute Adana Regional Directorate, Adana Culture Education Art and Research Association (NGO), Mersin Chamber of Trade and Industry, Toroslar Municipality and Çukurova Journalists Association (NGO). The General Secretariat is the executing body of the ÇKA and includes sub-organs such as the Planning and Programming Unit, Project Implementation Unit, Monitoring and Evaluation Unit, Investment Support Offices and (Administrative) Support Services Unit. The ÇKA provides specific incentives and financial support to encourage economic and social development of the region. These incentives and support measures are summarized in Figure 6-8. Between 2008 - 2015, ÇKA provided 216 million TRL to 690 projects through 22 financial support programs. These support mechanisms allow stakeholders to contribute to the regional development plan objectives.

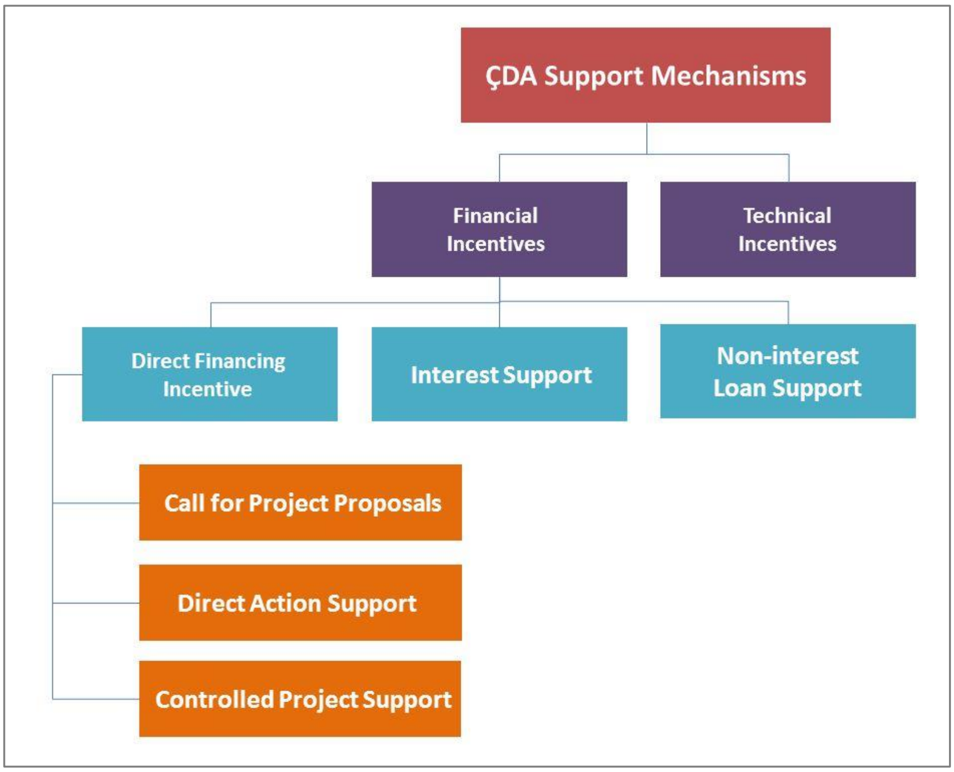


Figure 6-8: ÇKA Support Mechanisms (Source: ÇKA[59])

6.2.1.2. Çukurova Regional Plan

The high-level strategic planning and policy documents drafted by MoD and endorsed by the parliament (Figure 6-4) provide clear directions for ÇKA when drafting its regional development plans and investment guidance/supports/incentives. ÇKA acts as a regional moderator and facilitator for the development of Regional Development Plans in a participatory and inclusive way. The **2010-2013** and **2014-2023 Çukurova Regional Plan** take national and regional priorities and strategic targets into consideration and reflect them as concrete actions and road maps. As the MoD does, ÇKA pays maximum attention to geographical, thematic and sectoral participation during the planning process. During the preparations of the 2014-2023 Plan, 8 sub-regional meetings, 9 sectoral workshops, 18 thematic workshops, 2 development council meetings were conducted. In total, 775 participants had the opportunity to give direction to the regional planning process.

The current regional development plan draws attention to Çukurova Region's strategic importance as a center of investment attraction particularly in transportation, logistics, and health and tourism sectors; and as a potential energy hub which bridges the Middle East, Mediterranean and Europe. The vision of the 2014-2023 Plan is "to be the leading region of Eastern Mediterranean which transforms its strategic location and rich resources into value". In order to realize this vision, 6 strategic objectives are defined:

(1) to be an international center of attraction and production base,
(2) to eradicate interregional disparities,
(3) to solve social adaptation issues,
(4) to develop human capital,
(5) to ensure green development and environmental sustainability,
(6) to have attractive metropolitan areas with high living quality.

Energy and logistics infrastructures are seen as enabling factors in order to meet these objectives and therefore expansion, reliability and resilience of such assets have utmost importance for the region's development and prosperity. (Section 6.3 focuses on how planning and decision making interacts at local and regional level particularly in the context of infrastructure investments in the energy and logistics sectors).

It is also noted that the ÇKA produces knowledge reports which feed into regional development plans. Examples of such reports are: Investment Opportunity Reports, Machinery and Equipment Sector Report, Energy Sector Report, Competitiveness of Port Cities – Case of Mersin, Adana Agricultural Irrigation Infrastructure Analysis.

6.2.1.3. Provision of information on natural hazards in Çukurova

In addition to sectoral reports, ÇKA also delivers district status reports which also include (zoning based) seismicity maps. ÇKA also runs a web portal called "Invest in Çukurova" which aims to provide potential investors with a one-stop-shop for their information needs. Although currently no specific information is provided regarding risks and hazards in the region, this portal could be utilized to present such information.

When focusing on regional planning and disaster risks, ÇKA puts emphasis particularly on measures regarding climate change adaptation, disaster risk reduction, and implementation of research and monitoring systems to better understand vulnerability and risks. Unfortunately, finding risk/hazard assessment data at the regional level is relatively hard as most of the efforts have started very recently. For instance, while drought management plans are being prepared on a basin scale in Turkey, these plans will not be finished until 2023. The Project on Climate Change Impacts on Water Resources (led by Ministry of Forestry and Water Affairs) which covers climate change impacts, vulnerability assessment and adaptation was finalized in 2016. The project identified the impact of climate change scenarios on surface and ground water and determines adaptation activities in all 25 river basins of Turkey, including Seyhan and Ceyhan Basins. Among the goals of the General Directorate of State Hydraulic Works (DSI) in line with the DSI Strategic Plan (2015-2019), flood hazard maps will be prepared and early warning systems will be set up at regional level. Updated seismic maps are prepared by MTA but no high resolution climate hazard maps have been produced yet. The MoEU has also carried out a number of adaptation projects at Seyhan Basin level[xxiii].

6.3. Infrastructure investment planning and decision making

6.3.1. Overview

This section focuses on how planning and risk assessment interact in the context of the energy and transport & logistics sectors, particularly when it comes to investment decision making regarding new critical infrastructure. The desk-based research in this section is supported with key findings from 21 semi-structured interviews conducted in Ankara, Adana and Mersin during the course of the CIRA.

The country's 2023 long term development vision and 10th Development Plan (2014-2018) promote particular investment directions and themes. The plan foresees an increase in public and private investments for developing new infrastructure projects, with public and private sector investments considered as complimentary. It also distinguishes between the roles as the private sector has not been sufficiently active in investing in economic and social infrastructure areas, and the state's role in eradicating regional disparities is a totally different motivation compared to profit maximization required by the private sector.

The 10th Development Plan promotes specific targets for transport & logistics and energy sector investments, namely:

[xxiii] See the Strategic Steps to Adapt to Climate Change in Seyhan report which can be accessed here: http://www.mdgfund.org/sites/default/files/ENV_CASE%20STUDY_Turkey_Strategic%20Steps%20to%20Adapt%20to%20Climate%20Change%20in%20Seyhan%20River%20Basin.pdf

- **Turkey as a logistics hub**: Large-scale ports and their rail and road connections, road networks including divided highways, high-speed rail lines and electrification;
- **Turkey as an energy hub**: Installed capacity from 58 to 78 thousand MW, domestic source based generation, energy efficiency, transit route projects).

Transport & logistics and energy are key areas through which Turkey promotes itself to global investors. According to IPSAT, among the top 10 reasons to invest in Turkey, the following points are emphasized[60]: (i) Modern technological infrastructure in transportation and energy; (ii) well-developed and low-cost sea transport facilities; (iii) railway transport advantage to Central and Eastern Europe; (iv) well-established transportation routes and direct delivery mechanism to most EU countries; an important energy terminal and corridor in Europe connecting the East and the West.

6.3.1.1. Public and private sector infrastructure investment

As emphasized in the 10th Development Plan, Turkey strives for more public infrastructure projects in order to meet rising needs. For instance, annually, Turkey spends around 30% of its government budget on transport infrastructure. The importance of public infrastructure investment projects to the Turkish economy is significant. According to studies, Turkish public infrastructure capital investments are found to be a strong driver for economic growth, and more effective when compared to other OECD countries[61]. Therefore, Turkey continues its investments in modern infrastructure projects particularly in enabling sectors such as energy and logistics amongst others (see Figure 6-9).

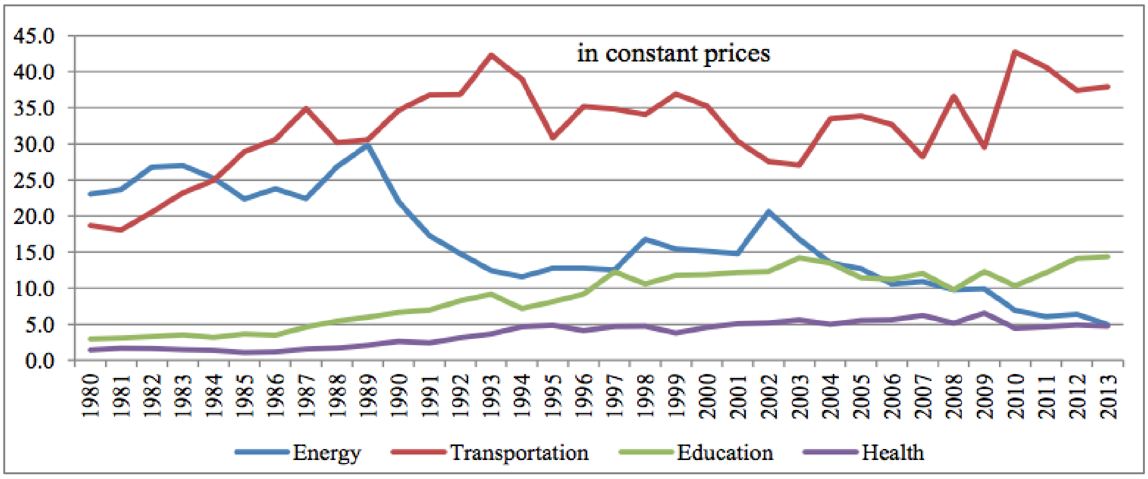


Figure 6-9: Sectoral share of public infrastructure investments in public investments (Source: ISPAT, 2013) [62]

The government allocated USD 26 billion to the infrastructure sector in 2013 alone, with majority of this budget for the transportation sector, followed by education, energy, and healthcare. Turkey ranked second highest among 139 emerging economies in 2014 in infrastructure commitments. The Turkish government signals strong commitment regarding the rapid growth in the infrastructure sector.[63] In order to realize the 2023 vision for goals to be reached by the Republic of Turkey's centennial, highways, bridges, airports, power plants and other mega projects remain on schedule. The share of infrastructure industry – including energy and transportation – is expected to surpass the residential and non-residential industry by 2022. Therefore, as the World Bank underlines, *"such economic conjuncture and aspirations requiring significant infrastructure investments in Turkey, also calls for enhanced measures in ensuring resilience of such critical infrastructures"*[xxiv].

National actors involved in the public investment process in Turkey typically bear high level policy, planning and programing documents in mind when bidding for new investments. An indicative

[xxiv] World Bank note on the Critical Infrastructure Industry & Investments in Turkey

timeline for this process is summarized in Figure 6-10. (A similar path is followed by regional actors, regarding regional-level public investments).

By their nature, infrastructure projects tend to be large-scale and the state plays a catalyzing role for new investments by providing public finance or participating in public-private partnership (PPP) models. The term Public-Private Partnership (PPP) refers to *"a long term partnership between the public and private sector in order to finance, implement and operate infrastructure services conventionally by the public sector*". According to World Bank studies, Turkey ranks third among 10 emerging countries in terms of the total contract value of PPP project stocks. Over USD 115 billion[64] worth of infrastructure projects tendered through PPPs are either finalized or in the construction phase in Turkey. It is noteworthy that the number of PPP projects in energy and logistics domains constitute a significant portion of the total PPP projects in Turkey (see Figure 6-11). This dominance is linked to the privatization process and the governments' intention to focus more on social infrastructure such as healthcare and education.

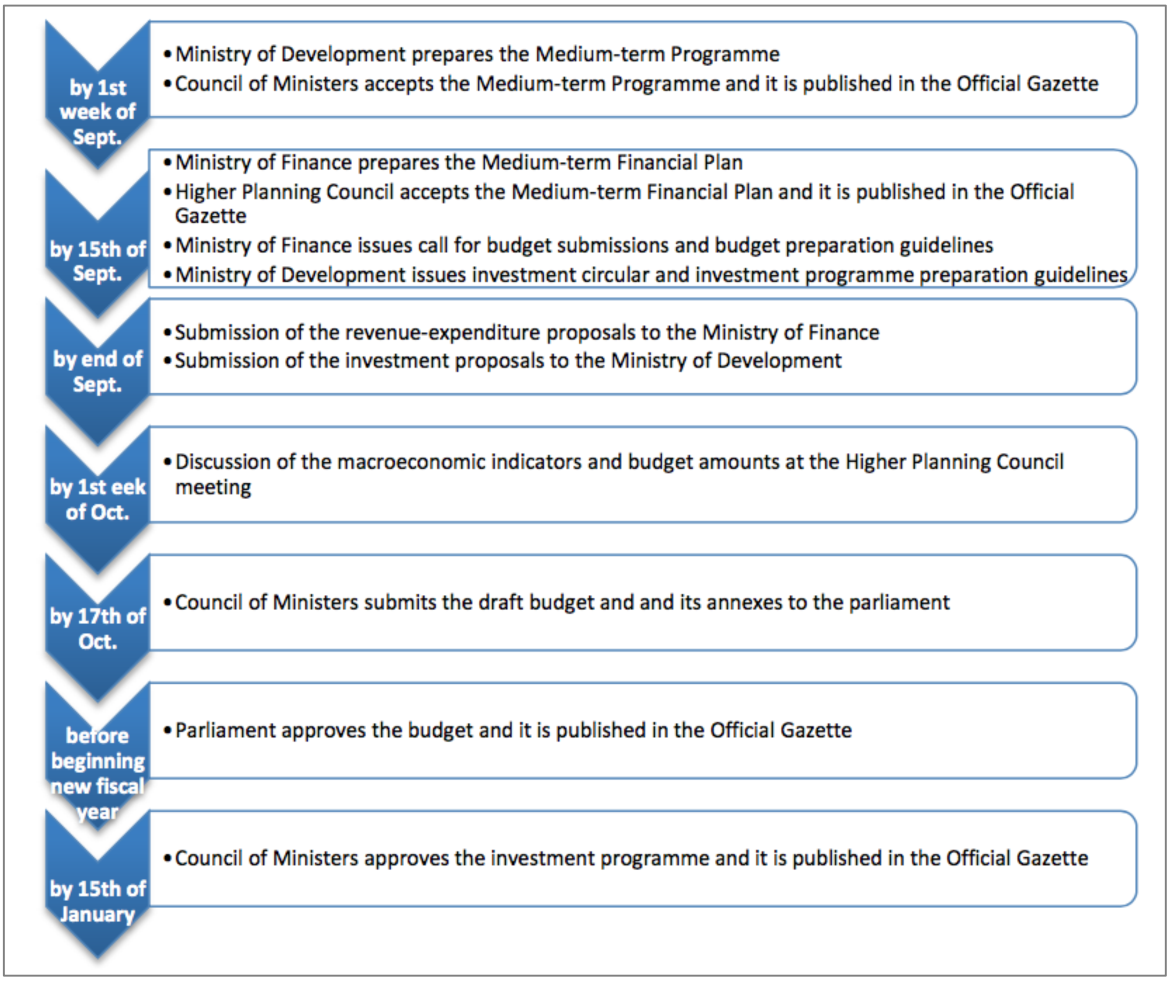


Figure 6-10: Indicative timeline for public investment process in Turkey. (Source: MoD, 2003)[65]

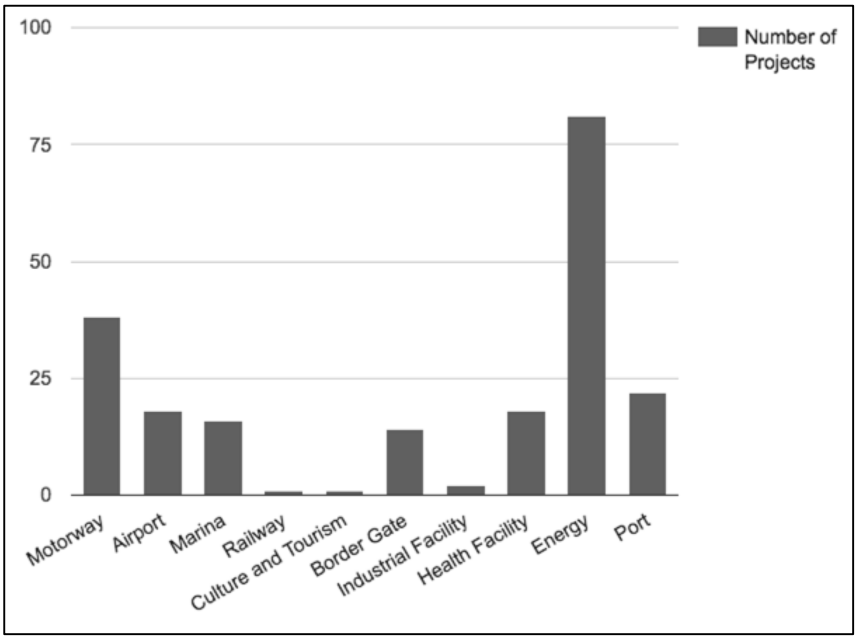


Figure 6-11: Distribution of PPP projects in Turkey by sector (Source: MoD,2017)[66]

In Turkey, the share of public investments in GDP is much below the private investment share which is an indication that Turkey has become an attractive destination for Foreign Direct Investment (FDI). The 'ease of doing business' in Turkey is either equal to or higher than Europe and Central Asia and Middle East and North Africa countries; and the country has a well-established enabling regulatory framework with regards to large infrastructure investments.

In 2015, the B20[xxv] Infrastructure and Investment Taskforce underlined that annually the world spends approximately USD 9 trillion on infrastructure, some USD 2.6 trillion of which goes into economic infrastructure, particularly on transportation and energy generation. It is expected that the gap in economic infrastructure will rise to USD 15 trillion to USD 20 trillion. Logistics and energy infrastructures are vital components of competitiveness and economic development of Turkey and therefore investments in these areas are on the rise.

In addition to public investments and the PPP model funded investments, Turkey provides specific incentives for investors. These incentives are available to private investors for the implementation of investment activities in a number of selected sectors and/or regions depending on the scale of investment. The types of investment incentives available in Turkey are shown in Box 6-2).

Box 6-2: Investment incentives provided by Turkey (Source: KPMG, 2016[67])

Investment Incentives in Turkey

A. **Regional and sector-based investments:** Turkey is separated into six regions based on the development level of the districts/cities in these regions. The first three categories (I to III) represent well developed regions. Note that Adana is Region II and Mersin is Region III (see Figure 6-12).
B. **Large scale investments:** Investments in excess of at least TRY50 million where such amount increases depending on the industry of the investment.
C. **Prioritized investments:** This type of investment can benefit from incentives that are granted to Region V investments. Large scale investments in energy and logistics sectors may qualify as prioritized investment.

[xxv] The Business 20 (B20) is a forum through which the private sector produces policy recommendations for the annual meeting of the Group of 20 (G20) leaders.

D. Strategic investments: A strategic investment is one where the minimum fixed amount of the investment should exceed at least TRY50 million and the added value that is expected to be provided by the potential investment should be a minimum of 40%.

Figure 6-12: Regional incentives map of Turkey (Source: Ministry of Economy, 2013[68])

In addition to these incentives, the **Energy Investments Follow-up and Monitoring Commission** was set up in 2016 under the Ministry of Energy and Natural Resources to ease investment in energy production and transmission. There is a feed-in-tariff system for encouraging renewable energy investments in the country. Apart from the incentive mechanisms and flows of finance into infrastructure development, there is a need to make investment conditions attractive for potential investors. For this purpose, two non-state actors emerged to strive for this agenda (Box 6-3). At the regional level, Investment Support Offices of the Regional Development Agencies provide support in this sense.

Box 6-3: YOIKK and IAC (Source: ISPAT)

The Coordination Council for the Improvement of the Investment Environment (YOIKK) is a critical structure where the private sector contributed to improving investment conditions. YOIKK has 10 technical committees working on specific issues with participation of both public and private institutions and aims to rationalize regulations on investments in Turkey, develop policies by determining the necessary arrangements that will enhance the competitiveness of the investment environment, and to generate solutions to the administrative barriers encountered by domestic and international investors in all phases of the investment process.

Investment Advisory Council of Turkey (IAC) is a platform which has global outreach that aims to receive recommendations of executives of multinational companies and international institutions concerning the business environment and investment conditions in Turkey. The recommendations stated in annual meetings by the Council members regarding the business environment in Turkey are taken to the agenda of YOIKK Technical Committees and in the following Investment Advisory Council meetings.

As emphasized previously, and like planning, investment decision making with regards to infrastructure projects is aligned with higher-level policy, programs and strategies. The guiding documents on national planning and investment decision making in Turkey provide clear directions to regional administrations such as the Regional Development Agencies. There are numerous strategy documents that feed this process as well (such as the Regional Development National Strategy 2014-2023, Government Programs, the vision of government programs, government vision regarding mega-projects etc.).

In Çukurova's case, the region is seen as a logistics and energy hub for the Eastern Mediterranean. The role of existing logistics and energy infrastructures (such as Mersin International Port, pipelines, Adana Airport etc.) is central according to this vision. New infrastructure projects are planned accordingly and can be traced via strategic plans of relevant institutions e.g. The Çukurova International Airport investment via PPP model is among the actions in the General Directorate of State Airports Authority's Strategic Plan for 2014. Similarly, the vision for Ceyhan as a global energy terminal and energy specialization zone can be found in the 62nd Government Program. Çukurova Development Agency has contributed to and developed its Regional Plan and Investment Reports (as well as investment map) in line with this overall perspective derived from the higher level of investment planning with a participatory approach. On the other hand, stakeholders in the region (such as chambers of trade) have also strived to map investment gaps and conducted research on this area. Mersin Chamber of Trade and Industry and Mersin Chamber of Shipping's Logistics Strategy Report (2009) is a good example of such efforts. There are also bottom-up interactions when it comes to infrastructure investment planning and decision making. Regional dynamics also affect higher level planning. For instance, stakeholders in Mersin made the first application in Turkey for being a Specialized Organized Industrial Zone in Logistics[69].

Public and private investment decision-making regarding energy and logistics infrastructures are conceptually explained in Figure 6-13. The conceptual diagram does not represent all details leading to a decision, but provides an overview of the kind of interactions among the actors which are happening in the Çukurova Region when it comes to infrastructure investment decision making, and how risk assessments relate with this process and interactions.

Ultimately, private and public sectors have different motivations when it comes to investing in infrastructure projects. A public institution may consider developmental needs of the country or a particular region whereas a private sector company may solely focus on profit maximization. On the other hand, both of the actors consider similar economic, social and environmental feasibility aspects before deciding to invest in a project, particularly long-lasting ones like energy and logistics infrastructure. Furthermore, both actors conduct Environmental Impact Assessments and undergo Permits and Licensing procedures etc.

At this stage or later, certain internal or external pressures or changes might occur and the investment may be halted. For instance, a macroeconomic shock might force a governmental institution to delay or cancel a large infrastructure project. Stakeholder participation can either ease or constitute a barrier to a large scale project as such projects will likely have larger impacts on social and environmental systems. Sometimes, despite all counter facts, an investment decision may be made for strategic reasons. So, there is always a room for higher level intervention in the final investment decision with regards to critical infrastructure projects.

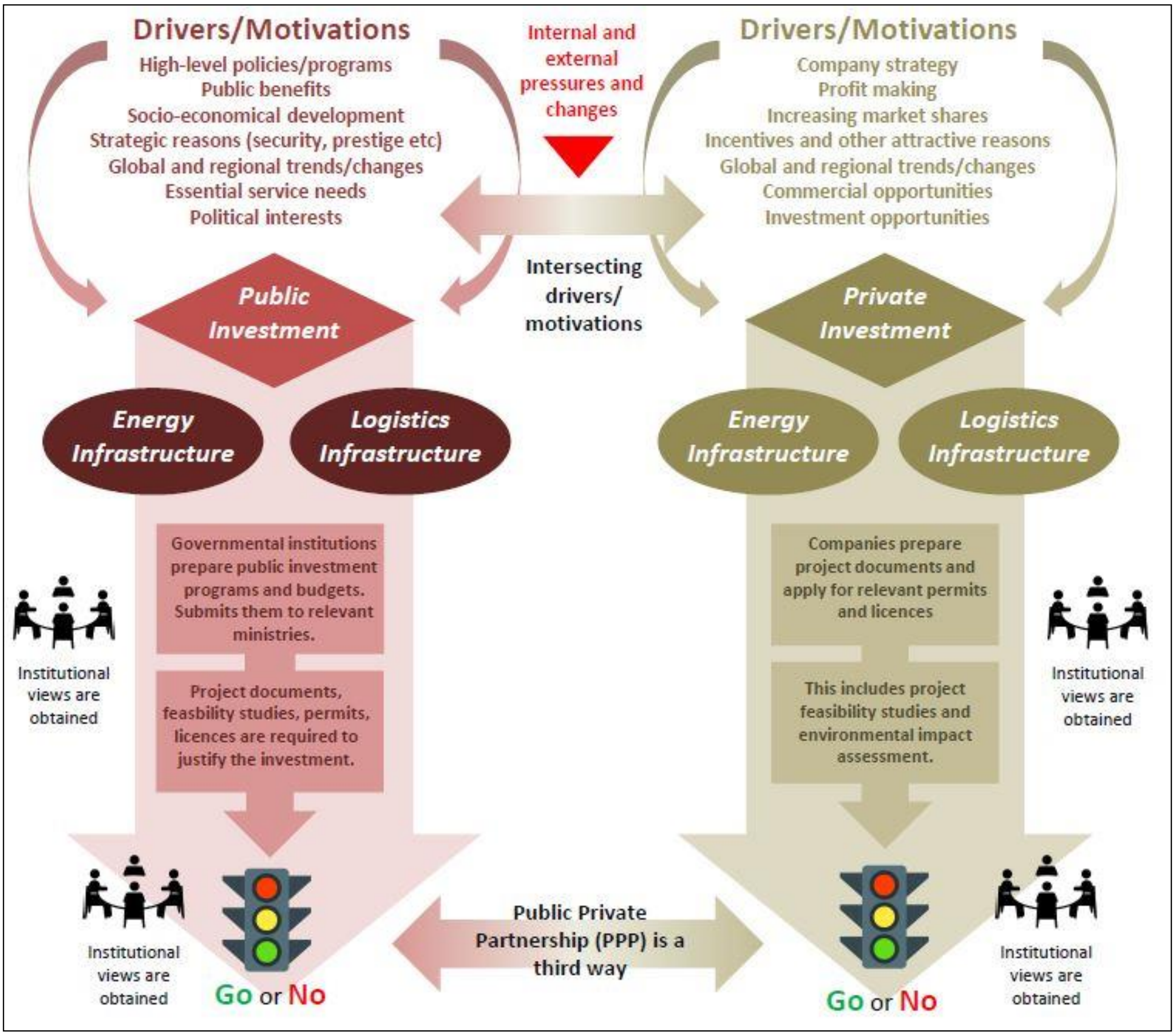


Figure 6-13: Conceptualized investment decision making in Turkey (Source: Report authors)

6.3.1.1. Risk assessments within infrastructure investment planning and decision making

Governmental institutions strictly follow high level policies, programs and budgets when developing their proposals for new infrastructures whereas the private sector is more flexible. From location selection to license and permitting, both actors should comply with similar documentation. In the critical infrastructure context, both public and private sectors prepare project documents, feasibility studies, environmental impact assessment reports and they both obtain the same permits. Risk assessment is a part of project application and permitting processes. Some of the risks, including geological risks, are elaborated in detail whereas others – notably climate change – are not. It should be underlined that there is no specific section on climate related risks at the feasibility report or EIA template stage.

In the context of climate change and seismic risk information exchange, dialogue between governmental institutions and project applicants is limited but does take place. Most of the time, private service providers are used for more detailed risk assessments.

6.3.2. Central / regional infrastructure planning case studies

In Turkey, it is observed that the public sector is increasingly financing new infrastructure projects in transport & logistics, but has a decreasing share in energy infrastructure investments. This is mostly due to the market liberalization in the energy sector and the public sector's motivation to shift its financing to socio-economic infrastructure (such as health and education). Public private partnership (PPP) infrastructure projects are on the rise, and the focus of PPP projects is on energy and logistics.

Interviews conducted for this project confirm that private and public sectors have different motivations but follow conceptually similar paths when it comes to infrastructure investment projects. As already noted, the main drivers and motivations of the investment decisions taken by public and private sector can be different. Although there are intersections, public institutions follow certain policy and strategy aspects whereas the private sector tends to act reactively to external and internal factors. The observed paths followed from decision to application process are similar to each other for all sectors (see Figure 6-14). Only slight formatting changes apply depending on the sector (i.e. for EIA, there are specific guidelines for a thermal power plants, motorway, and many other project types).

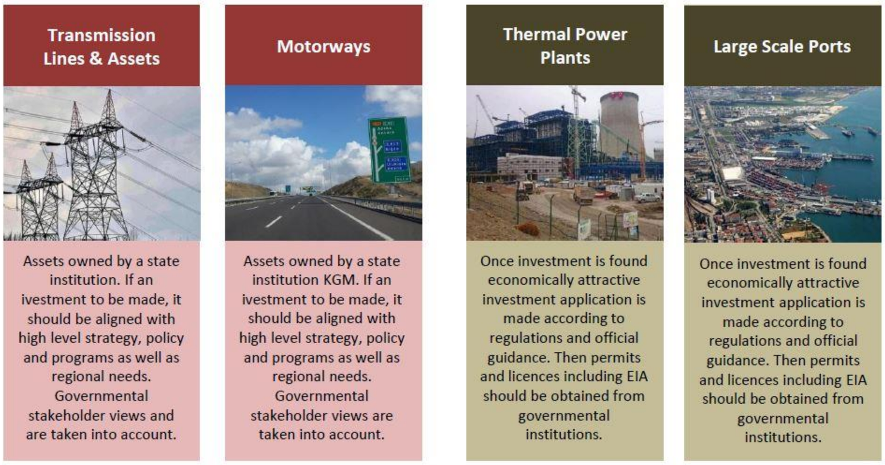


Figure 6-14: Examples of public (red boxes) and private (brown boxes) infrastructure investment decisions (Source: Report authors)

To elaborate more on this subject, two specific examples are provided in Annex A4.6, one public owned and one private owned large infrastructure. An analysis was conducted on which plans the investor should take into account and which permits are needed at central and regional levels in order to better identify entry points for risk assessment.

6.4. SWOT analysis and adaptive capacity

6.4.1. Introduction

One of the key aims of the CIRA is to help identify entry points in the planning process for building the resilience of infrastructure in the Çukurova region. To aid this process a SWOT analysis was conducted, focusing on the region's current ability to achieve resilient energy and transport sectors. The SWOT was carried out by groups of participants (55 individuals) at the 1st CIRA risk assessment workshop. The participants represented a broad range of stakeholders, including those responsible for managing and operating the region's CI such as the ports, railways, power generation facilities and pipelines. The same participants were also requested to fill out a questionnaire on the level of Adaptive Capacity within their organisations. The sub-sections below outline the outcome of both the SWOT and Adaptive Capacity assessments, based on the information provided by the participants.

6.4.2. SWOT analysis on the region's ability to achieve resilience in the energy and transport & logistics sector

Participants assessing the SWOT of the region were asked to consider the region's current ability to achieve resilience in the energy and transport & logistics sectors. Participants were also free to discuss the region in general, for examples its strength as a geographical crossroads between Europe, Turkey and the wider Middle East. Figure 6-15, Figure 6-16, Figure 6-17 and Figure 6-18 summarise the outputs from the SWOT analysis, dividing the observations between those focused on specific sectors and others/ general observations.

Both the energy and transport sectors were reported as having a strong strategic presence in the region. Researchers and infrastructure managers / asset owners are already working on improving resilience and this is reflected in updated earthquake regulations. However, a lack of planning, particularly in the transport sector is seen as a weakness, as is relatively low levels of awareness about climate change risks. The potential for renewable energy and Mersin International Port's advantageous geographical location are both seen as strong opportunities for the region. In turn, threats are perceived to come from the impacts of climate change, as well as wider political instability and a deteriorating security situation.

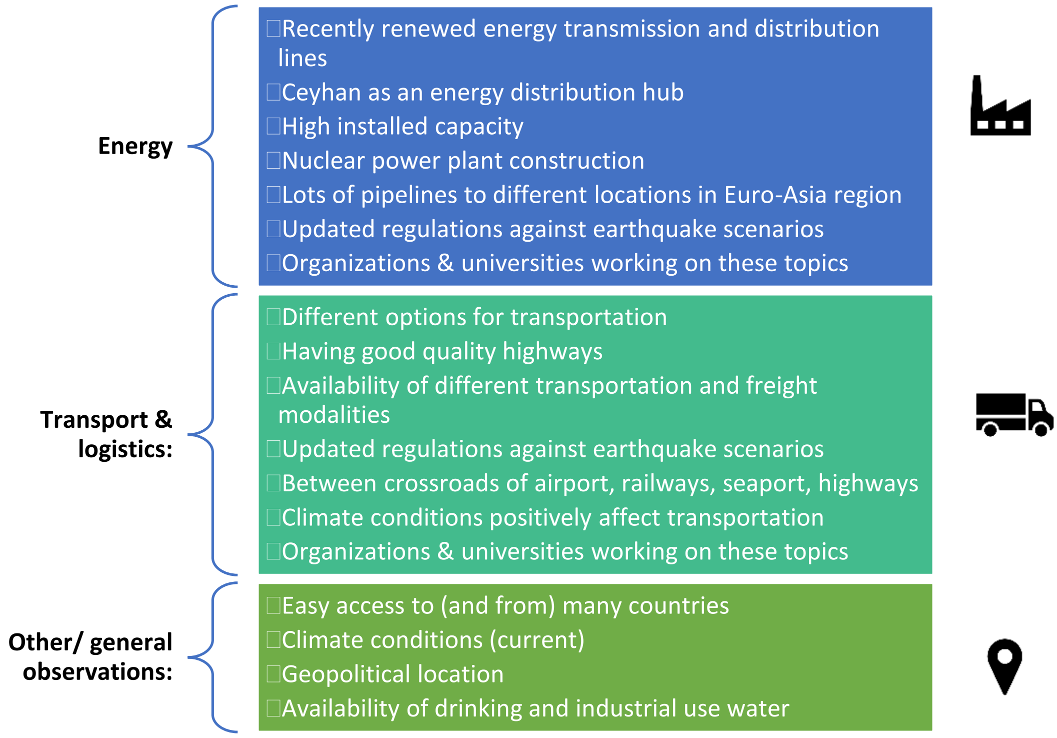


Figure 6-15: Strengths of the energy and transport & logistics sectors in Çukurova identified by participants at the 1st CIRA risk assessment workshop. (Source: Report authors).

Energy

- Unlicenced energy production (where it is less than 1 MW)

Transport & logistics:

- Slow pace of modernization in railway infrastructure
- Poor status of the road that connects the region to Antalya
- Lack of planning in transportation
- Heavy reliance on highway transportation compared to railway at present
- Lack of awareness on climate change and impacts of natural hazards

Other/ general observations:

- Located at the coastline (exposed to relevant risks)
- Lack of qualified labour force
- Lack of training/awareness on disasters and emergency situations
- Planning problems at urban scale
- Insufficient incentives for industrial facility and industrial region investments
- High unemployment figures
- Open channel irrigation
- Insufficient rain drainage channels

Figure 6-16: Weaknesses of the energy and transport & logistics sectors in Çukurova identified by participants at the 1st CIRA risk assessment workshop. (Source: Report authors).

Energy

- Availability of renewable energy resources such as solar power, wave energy, off-shore wind power
- Increasing the number of small power plants (<1MW)
- 10th National Development Plan specifies Çukurova Region for future investments

Transport & logistics:

- Availability of a large-scale port
- Advantageous (geographical) location of the port
- Railway from Europe to China passes via Adana (planning phase)
- Çukurova airport (under construction)

Other/ general observations:

- The region is suitable / favourable for new project investments
- Educated young population
- Proximity to big cities
- Cultural diversity and rich heritage
- Water potential is high
- Agricultural production potential is high

Figure 6-17: Opportunities for the energy and transport & logistics sectors in Çukurova identified by participants at the 1st CIRA risk assessment workshop. (Source: Report authors).

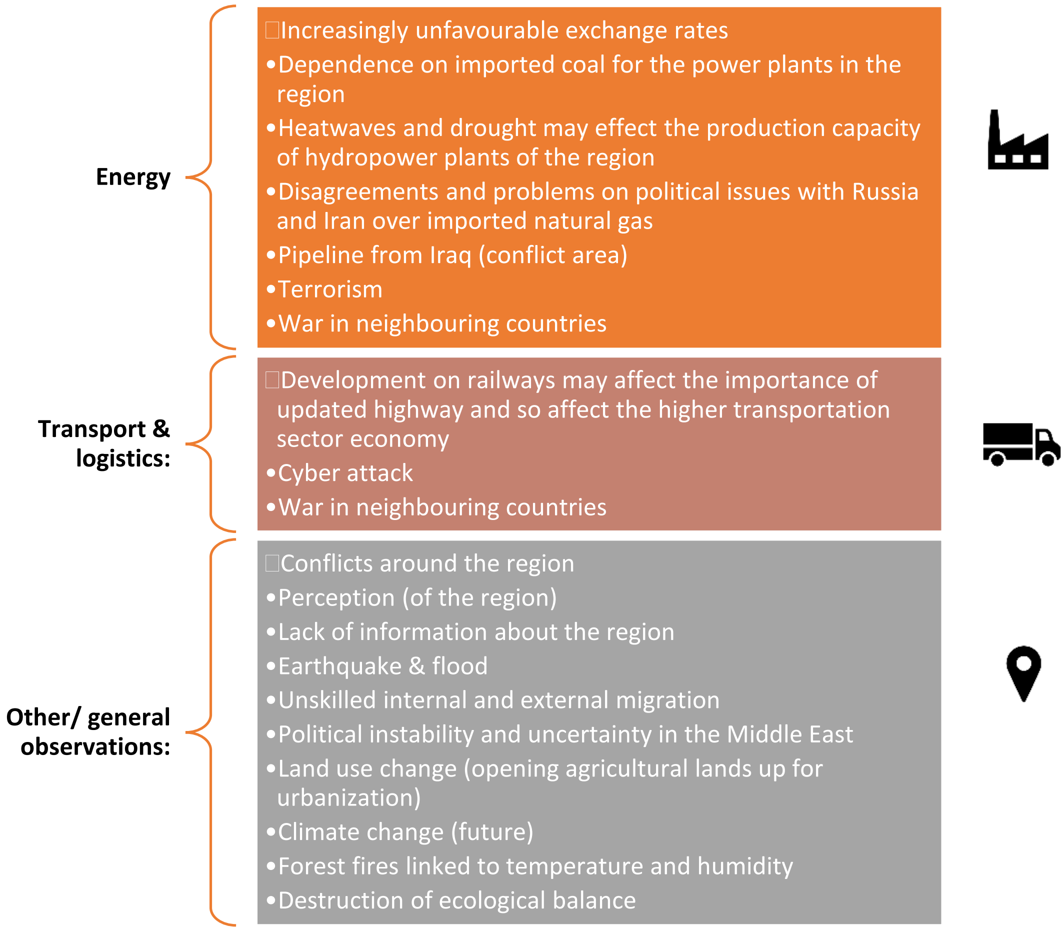


Figure 6-18: Threats facing the energy and transport & logistics sectors in Çukurova identified by participants at the 1st CIRA risk assessment workshop. (Source: Report authors).

6.4.3. Adaptive capacity of stakeholders in Çukurova Region

The Intergovernmental Panel on Climate Change (IPCC)[70] defines Adaptive Capacity as “the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.” In order to measure adaptive capacity in the Çukurova region, workshop participants were asked to respond to questions about their organisations’:

1. **Level of awareness** of information on adapting to natural hazards,
2. **Technical capacity** to understand risks and prioritise needed actions,
3. **Level of progress** in evaluating risks and taking action to adapt,
4. Areas for **improvement.**

There were 32 respondents to the questionnaire in total, each of which had spent an average of 12 years at their respective institution. The full questionnaire can be found in Annex A4.6. The geographical scope and sectoral breakdown of the respondents’ institutions can be seen in Figure 6-19. The majority of respondents represent organisations with jurisdiction within the Çukurova region and, despite the focus of the workshop, most reported not being directly involved in the transport or energy sectors.

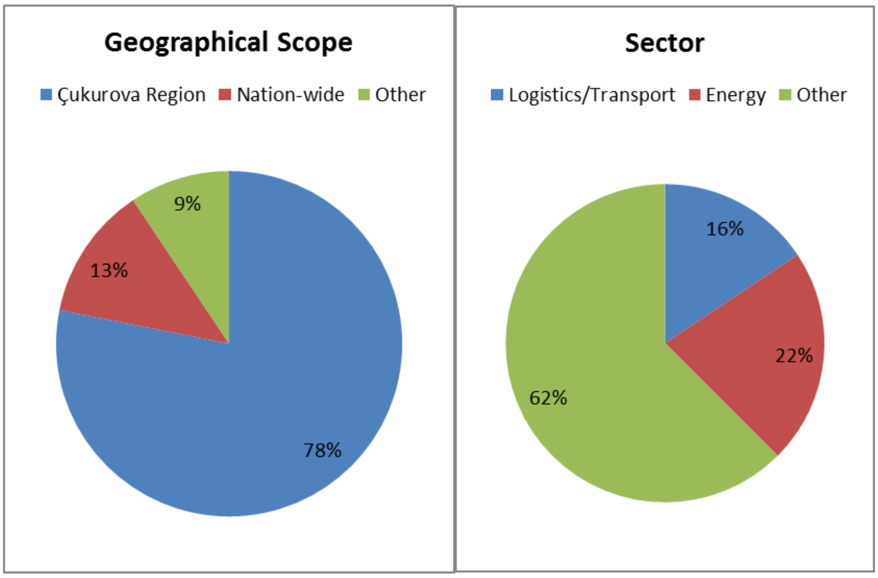


Figure 6-19: The geographical scope of respondents' institutions (left) and their sectoral focus (right) . (Source: Report authors).

Overall level of awareness of information on adapting to natural hazards: MEDIUM

Awareness of two key documents, the National Climate Change Action Plan (2011-2023) and the Disaster and Emergency Management Strategic Plan (2013 – 2017), was used to assess organisations' general 'level of awareness' of information on adapting to natural hazards. Figure 6-20 shows that almost all respondents stated that their organisation knows about these two documents. Around 40% reported that their organisation had a 'fairly low' or 'very low' awareness level, and around 60% reported 'fairly high' or 'very high' awareness. This overall 'medium' level of awareness is reflected in Figure 6-21 which shows that around 70% of respondents were satisfied with the amount of information they have, to be able to plan for geophysical hazards and a changing climate.

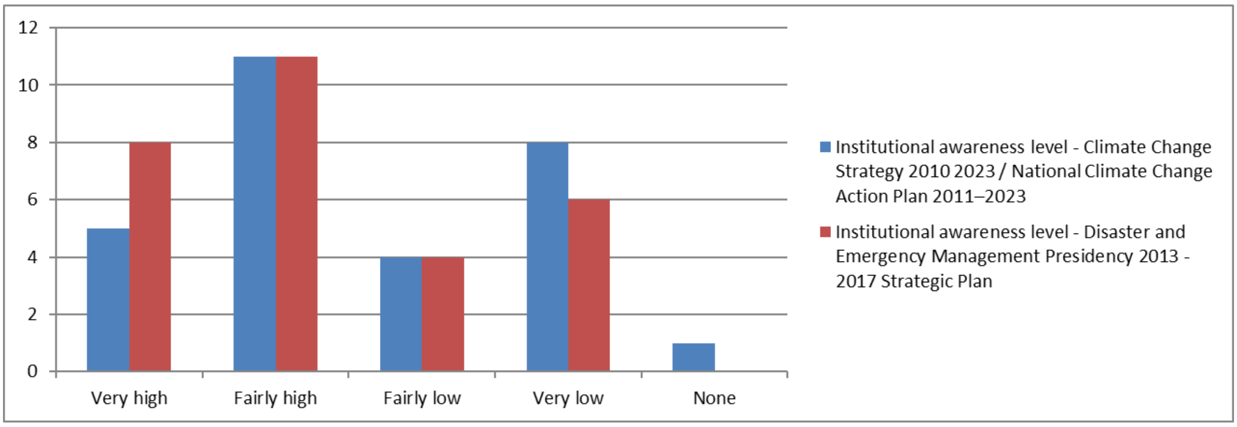


Figure 6-20: Institutional awareness level (according to the number of respondents on the vertical axis) of the National Climate Change Action Plan, 2011-2023 (Blue) and the Disaster and Emergency Management Strategic Plan, 2013 – 2017 (Red) . (Source: Report authors).

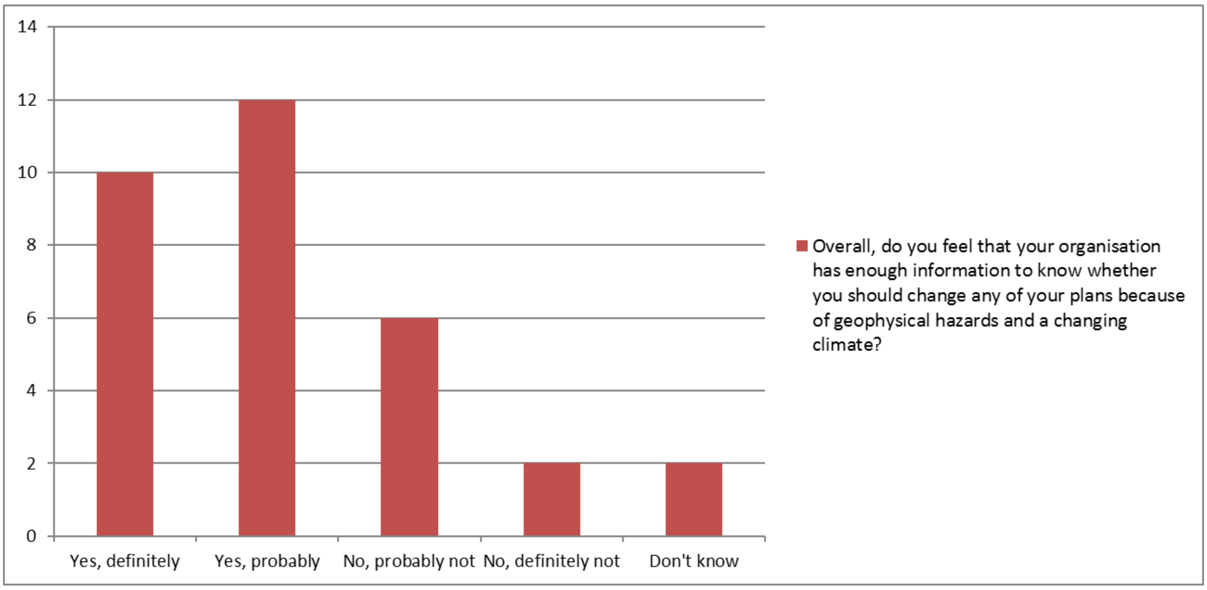


Figure 6-21: Satisfaction with the level of information on geophysical and climate hazards (according to the number of respondents on the vertical axis) . (Source: Report authors).

Overall level of technical capacity to understand risks and prioritise needed actions: LOW

The respondent's self-assessment of technical capacity to understand geophysical and climate risks and prioritise needed actions is summarised in Figure 6-22. It shows that nearly half the respondents reported weak or no capacity, suggesting that whilst the information may be available, the expertise to assess risks and prioritise actions is potentially lacking.

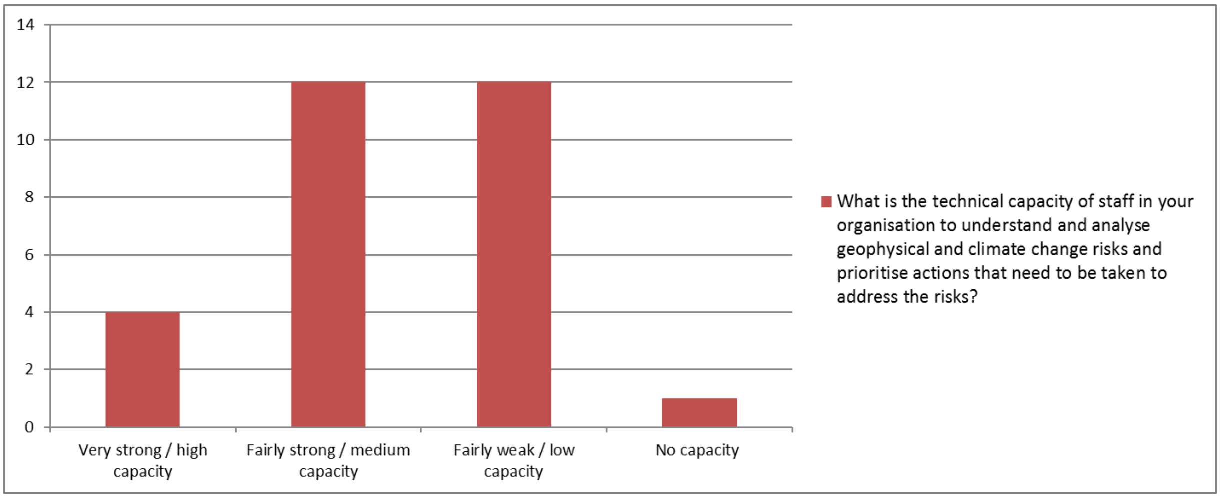


Figure 6-22: Self-assessment of organization's level of technical capacity (according to the number of respondents on the vertical axis) . (Source: Report authors).

Overall level of progress in evaluating risks and taking action to adapt: MEDIUM

Respondents were asked to assess the progress their institutions have made in assessing risks and taking adaptive actions. Encouragingly, 38% reported that their institutions have reached the point of integrating natural hazard risk management into their planning (see Figure 6-23). A significant minority (28%) 'didn't know' and so there remains a degree of uncertainty over the assigned 'medium' level of progress. However, none of the respondents reported "not thinking about natural hazards at all".

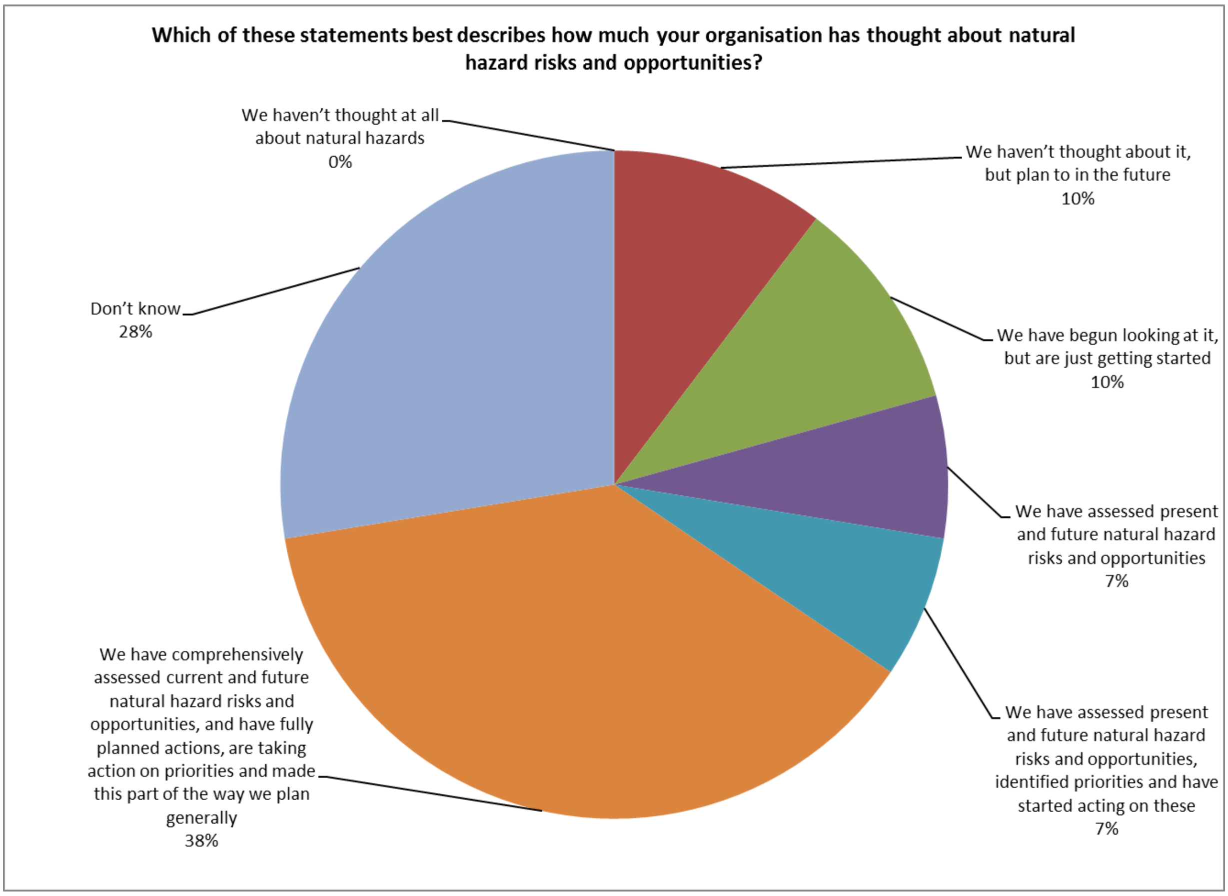


Figure 6-23: Self-assessment of level of organisation's progress in evaluating risks and taking action to adapt (by % of respondents). (Source: Report authors).

6.4.4. Areas for improvement

Some eight areas which would enable improvement were selected by respondents to the questionnaire (in rank order):

1. Information is easy to obtain, understand and targeted to my organisation's needs
2. Good understanding of how current and future natural hazards may affect my organisation
3. Sufficient staff (numbers, expertise and time) and budget to understand and manage natural hazard risk
4. Good understanding of the benefits of adapting to climate change and other natural hazards
5. Better access to finance that could help my organisation prepare and take action
6. Better management, distribution and use of natural resources that can support adaptation (e.g. land use, water resources, biodiversity etc), both at the regional level as well as within my own organisation
7. Better information about technological solutions and strategies for increasing resilience
8. Unified, clear and robust climate change and disaster risk policy & governance, cascading from national through to regional government

All 8 areas were regarded as 'very important' or 'somewhat important' by most respondents (see Figure 6-24), suggesting there is an appetite for more capacity building. The idea with the most number of 'very important' votes was for "Information is easy to obtain, understand and targeted to my organisation's needs". This suggests that while information is out there it is not necessarily tailored to the specific needs of the organisations themselves.

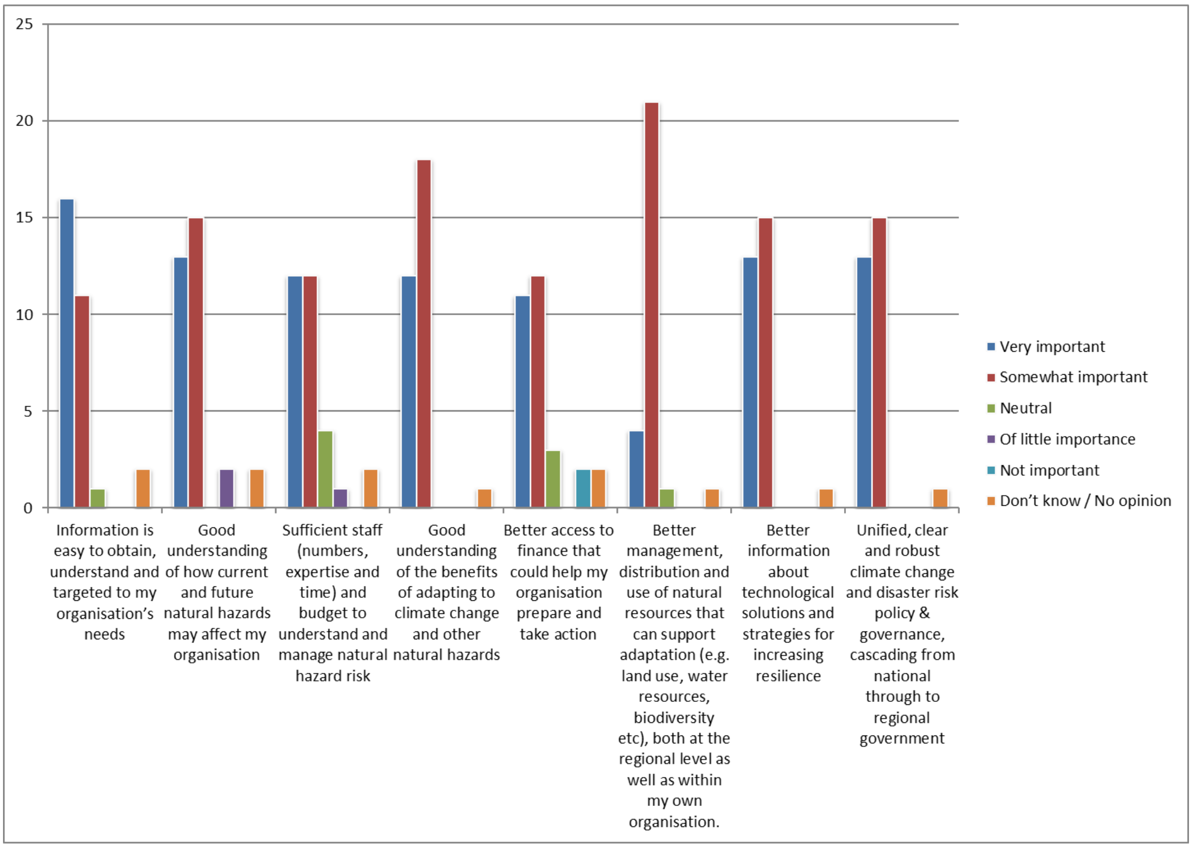


Figure 6-24: Level of importance ascribed to different areas which would enable improvement (by number of respondents). (Source: Report authors).

7. Recommendations for improving the resilience of Critical Infrastructure

Summary of key points

- The principles of critical infrastructure resilience should focus on both national and regional policymakers and should work together to achieve an overall objective of increased resilience in CI planning and operation.
- A common understanding of CI resilience should be defined among relevant stakeholders and existing standards and policies should be evaluated and strengthened.
- Critical sectors and assets need to be defined and their criticality evaluated; for an efficient implementation of a resilience framework, public-private partnerships (PPPs) are considered crucial.
- Sector dependencies and interdependencies should be identified and take into account not just regional or national dependencies, but also cross-border/transboundary considerations.
- A better understanding should be developed of hazard and risk management, with comprehensive risk management strategies put in place.
- Risk assessment and management should be supported by capacity building, awareness raising and addressing gaps in knowledge.

7.1. Risk management policy and best practice

This section draws on analysis in earlier sections along with the findings of the 1st CIRA risk assessment workshop and a literature review, to provide policy recommendations on how to improve integration of risk management and resilience for CI within the Çukurova regional development and investment planning process. It identifies needs for further studies and activities for CI resilience and prioritizes them at regional level. The development of this policy guidance has also been informed by other strategies/ policies for CI resilience; examples of best practice from other countries are presented in a catalogue.

Figure 7-1 presents a conceptual overview of this policy guidance, which is organized in three sub-sections:

Section 7.1.1 provides key principles for national and regional policymakers that promote resilience covering:

- Developing a common language on CI resilience;
- Extending regulatory frameworks;
- Identifying CI sectors, assets and their criticality;
- Developing a public private partnership framework for CI resilience;
- Identifying sector dependencies and interdependencies;
- Developing a better understanding of hazard and risk management; and
- Raising awareness.

This section focuses on both national and regional aspects based on the findings of the literature review. These are the general CI resilience principles which are then used to develop a regional agenda in Section 7.1.2.

Section 7.1.2 draws on Section 7.1.1 to identify and prioritise activities and further studies to be undertaken at the regional level. Following the general recommendations provided in Section 7.1.1, this section proposes dedicated actions for the Çukurova Region on CI resilience. During the creation of proposed actions, particularly the *strengths of the Çukurova Development Agency* (Çukurova Kalkınma Ajansı - ÇKA) were taken into account. The *unique position* of ÇKA provides value for implementation of the proposed agenda of the project, as well as further steps. Having *regional development* as main goal, ÇKA has a role to bring public sector, private sector and NGOs together and facilitate the coordination among these actors. In the concept of the CIRA project, having coordination power among local authorities, CI owners/ operators and NGOs in the region is a critical factor to orchestrate the CI resilience efforts *(local coordination power)*. ÇKA is also known for its *financial support programs*. Its financial mechanism allows to intervene regional development problems and encourages the regional development through grant scheme based on defined regional priorities. ÇKA's *mediator role* eases the problems that arise from the limited coordination capability of central authorities on the local level. This is important since the CI resilience efforts should go beyond the central approach and be coordinated on a regional level (being aware of region-specific issues). Furthermore, ÇKA prepares *policy recommendations* based on their studies and shares these with relevant central authorities. Those studies are not only done regionally and nationally but also international cooperation is an option (experience sharing, benchmarking, participating EU funded projects).

Section 7.1.3 provides a catalogue of best practices on CI resilience, showing examples of applications in different countries identified through a literature review. The catalogue aims to demonstrate different aspects of measures to improve CI resilience which have been put in place in different contexts. Best practice cases from the US, the UK, and Australia were selected, due to their well-established know-how on CI resilience at national and regional levels. The Mexico City case is listed due to its similar economic dynamics to Turkey. Two European cases were selected because of Turkey's aspirations on alignment to EU standards. While all these examples refer to improved planning for climate resilience, three further cases (Tajikistan, Mexico, Uruguay) are illustrated that focus on risk financing mechanisms. Due to the identified low coverage of climate change related risks in Turkey and consequently in the Çukurova Region, the catalogue puts specific emphasis on climate change issues, in order to raise awareness on the topic.

Annex A5.1 demonstrates how the recommendations in this policy guidance have been informed by earlier CIRA work.

7.1.1. Key critical infrastructure resilience principles

This section presents key principles for improving CI resilience, focusing on both national and regional policymakers. These are the general CI resilience principles which are then used to develop a regional agenda (Section 7.1.2). The principles have been informed by a literature review of best practice on CI resilience from other countries, together with the findings of earlier sections of this report, and the workshops conducted for the CIRA. (See Annex A5.1 for further details).

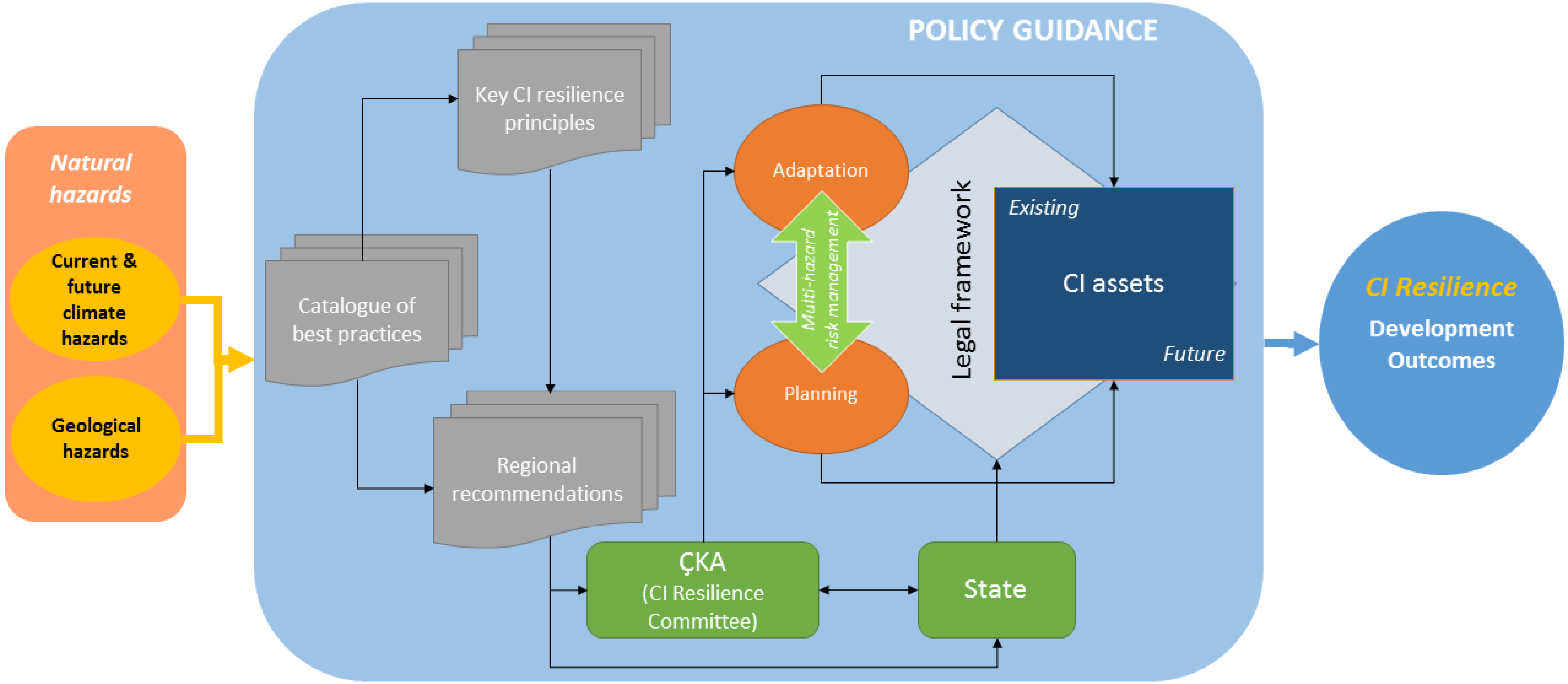


Figure 7-1: Conceptual overview of this policy guidance. (Source: Report authors).

Figure 7-2 illustrates how the principles can work together towards the overall objective of increased resilience in CI planning and operation. A **CI resilience strategic plan**, backed by strong political commitment, needs to be defined in close iteration with all relevant stakeholders and communicated effectively. A **common understanding of CI resilience** should be defined among the relevant stakeholders and **existing standards and policies** should be evaluated and strengthened. This would lead to identification and analysis of the contextual gaps in the policy arena, resulting in recommendations for improvements in the policy domain. As a key component of the CI resilience framework **critical sectors and assets** need to be defined and their **criticality** evaluated. For an efficient implementation of this framework **public-private partnerships (PPPs)** are considered crucial. PPPs to foster CI resilience are key during the entire process from identifying and evaluating risks to developing sector-specific plans to improve CI resilience.

Effective partnerships help prevent or at least mitigate essential service disruption from adverse impacts and should be considered the centrepiece of the CI resilience strategy framework. The establishment of an **information sharing** mechanism based on this partnership improves cooperation and collaboration among stakeholders. Information sharing among stakeholders is considered beneficial at all levels of the strategy development process, to maximize the level of preparedness, as well as during emergency operations. Under this broader PPP collaboration, input from the scientific stakeholder community provides **research and development** addressing knowledge gaps and technological model construction. In an increasingly complex operational environment, resilience should be seen as a cross-sectoral approach and asset and sector dependencies should be evaluated in the PPP context. Comprehensive **risk management** strategies need to be defined accounting for regional hazards and vulnerabilities of exposed CI assets. **Awareness raising** activities support capacity building and address knowledge gaps at all levels which are impeding CI resilience.

All these steps jointly contribute to building a resilient CI operation environment. Each one is discussed in further detail in the following sub-sections.

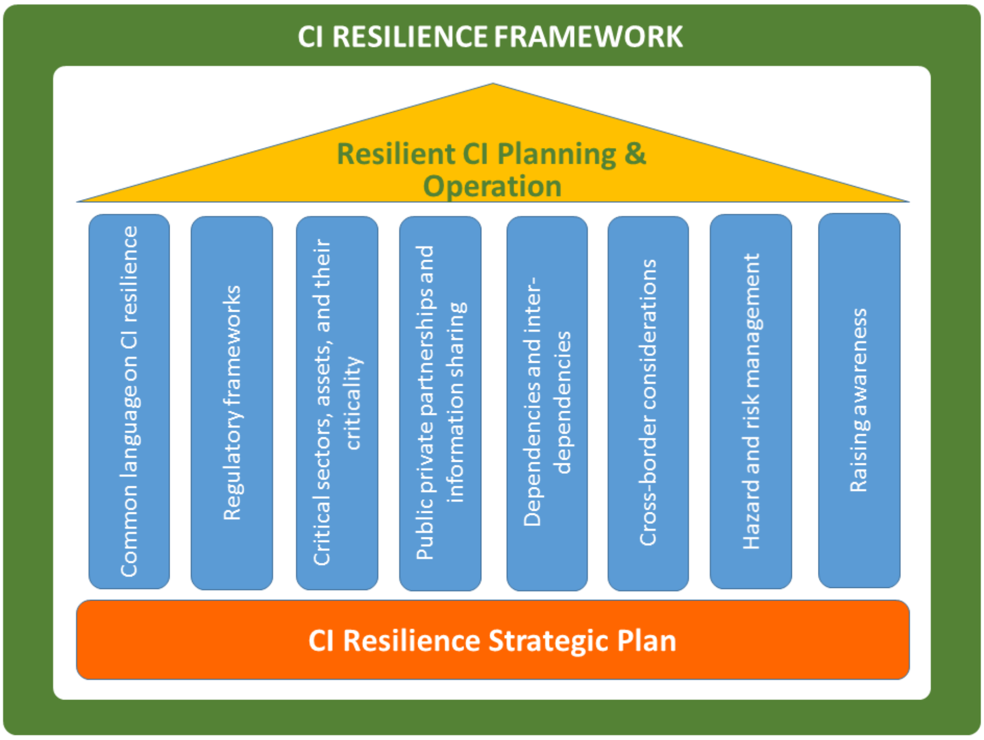


Figure 7-2: Key pillars of a critical infrastructure resilience framework. (Source: Report authors).

7.1.1.1. Develop a common language on CI resilience

Today's business and societal systems face increasing complexity in a more hazardous environment marked by interconnection and interdependencies across global networks, and hence the failure of one element of a system can have cascading impacts. It follows that resilience also needs to be considered in a system-wide, integrated manner, and Figure 7-3 illustrates how various facets of resilience are related. Comprehensive operational multi-hazard risk management ensures a higher level of organizational resilience which consequently improves the resilience of individual CI sectors. The key role of CI resilience in overall infrastructure risk management implies a strong influence on community resilience and overall disaster resilience. The roles of public and private sectors need to be continuously re-evaluated to mitigate risks most efficiently and ensure continuity of basic functions/services in the face of disasters.

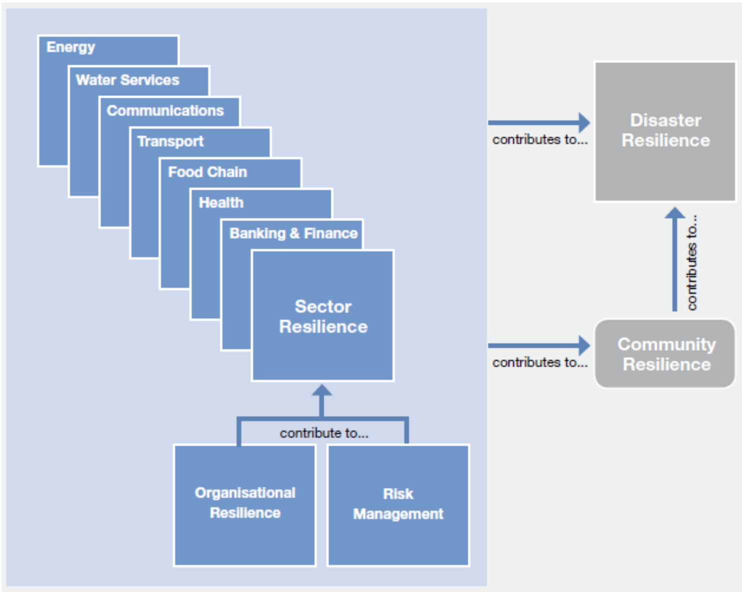


Figure 7-3: Relationship between CI sector, disaster and community resilience. (Source: Australian Government, 2010 [71])

The status of resilience is a risk-based and on-going dynamic process whereby the various vulnerabilities of CIs are addressed. The process of achieving CI resilience involves designing a new infrastructure asset, or adapting an existing infrastructure and maintaining functional integrity, so that potential damage can be minimized in case of a disaster event. If any disruption occurs due to an impact, a resilient system enables returning to normal operation rapidly after the event without or with minimal service disruption.

An important first step towards strengthening CI is establishing a common language on infrastructure resilience. This process should include developing sector specific understanding of resilience by public and private sector stakeholders. It is necessary to develop a sector-based conceptual structure on the common principles for the resilience of CI against possible threats. A common understanding would help better policy and strategy development.

In Turkey, there have been some on-going efforts in the CI resilience domain in recent years. *The latest National Development Plan*[72], emphasises *"taking measures which aim to strengthen infrastructures and ensure that new constructions are built resilient to disasters"*. One of the most recent guidance documents is the Prime Ministry's Disaster and Emergency Management Authority (AFAD)'s *Roadmap on Critical Infrastructure Protection: 2014-2023*. AFAD, the responsible authority for CI protection related work, uses the term *"protection"* in that document, instead of *"resilience"* and asks every ministry in Turkey to appoint at least two staff to evaluate CIs that fall under their area of responsibility. Additionally, AFAD proposes to organize a workshop to come up with a clear definition of CI. However, there is no reported output yet[73].

To summarize, in Turkey, the concept and the implementation aspects of CI resilience are very limited in existing plans, and a common understanding on resilience principles would be the first step to improve this situation. However, in the scope of the CIRA project, this has already been addressed in the Çukurova Region.

7.1.1.2. Extend existing regulatory frameworks

In Turkey, in the CI resilience context, policy development has focused mainly on regulations regarding the EU alignment aspirations. In that regard, AFAD published the *"Roadmap on Critical Infrastructure Protection: 2014-2023"* in 2014[74]. This document looks at the issue from a technological disaster perspective. In addition to that, a number of CI protection strategy and action plans were produced at different levels from different government institutions and regarding different hazards. **These plans, however, do not reflect an inclusive strategic coordinated approach and also lack any monitoring of implementation.**

The only CI-specific decree enacted in Turkey refers to protection from cyber security breaches. It identifies a set of sectors as having CI assets from an information security point of view[75] (MoTMAC, 2013). This thematically-restricted framework does not cover all aspects of CI resilience and fails to provide guidance in managing all possible hazards/risks. Figure 7-4 demonstrates the limited scope of cyber security and how it partially overlaps with CI protection.

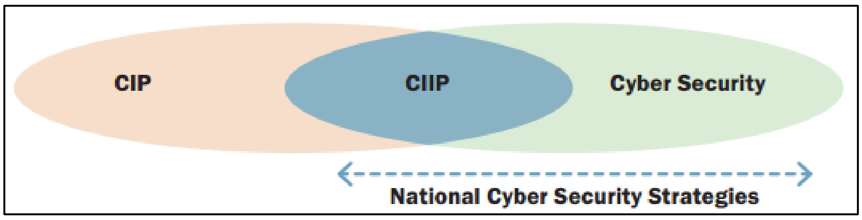


Figure 7-4: Relationship and coverage between critical infrastructure protection (CIP), critical information infrastructure protection (CIIP) and cyber security. (Source: The GFCE and Meridian, 2016[76])

This single threat approach does not reflect all the risks that CI assets are facing. As the Risk Assessment Phase of the CIRA Project reveals, the possible climate related impacts on CIs makes the region considerably more vulnerable over time, and this trend will likely continue to intensify in the near future. On the other hand, in line with the latest *National Development Plan*, there are plans for several large new CI asset investments to establish the Çukurova Region as an energy hub and significant logistics centre. In order to make this development strategy sustainable, resilience of assets in these sectors should be considered of utmost importance, particularly in the climate change context. On the contrary, a lack of planning to achieve resilience, particularly in the transport sector, was flagged up as a weakness by participants at the 1st CIRA risk assessment workshop. However, **in Turkey, there is no policy requirement to include changing climate risks in infrastructure planning and neither do infrastructure operators have to assess and implement climate adaptation action plans in on-going operations. This applies to Public Private Partnership legislation as well, given the high market share of these types of projects in energy and transport sector investments that do not refer to the changing climate risk landscape.** Despite an existing number of plans and programs about climate change that aim at integrating climate change adaptation into national, regional and local policies, climate related risk understanding, experience and expertise is low in the Çukurova Region and in Turkey. Given the climate related risk characteristics of the Çukurova Region, this is an important challenge for CI resilience. Following the outline of the national development plan, the ÇKA[77] confirms climate change adaptation as one of the priority areas in *the 2014-2023 Çukurova Regional Plan*. However, implementation actions cannot be initiated without national policies being in place.

To conclude, **Turkey lacks the necessary broader regulatory framework on CI resilience covering multi-hazard risk management, including the potential adverse impacts of climate change. The current policy framework should be improved by the government to also include hazards that are not currently addressed and better reflect principles of CI resilience with a clear and robust policy and governance of climate change and disaster risk, cascading from national to regional government.** An improved legislative framework that enforces certain assessments and implementation standards considering current climate conditions and potential future climate risk (e.g. design standards, site selection decisions, feasibility studies and environmental impact assessments in the investment planning phase of a development project[78] (EC, 2016)) would improve preparedness.

In the Çukurova Region, importance of the CI resilience topic has been highlighted by the ÇKA and there are on-going efforts to carry out research to address this gap in the existing policy setting.

7.1.1.3. Identify critical infrastructure sectors, assets and their criticality

Relevant government organizations should **define CI sectors** based on an identified list of criteria. This selection of sectors should not be too broad for practical reasons. Following that, **an initial set of CI assets should be identified** at the national level. Then, central government should cooperate with regional and local authorities and private sector representatives to **re-evaluate that list** and potentially identify further assets that are critical for the region. Specific influences of the assets at national and transnational scale should also be highlighted in this process. AFAD's 2014 Roadmap already provides a comprehensive definition of CI:

> *"Combination of networks, assets, systems and structures which can have serious impacts on health, security, and economy of citizens due to adverse impacts on environment, society order and public services that occur as a result of partial or complete loss of functionality of such networks, assets, systems and structures."*

The roadmap emphasizes that *scope, scale and time impact* are important factors to consider when identifying CI assets.

A comprehensive identification of CI assets enables decision makers to assess possible impacts to the functioning of businesses and society in the face of a disaster. An *a priori* defined **criticality scale** should be developed to help categorize the critical assets based on possible impacts. Furthermore, determining the most significant CI assets and their criticality helps in prioritisation and targeting of mitigation strategies to reduce their vulnerability. *AFAD's Roadmap* proposes that responsible staff in each sector should identify CIs, but it does not provide any practical solutions and criteria for prioritisation of CIs.

In the CIRA project, the process for identifying critical infrastructure was detailed in Section 4.

7.1.1.4. Develop a public-private partnership framework for CI resilience

Develop a public-private partnership

Partnership should bring many public and private sector bodies, infrastructure owners/operators and technical experts together to set out a sector-based CI resilience framework. Working with stakeholders to develop tailored sector and cross-sectoral resilience plans can enable the public and relevant private sector actors to understand the vulnerability and risk of critical assets and facilitate coordination of risk assessment and management on relevant regional hazards (including future climate trends)[79] (WB and PPIAF, 2016). Partnership should help defining dependencies between different sectors as well as developing policies and programs. **Such a partnership should be the centrepiece of the government's CI resilience strategy.**

Due to ÇKA's participatory conceptual setup (See Section 6.2.1.1), a fruitful environment for partnerships between public and private institutions is facilitated by providing its representatives access to the regional decision-making process. This is particularly relevant given that the majority of CI assets are owned and operated by the private sector. **ÇKA's inclusive structure can serve as an enabling factor to attract attention among a diverse group of stakeholders (including those that are most vulnerable to shocks) for the successful development of a regional CI resilience partnership**.

Moreover, the CIRA planning paper highlights a growing concern on the lack of dialogue between central and regional actors. This also includes misunderstandings of regional dynamics from the perspective of central government that can lead to amplification of contextual vulnerabilities. **CI resilience efforts should follow a systems-based approach, i.e. go beyond centralized policies and actions, and regions' resources and limitations should also be taken into account to create an environment for CI resilience.** ÇKA should be in a strong position to address this gap given its structural setting between national authorities and regional stakeholders. **ÇKA can act as regional moderator and facilitator, and could promote the establishment of a *"regional resilience committee"* to coordinate CI resilience activities and initiatives with relevant stakeholders from both public and private domains via** Public-Private Partnerships (**PPPs)**. Such sector-based as well as cross-sectoral governing functions are used in the partnership model in the USA (see Figure 7-5). The figure highlights the regional-level coordinating role.

In fact, Turkey was one of the first countries to anchor PPP regulation in its legislative system via a dedicated law enacted in 1994. This PPP legislation addresses various CI sectors such as transportation, energy, water supply and treatment[80]. PPP models are already used successfully in investment contracts in Turkey which provides an experience basis to build on. These models should be extended to include risk considerations during the entire process of these collaborative partnerships. Resilience is thereby built by taking into account possible threats in the regulatory requirements and addressing risks in the investment decisions.

There are also international cases which can provide valuable approaches to increase CI resilience through PPP. For example, Tajikistan's climate resilience financing facility, CLIMADAPT[81;82], combines financing with innovation to counter effects of climate change. CLIMADAPT provides funding to scale up financing for climate resilience through local banks and microfinance institutions. It also offers climate resilience assessments which support clients in recognising climate risks and finding appropriate technical solutions. **Developing financial facilities can be a practical example in terms of making climate-resilience technology affordable and accessible to the private sector**.

Create an information sharing mechanism

One of the main reasons for establishing a PPP for CI resilience is information sharing. In this context, trust is considered a key issue and without the governing function of public authorities, it is difficult to establish trusted relationships among partners, partly due to competing interests. **ÇKA should therefore act as a facilitator to enable the building of trusted relationships between public and private sector stakeholders and creating information sharing mechanisms to strengthen resilience in the Çukurova Region**.

It is necessary to define who shares what information and when, in the network of public and private stakeholders. Such a structured information sharing network would provide a platform to exchange and discuss CI related information (such as hazard and vulnerability maps and risk mitigation and adaptation measures) and good practices in the resilience context. Such a cooperative environment would raise the overall awareness and be beneficial for developing strategies to mitigate risks and facilitate better decision making. Furthermore, ÇKA could use this platform to provide targeted warnings about possible threats to CIs and advise on actions. The private sector could share asset-specific vulnerability and risk information to complement information provided by the regional authorities.

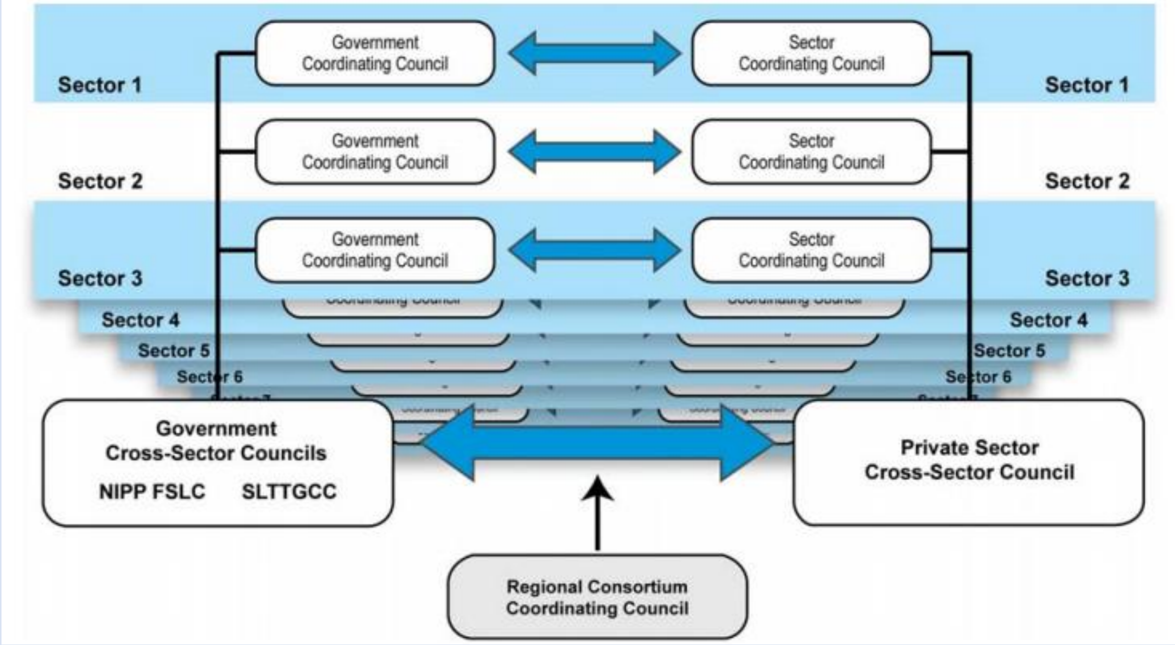


Figure 7-5: The U.S. National Infrastructure Protection Plan, Sector Partnership Model. (Source: NIACC, 2008[83])

Box 7-1: Trusted Information Sharing Network of Australia

The Australian Government established the Trusted Information Sharing Network (TISN) for CI resilience with the aim of building a partnership between business and government. It brings CI sectors together in a non-competitive environment to raise CI risk awareness, share information on risk assessment and mitigation techniques, and build resilience capacity within organisations. Via this network business is also able to bring issues to government that are seen as impediments to achieving CI resilience. The TISN provides an important mechanism to foster cooperation between public and private stakeholders on mutually important issues.

The TISN considers all hazards for its operations. It comprises seven CI Sector Groups and two Expert Advisory Groups. TISN members include owners and operators of CI, Australian, State and Territory government agency representatives, and peak national bodies. The TISN, through its Sector and Expert Advisory Groups, promotes CI resilience to owners and operators, including advertising the need for investment in resilient, reliable infrastructure with market regulators. ***Sector Groups*** *connect government and the individual owners and operators. Their purpose is to assist owners and operators to share information on issues relating to generic threats, vulnerabilities and to identify appropriate measures and strategies to mitigate risk.* ***Expert Advisory Groups (EAGs)*** *provide advice on broad aspects of CI requiring expert knowledge. EAGs consist of different experts from both within and outside the TISN.* ***Communities of Interest*** *(CoI) provide cross-sectoral consultation between owners and operators and government on specific matters[84].*

Collaborate with the academic sector

In addition to the collaborative activities between regional authorities and the private sector outlined above, academic institutions can provide substantial input by addressing scientific knowledge gaps identified by the stakeholders so that CI resilience activities are in line with the best available knowledge. They can undertake research and development to develop and evaluate models for assessing risks to CI and appraising risk management measures. More specifically this includes technical aspects of risk modelling, such as comprehensive hazard mapping, and accounting for complexity in sectoral inter-dependencies as well as development of policy recommendations. Establishing stronger collaboration with the scientific community can help to ensure that gaps can be addressed. **Regional knowledge is valuable in that regard which is why academic partners from within Çukurova Region should be involved in these processes by the ÇKA**.

7.1.1.5. Identify sector dependencies and interdependencies

CI dependencies and to a lesser extent interdependencies are increasing, and information infrastructure is increasingly interconnected with other infrastructures in different sectors. CI dependency and interdependency, as illustrated in Figure 7-6, are major challenges for risk management and make the entire system inherently vulnerable to CI disruptions due to cascading impacts. Increasing connections between sectors can increase the risks of cascading effect. The resilience of CI in Çukurova Region and across Turkey as a whole is highly dependent on the complexity and interconnectivity between different sectors.

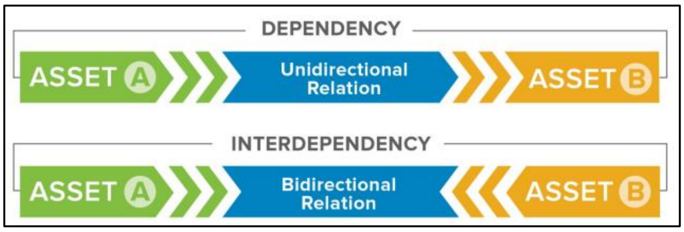


Figure 7-6: Dependency and interdependency between two assets. (Source: Petit et al, 2015[85])

Figure 7-7 provides examples of interconnections from the US CI system. It gives an overview of interdependencies within and between sectors and illustrates examples for provided services. As seen in the figure, energy subsectors, oil and natural gas, and electricity, provide services within the energy sector and also across other sectors. The same is true for transportation.

(Sub)sector Generating the Service	(Sub)sector Receiving the Service: ONG	Electricity	Transportation	Water	Communication
ONG		Fuel to operate power plant motors and generators	Fuel to operate transport vehicles	Fuel to operate pumps and treatment	Fuel to maintain temperatures for equipment; fuel for backup power
Electricity	Electricity for extraction and transport (pumps, generators)		Power for overhead transit lines	Electric power to operate pumps and treatment	Energy to run cell towers and other transmission equipment
Transportation	Delivery of supplies and workers	Delivery of supplies and workers		Delivery of supplies and workers	Delivery of supplies and workers
Water	Production water	Cooling and production water	Water for vehicular operation; cleaning		Water for equipment and cleaning
Communication	Breakage and leak detection and remote control of operations	Detection and maintenance of operations and electric transmission	Identification and location of disabled vehicles, rails and roads; the provision of user service information	Detection and control of water supply and quality	

Figure 7-7: Overview of generic interdependency among CI sectors in the US. (Source: DHS, 2015[86])

A disruption in an asset can trigger interruptions in the same sector or different sectors and the cascading impacts can be local, regional, national or transnational depending on the interconnections.

Understanding system-wide risks and cascading impacts within supply chains is crucial to increase the level of CI resilience. High level collaboration is needed to address the complexity of interconnections within and between sectors and cascading effects. Ideally, the previously proposed *"regional resilience committee"* which consists of a diverse group of stakeholders including government agencies, CI owners and operators, local and regional planning authorities, civil organizations and academic entities should provide a non-competitive environment to evaluate sectoral and cross-sectoral dependencies and interdependencies and identify potential cascading impacts from infrastructure disruptions regionally, nationally and transnationally.

After identifying dependencies and interdependencies, potential measures should be evaluated for mitigating cascading impacts. For instance, energy sources can be diversified and other sources can be considered as alternatives in transportation and other sectors. Especially, given the potential renewable energy capacity of the Çukurova Region, private sector investment in such sources can be encouraged by regional authorities in line with the national strategy. This would reduce the dependency on single energy sources, as well as on imports (as already highlighted in Section 3 referring to Turkey's Tenth Development Plan: 2014-2018, the Çukurova Regional Strategic Plan, and The Ministry of Energy and Natural Resources Strategic Plan: 2015-2019), increase energy security via diversification and create redundancy across all sectors. It can also meet the objective of those plans in terms of increasing the share of renewables in power generation.

Box 7-2: The Australian Critical Infrastructure Program for Modelling and Analysis (CIPMA)

CIPMA is an IT service developed by the Australian Government and technically managed by the Attorney-General's Department and Geoscience Australia which uses a vast array of data and information from a range of sources (including CI owners and operators) to model and simulate the behaviour and analyse dependencies of CI systems.

CIPMA uses an all hazards approach in its models to determine the potential impacts of different hazards and threats (human and natural) to CI assets. Owners and operators of CI can use this service to mitigate disaster impacts or respond to and recover from an adverse event. CIPMA furthermore supports policy development on national security and CI resilience.

CIPMA offers an important capability to support PPPs, and relies on mutual commitment from all involved stakeholders such as CI owners and operators, regional and national government agencies for its on-going development. As a key output, CIPMA can illustrate the relationships and dependencies between CI systems, and the cascade impacts from a failure in one sector on the operations of CI in other sectors[87].

7.1.1.1. Consider cross-border / transboundary interdependencies

The strategic importance of Çukurova Region, and its CI assets (transport & logistics, pipelines) in bridging between Europe and the Middle East, Caucasus and Asia drives the need for cross-border interdependencies to be taken into account in CI resilience planning. This is a key principle of the EU critical infrastructure resilience framework with which Turkey wishes to align[88]. The EU defines 'European critical infrastructure' or 'ECI' as that which is located in Member States and "*disruption or destruction of which would have a significant impact on at least two Member States*".

7.1.1.2. Develop a better understanding of hazard and risk management

Assessing multi-hazard risks to CI, analysing their vulnerabilities and understanding the cascading impacts of interruptions on economy and society is crucial for making CI assets resilient. It enables decision-makers to develop sound risk management strategies and to implement appropriate actions to increase CI resilience (**risk-informed decision making**).

Comprehensive risk assessment should provide entry points for CI resilience in development plans. Establishing a risk-based approach as the driver for CI investments can increase the resilience of assets against disasters. This must be incorporated in regional and national development plans. However, various public sector investments (including strategic ones) have been made in the past, despite assets' high risk profiles. Regional dynamics and planning can have limited impact on such central decisions.

According to *the Tenth National Development Plan*, some progress has been achieved in measures for risk mitigation activities in Turkey. However, there are still not many specifics about CI resilience in compliance with multi-hazard risk assessment in such strategic plans that could support investment decisions. For instance, in *the 2013-2017 strategic plan of AFAD*[89], critical assets are not mentioned and only loose connection is provided on *"increasing the awareness and preparedness level of organizations"* without referring to CI.

In Turkey, CI risk assessment forms part of project application and permitting processes of investments. **Seismic risk is elaborated in detail whereas adverse effects of climate change are not included in project feasibility studies or environmental impact assessments.** Internationally, however, it is recommended to build climate change into these assessment processes from the very beginning during the project development phase, and that climate change issues should be considered according to the specific context of a project[90]. Given the increasing impacts of climate related disasters in the Çukurova Region, this situation is putting the region's CIs at high risk.

Consideration of natural hazards and climate change is lacking in regional land use planning and management as identified in the stakeholder SWOT consultation undertaken during the 1st CIRA risk assessment workshop. It must be acknowledged that asset site selection and land use planning are highly important, along with design, construction and operation standards considering current and future risks[91] for mitigating the effects of geological and climate related hazards. **Consideration of these hazards should be incorporated into site selection/ land use decisions and other infrastructure development and operation stages by the central authority to minimize risks. Hazard maps describing geological and climate related characteristics should be produced regionally and updated periodically by the responsible government bodies.** Finding detailed hazard data at the regional level is relatively hard in Turkey as most of the efforts have started very recently. For instance, seismic maps are updated by the General Directorate of Mineral Research and Exploration. However, no high-resolution climate hazard maps have been produced despite the high risk of potential adverse impacts of climate change in the region **which prevents sector and asset specific impact assessment**. Flood hazard maps and drought management plans are still under preparation, as indicated in the CIRA planning paper. As it is stated in *the Tenth National Development Plan*, there is still need to prepare comprehensive disaster hazard maps. These hazard maps are fundamental for designing protective actions of CIs and policy developments. These maps should be incorporated into spatial planning tools including land use management, zoning, evaluation and updating of building codes, as well as insurance processes.

Physical (spatial) plans can offer an effective tool for better integration of risks posed by natural hazards at various levels of planning. Coarser-scale plans, e.g. Regional Plans and Metropolitan Master Plans are better suited to considering systems-based thinking, accounting for management of interdependencies and cascading impacts. Finer-scale plans such as Urban Master Plans, Urban Implementation Plans and Rural Development Plans can be used to map natural hazards and to zone areas at high risk which may be unsuitable for certain types of development, including CI.

The sub-regional Environmental Plan offers an entry point within which to incorporate natural hazard risk assessment and management, for example, addressing hydrological risks (drought, flood), how they may change in the future due to climate change, and the consequential impacts on energy generation or transport accessibility.

In Turkey, there is a discrepancy between central actions and regional/local needs due to a lack of coordination between authorities at different levels. This also applies to conflicts between planning and implementing bodies. There should be an enforcement of land use management and spatial planning considerations by the government that would eventually result in better alignment of planning and implementation. Government should require that these plans incorporate information on natural hazards and the implications of natural hazards for planning decisions.

7.1.1.3. Raise awareness

Awareness raising and educational activities on CI resilience should be organized for public and private stakeholders for capacity building purposes. **Academia could support** these activities from a scientific and technical perspective. Awareness raising should aim to enlighten stakeholders on **international research and best practices. It should encourage active participation in international knowledge exchange activities** on how to build resilience into CI planning, and engage CI owners and operators in the process. Furthermore, it should facilitate a better understanding on the current and future natural hazard parameters on which to base CI investment decisions. Also, **dedicated events can be organized to draw upon external knowledge for addressing region-specific CI resilience needs** (e.g. a workshop on Severe Weather and Critical Infrastructure Resilience was organized for the Washington DC area, hosted by the Center for Clean Air Policy, the District Department of the Environment and the District Office of Planning[92]).

Box 7-3: Resilient Cities Forum

Resilient Cities is a global forum on urban resilience and adaptation convened annually in Bonn, Germany. The congress series provides an international platform to share the latest information, good practices, challenges, and innovations for creating more resilient cities. Local governments are provided with a unique opportunity to share ideas and build partnerships through direct exchange with fellow cities and a community of international experts. The forum brings together diverse stakeholders to explore common topics of interest and to tackle challenges facing cities at all stages of resilience planning. Discussions between researchers and practitioners bridge the gap between science and policy to foster the development of integrated approaches with original, evidence-based solutions. In 2017, the Resilient Cities Congress gathered more than 440 participants – 25% of whom represented local governments – to discuss innovative solutions and best practices for urban resilience and climate change adaptation[93].

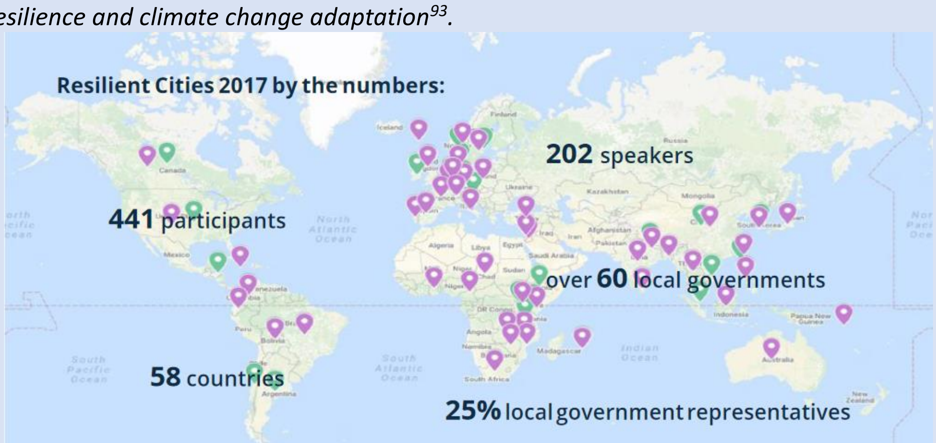


Figure 7-8: Resilient Cities 2017 congress by the numbers. (Source: ICLEI, 2017[94])

7.1.2. An agenda for identification and prioritization of further studies and activities at the regional level

Based on the assessment of existing frameworks and developments as well as corresponding gaps and needs, a set of measures have been identified and prioritized to be undertaken at the regional level for ÇKA to provide guidance on how to build CI resilience. They are set out below in the order in which they should be undertaken, thus providing a step by step approach:

1. ***Create a regional CI resilience coordination committee:*** An overall **coordination authority** which is tasked with promoting the resilience of regional CI assets should be established by ÇKA, working in partnership with stakeholders in the region. In some countries, dedicated agencies were founded for this purpose, while in others, existing institutional capabilities are utilized. **Key stakeholders from energy and transport sectors, local authorities, the private sector, NGOs and academia should be invited to join the committee; their roles and responsibilities should be clearly defined; and their strong commitment to achieve regional CI resilience needs to be ensured**. ÇKA's existing collaborative structure can provide great value to creating such a committee. The committee would be the first of its kind in Turkey and can lead other regions by example.

2. ***Increase awareness on the concept of CI resilience:*** According to a survey of participants at the 1st CIRA risk assessment workshop, most participants reported having "weak" or "no" technical capacity to understand geophysical and climate risks and prioritise needed actions. It is important to initiate the process of building capacity to address these risks in the Çukurova Region. In order to build conceptual and technical capacity for CI resilience, **awareness raising activities** should be performed periodically under the guidance of the proposed resilience committee targeting different stakeholders. One of the activities can be to **promote learning from good practices** on how to build resilience into CI planning, and how to engage CI owners, investors and operators in the process. The CI resilience committee can organize **training workshops** for decision-makers in the region on the concept of CI and conducting and interpreting vulnerability and risk assessments for current hazards and under conditions of climate change. They can guide decision-makers on where to access risk assessment and scenario planning tools and data, to help stakeholders make risk-informed decisions. In addition to recurring training programs, ÇKA could also trigger formation of new networks, for instance focusing on the relationship between climate change, infrastructure, the local economy and competitiveness and/or related topics. ÇKA should work with other regional decision-makers to examine demographic trends and future demand for infrastructure in the Çukurova Region, and assess the future competition for shared resources such as water in light of climate change projections. It would also be beneficial to extend the scope of regional capacity building programs to include **organization and participation at special events like workshops and conferences** (for example the Resilient Cities Forum, see Box 7-3). Another potentially beneficial awareness raising activity could be **launching of national/ international competitions** like the Rebuild by Design competition (which is helping cities and communities around the globe to become more resilient through collaborative research and design) to incentivise the generation of creative solutions.

3. ***Form a close collaboration and an information sharing mechanism:*** In addition to the *"proposed core regional CI resilience coordination committee"*, a **close collaborative partnership with all relevant stakeholders and an information sharing mechanism** should be established. Again, the structure of ÇKA can facilitate the implementation of this objective and the new committee could serve as a platform for CI resilience activities in the region. Both government authorities and private sector can gain benefit from this collaborative environment.

4. ***<u>Define CI resilience and strategies:</u>*** During the re-evaluation process of previously identified assets at the national level (as described in Section 7.1.1.3), the committee should support national authorities and **identify the critical regional assets in the energy and transportation sectors**. To start building resilience of the most critical assets, the **criticality level of selected CIs** should be categorized based on an *a priori* defined scale. If no national level identification of CI has been carried out, the *"regional CI resilience coordination committee"* may proactively propose a method of selection and recommendation for which assets in the region are critical. Resilience should be considered as a cross-sectoral approach and **interdependencies** should be defined based on that. The committee can work with all relevant stakeholders to identify key dependencies and interdependencies of CIs in the region and map how CI assets, system, or network failures could impact other socio-economic systems; mapping potential cascading effects from infrastructure disruptions regionally, nationally and transnationally. Subsequently **CI resilience strategies** need to be defined to reduce the disruption of essential services resulting from multiple natural hazards relevant in the regional context. This should be in line with the state's legislative and governance framework and ÇKA's regional development plan on CI resilience or should address gaps therein. Since there are currently substantial aspects missing in the central framework **the committee could provide more clear and robust input from the regional perspective for the update process**.

5. ***<u>Integrate CI resilience principles into multi-hazard risk management:</u>*** The *"regional CI resilience coordination committee"* should **promote integration of CI resilience principles into a comprehensive multi-hazard risk management strategy**. Regional risk assessment as implemented in the CIRA project helps to determine relevant CIs at risk and the impact on essential services (via applying the RiskAPP Software) as well as cascading impacts due to sector inter-dependencies. A similar scenario-based approach could be applied for asset planning as well. The model output can provide the basis to **define necessary measures to increase the resilience of existing assets at risk and plan new assets in a more resilient way**. The committee can evaluate this output in order to propose risk mitigation options in joint discussion with the respective stakeholders. To provide more accurate estimations of risk, **regional data and projections on natural hazards are required.** These can then serve to produce more precise hazard and risk maps and provide a basis for making better informed decisions.

6. ***<u>Implement Business Continuity Planning (BCP) across CI assets</u>***: Business Continuity Planning (BCP) is an important approach to dealing with emergency situations, and Business Continuity Plans should be developed for CI. Business Continuity Plans should be risk-based and developed for use for all kinds emergency situations that may affect a CI or interconnected CIs. A Business Continuity Plan should be thoroughly documented and should guide organisations on procedures and actions during an emergency. The plan should contain organisational aspects, i.e. how to be organised and how to communicate during and after an emergency situation. The plan should contain both structural and non-structural measures to ensure that continuity is achieved as quickly and practicably as possible after an emergency. Prevention and preparedness can be part of the plan, as well as response and recovery measures.

   Development of a BCP typically involves the following steps:

   - Performing a context analysis of the CI, its site characteristics, and organizational and legal aspects related to its design, operation and maintenance,
   - Undertaking a vulnerability assessment,
   - Undertaking a risk analysis to identify the impact of failure of CI, and evaluating the key risks to be mitigated,

- Identifying a set of risk response and recovery options, together with options for risk prevention and preparedness,
- Appraising the options to identify the most important ones to include in the BCP,
- Writing the BCP, including a description of how it will be implemented, along with its monitoring and review process.

7. ***Facilitate risk-informed decision making:*** Strategies, capabilities and governance structures in the CI resilience domain should be integrated to facilitate risk-informed decision making in the CI planning context. Risk information should be evaluated and used in investment decisions with regard to managing disaster risk, adapting to climate change impacts, and promoting overall development. The risk assessment phase of the CIRA Project revealed important results for the region's CI risk profile in particular related to adverse impacts of climate change. Furthermore, there is **limited knowledge on incorporating climate resilience into risk management related actions such as asset site selection, design, construction, operation and maintenance processes. The CI resilience committee in close collaboration with the ÇKA as an important actor of regional development can support risk mitigation studies, adaptation measures and capacity building activities addressing these issues in light of climate change to provide a sound basis for decision making. This can provide an opportunity for the Çukurova Region to increase climate resilience of its existing and planned assets.**

8. ***Support research and development activities:*** **Research and development activities should be supported to address gaps in risk models for CI resilience identified by the CI resilience committee**. Furthermore, a better understanding and communication of the underlying scientific principles and uncertainties related to hazard assessments and specifically climate change projections should be **promoted to inform planning of CI investments**. **Close collaboration is needed with the academic sector and other experts to transfer knowledge into action in the context of CI resilience.** In particular, region-specific knowledge can be beneficial in that regard. Academic partners within the region should therefore be involved according to their capacity. There was strong representation from academics from regional universities at the 1st CIRA risk assessment workshop. Additionally, national and international collaborations should be considered. With its financing role, ÇKA can support such collaborations, especially on climate change related studies, since there are gaps in the legal policy framework and implementation on managing climate risks. Feasible proposals can even be granted in the ÇKA's guided project support program since these identified areas are aligned with the regional development plan and strategies. **Results can be disseminated by the ÇKA and the CI resilience committee to increase the outreach to all relevant stakeholders and specifically addressing government authorities.** ÇKA can emphasise the need for an all-hazards risk management approach for CI up to the Ministry of the Interior (legal risks) and the Ministry of Development (planning, implementation, and operational risks). Similarly, the risk management approaches which are developed can provide guidance for other regions as a knowledge support model for resilient CI investments.

9. ***Provide evidence on the importance of climate resilience for critical assets:*** Using the models developed and their output, **the CI resilience committee, in cooperation with ÇKA can provide evidence** to stakeholders, regional and national authorities on potential climate induced adverse impacts for CIs as well as corresponding cost benefit analysis of adaptation options. Eventually, ÇKA can thus promote the adequate integration of climate resilience into planning decisions (such as pre-investment application process or establishment of PPPs).

10. ***Formulize international cooperation:*** International cooperation should be formulized and extended in order to strengthen cross-national resilience by the resilience committee. There are a number of **international knowledge sharing partnership models** (e.g. cities-to-cities, USAID's CityLinks Climate Partnership Program, World Bank's Global Platform for Sustainable Cities) which have been created to facilitate partners in learning from each other's experiences. Such platforms can facilitate capacity strengthening of regional and local governments and other stakeholders and provide exposure to funding opportunities and networking with actors from other regions who face similar challenges. Efforts to build CI resilience are thereby accelerated.

7.1.3. Catalogue of best practices for critical infrastructure resilience

The experience and practices of countries that have already adopted implementation mechanisms measures to increase CI resilience can help to provide guidance for the development of strategies and plans within the Çukurova Region.

Table 7-1 provides an overview of the selected international best practice cases. The table illustrates which hazards are addressed in each case and whether asset-specific or sector-specific examples are given. Furthermore, the CI resilience strategy implemented in the best practice cases is outlined, as relevant to the CIRA project context. Finally, the coordination approach on resilience is highlighted, along with the scale level at which the best practice is implemented.

The catalogue is not meant to be exhaustive; rather it aims to demonstrate different aspects of measures to improve CI resilience which have been put in place in different contexts. Best practice cases from the US, the UK, and Australia were selected, due to these countries' well-established experiences on CI resilience at national and regional levels. The Mexico City case is highlighted as Mexico has similar economic dynamics and infrastructure investment approaches to Turkey. Two European cases were selected due to Turkey's aspirations on alignment to EU standards. While these examples refer to improved planning for climate resilience, three further cases (Tajikistan, Mexico, Uruguay) are illustrated that focus on risk financing mechanisms. Due to the identified low coverage of climate change related risks in Turkey and consequently in the Çukurova Region, this catalogue puts specific emphasis on climate change issues, in order to raise awareness on the topic.

Full details of each of the case studies are provided in Annex A5.2.

Table 7-1: Catalogue of selected international best practice cases on CI resilience. (Source: Report authors).

Best Practice	Hazard Approach	CI Asset Specific	CI Sector Specific	CI Resilience Strategy related to the CIRA Project	Resilience Coordination	Scale
Mexico City, 100 Resilient Cities Initiative (Mexico)	Climate change as a priority	-	All	- Foster resilience integration in regional programs - Drive and support bottom-up contribution to a national resilience agenda - Drive and support regional projects	Resilience Steering Committee headed by Chief Resilient Officer	Regional
Resilience of New York State's Infrastructure (USA)	Extreme weather events	-	Transportation, energy, land use, insurance, infrastructure finance (thematic areas)	- Specific resilience recommendations for defined sectors - Crosscutting recommendations - Sector specific recommendations	New Chief Risk Officer or unit to coordinate all the stakeholders and activities	Regional
CI Protection in Austria	All-hazard (emphasis on changing climatic conditions)	-	All	- Anchored in broader national security strategy framework, setting the legal ground - Empowerment of provinces (regional level) to develop own adaptations to the overarching national plan - Promotion of trust-based PPP cooperation - National technical information sharing platform, linked to EU portal - Regular training and knowledge exchange	Federal Chancellery in coordination with provincial authorities	National with regional adoptions
Goods Movement Plan in NY and NJ (USA)	Extreme weather events	Port, Airport	Transportation	- System-wide assessment of supply chain needs and current deficiencies for improving reliability and redundancy	-	Regional
UK's Climate Resilient Infrastructure (UK)	Climate change	-	Transport, energy, water and ICT	- Embedding climate risk and resilience in the policy framework - Promoting better risk understanding - Role distribution among stakeholders - Monitoring and evaluating the progress in adapting to climate change	Respective departments	National
Heathrow Airport's Climate Change Adaptation (UK)	Climate change	Airport	-	- Comprehensive risk assessment - Climate change adaptation	Heathrow Airport Limited (tasked by the UK Government)	Asset level
Lake Macquarie Council Adaptation-Action (Australia)	Sea-level rise (and other climate change related risks)	Not specified	Not specified	- Risk assessment - Sea-level rise preparedness and adaptation policies	City Council	Regional
Victorian CI Resilience (Australia)	All-hazard	-	All	- Moving to all-hazard approach - More flexible partnership - Clear roles and responsibilities - Adopting a risk-based approach - Guide and monitor performance of government and industry stakeholders	Respective departments	Regional/ linked to national
Planning for Sea-level Rise in California (USA)	Sea-level rise	-	Transportation	- Consideration of the risks of sea-level rise when planning and developing transportation projects	Transportation Department	Regional
Interdepartmental Collaboration in North-Rhine Westphalia (Germany)	Climate change	-	-	- Enhance competence in climate change adaptation and facilitate interdepartmental exchange within and across municipalities	Local Network of Municipalities	Municipality level

7.2. Risk assessment and management options and strategies

7.2.1. Introduction

This Section presents climate and geological risk management options and outline risk management strategies for CI in the Çukurova Region. It is informed by outcomes from the previous steps of the CIRA and discussions with stakeholders at the CIRA risk assessment workshops.

The main aims of this Section are to:

- identify a list of prototypical assets and components and the most relevant natural hazards from the risk assessment;
- identify and categorize structural and non-structural risk management options for the prototypical assets;
- provide an overview of various risk management strategies / approaches and options appraisals processes.

In order to achieve the aims, an overarching framework is proposed to help identify and categorize the risk management options, which is considered relevant and applicable to managing both geological and climate risks.

7.2.2. Framework for identifying and categorizing risk assessment and management options

A number of frameworks have been developed for categorizing risk management measures to address natural hazards. The frameworks provide methodological approaches for defining and categorizing both structural and non-structural risk management options which contribute to overall resilience:

- **Structural options** include engineered solutions such as redesigning buildings and designing physical barriers to reduce damage from disaster events,
- **Non-structural options** include social solutions such as early warning systems, contingency planning, emergency response preparedness and risk transfer through insurance.

Annex A6.1 presents an overview of frameworks from the UK's Cabinet Office, CIRIA (Construction Industry Research and Information Association) as well as a framework applied in a recent port climate risk management study.

For the purposes of this report, a combination of World Bank[95] and UN[96] frameworks is proposed which covers a broad spectrum of activities which contribute to resilience (see Figure 7-9).

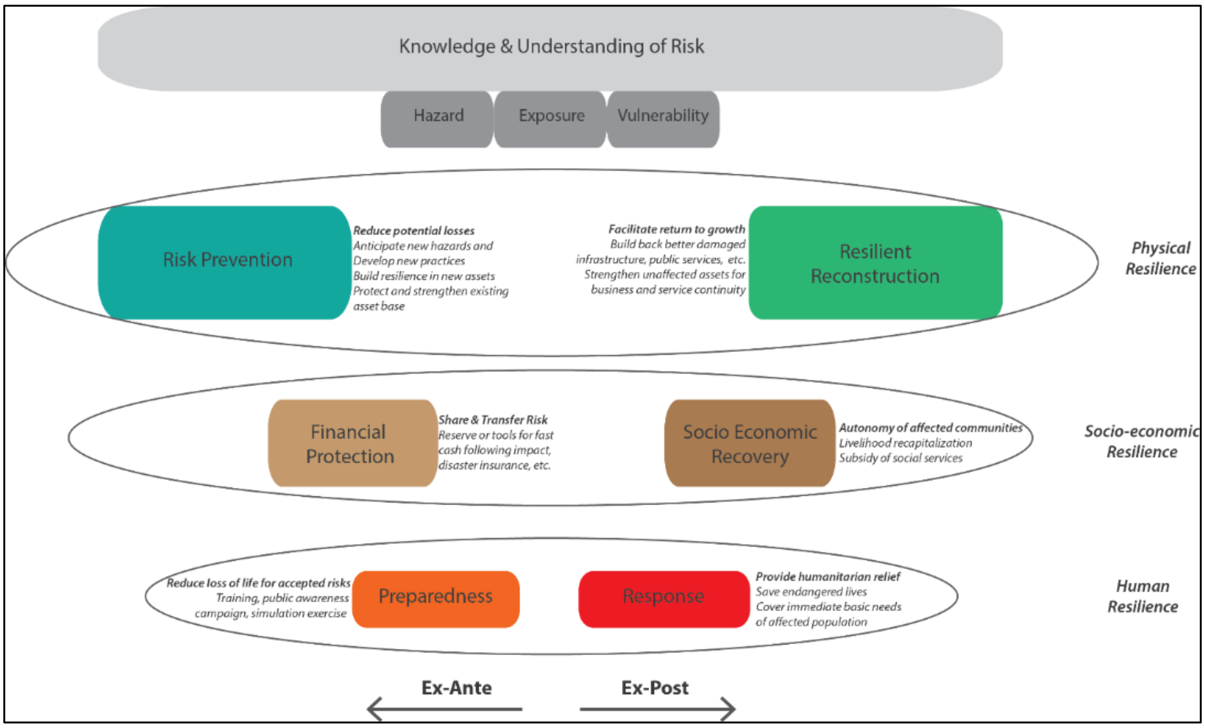


Figure 7-9: Framework for categorizing risk management measures applied in this report: (Source: Adapted from various sources).

The framework broadly defines categories of measures which can be undertaken ex-ante (prior to events) and ex-post (post-event) and provides sub-categories of resilience measures. These are briefly summarized in Table 7-2.

7.2.3. Decision-making in the face of future uncertainty

7.2.3.1. Introduction

Managing climate related risks is not unlike managing any other risk since both can be distilled down to the likelihood of a hazardous event occurring and the magnitude of losses as a consequence. However, climate risk assessment and management brings with it new dimensions and approaches due to the uncertainty behind climate projections and the range of climate futures that we are presented with. But, uncertainty is not an excuse for inaction, since economic activity continues to be successful within conventional, albeit nearer term, uncertainties such as geo-political instability, exchange rate fluctuations and changes in market demand. A primary difference here is that the success of hedging on resilience actions today may not be realized until decades into the future with respect to a changing climate.

Despite uncertainties associated with a future climate, the region's growth and competitiveness requires its CI to be resilient today and into the future, and this must incorporate a changing climate risk landscape to help deliver success in the longer term. When faced with potential hazards, the level of resilience achieved at the asset or regional level remains a function of an ability to continue to perform economically together with the adaptive capacity built into the system that allows and supports preparation, protection and fast recovery in relation to hazardous events.

The following sections discuss in further the principles of climate uncertainty, what a changing climate means for design and operation of CI and how robust decisions can still be made today despite climate uncertainty.

Table 7-2: Matrix of risk assessment and management measures. (Source: Report authors).

					Structural	Non-structural		
Type of measure	Description	UNISDR definition[97]	Ex-ante	Ex-post	Physical resilience	Physical resilience	Socio-economic resilience	Human resilience
Risk assessment	Qualitative or quantitative approach to determine the nature and extent of risk.	A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.	X					
Risk prevention	Reducing losses through anticipating events and through resilient design, operation and maintenance	The outright avoidance of adverse impacts of hazards and related disasters	X		X	X		
Risk reduction	Reducing damage caused by natural hazards… through an ethic of prevention.	The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events	X		X	X	X	X
Financial protection	Sharing and transferring risk and improving access to finance following an event	The process of formally or informally shifting the financial consequences of particular risks from one party to another thereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing	X	X			X	

					Structural	Non-structural		
Type of measure	Description	UNISDR definition[97]	Ex-ante	Ex-post	Physical resilience	Physical resilience	Socio-economic resilience	Human resilience
		or compensatory social or financial benefits provided to that other party						
Preparedness	Raising awareness, hazardous event response exercises etc.	The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions	X					X
Resilient reconstruction	Re-instating damaged infrastructure better designed to cope with hazardous events	[Re-instating a damaged] system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the reservation and restoration of its essential basic structures and functions		X	X			
Socio economic recovery	Re-instating the socio-economic environment, with greater resilience where practicable	The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors.		X			X	
Response	Reacting to, and recovering from, hazardous events	The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected		X				X

7.2.3.2. The cascade of uncertainty

There are uncertainties about how climate conditions will change in the future, due to uncertainties about:

- future changes in society (population growth and development),
- future greenhouse gas emissions that drive man-made climate change,
- how to model the earth's climate system at global and regional scales,
- impacts of climate change, and
- adaptation responses.

This so-called 'cascade of uncertainties' is presented in Figure 7-10. Although climate models are continuously improving, they are not yet good enough to predict future climate conditions with the level confidence that allows very precise adaptation decisions to be made today. Outputs from different climate models often differ for the same location. Taking rainfall as an example, models often disagree on the direction of change (i.e. whether rainfall will increase or decrease in the future at a given location), as well as the magnitude of change. This presents adaptation planners and infrastructure developers with a range of possible climate futures to consider, and because of this, can lead to a wide range of possible adaptation options to consider. Even with continued improvements in climate modelling, uncertainties in projections will remain for the foreseeable future.

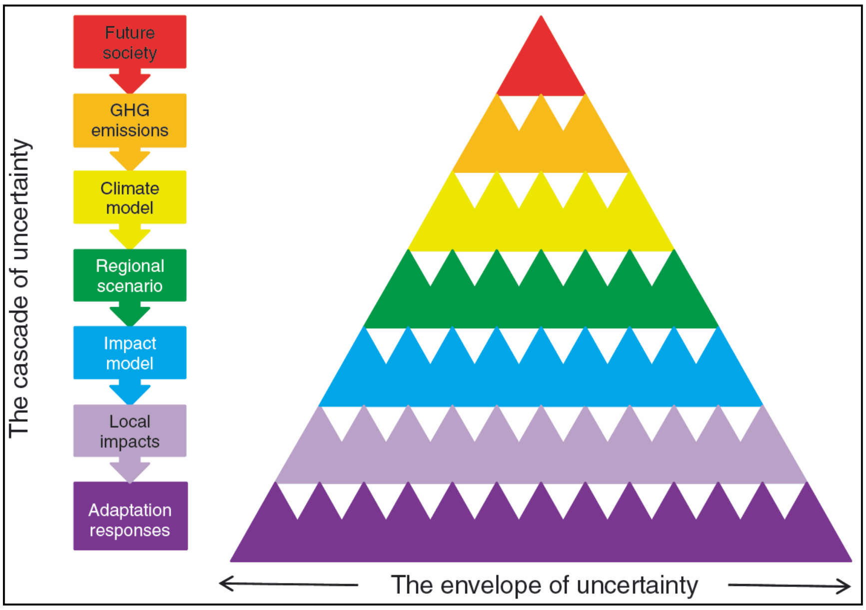


Figure 7-10: The cascade of uncertainty. (Source: Wilby and Dessai, 2010[98]).

As a result, decision-makers may feel that information about future climate change is too uncertain to be incorporated into infrastructure investments, and may consider ignoring it all together. However, this approach is flawed, with the overwhelming weight of scientific evidence finding that man-made climate change is already underway, and that future changes are inevitable. Instead, decision-makers need to identify ways of managing these uncertainties and making robust decisions despite them. This topic is discussed further in Section 7.2.3.4.

7.2.3.3. Consequences of climate change for design and operational thresholds for infrastructure

Design and operational thresholds and safety margins are commonly based on historic climate records. In a changing climate, these thresholds may be exceeded more frequently and threshold failures that were once considered exceptional but acceptable, may become more common and increasingly unacceptable. Unless adaptation measures are taken, assets may have to function within tighter margins between "normal" operation and their critical thresholds at which failure begins to occur. Over time, this can manifest itself in decreased efficiency of equipment and less margin before more significant management measures such as reduced operation, throughput etc. need to be implemented. Figure 7-11 illustrates the consequences of a non-stationary climate for critical design and operational thresholds.

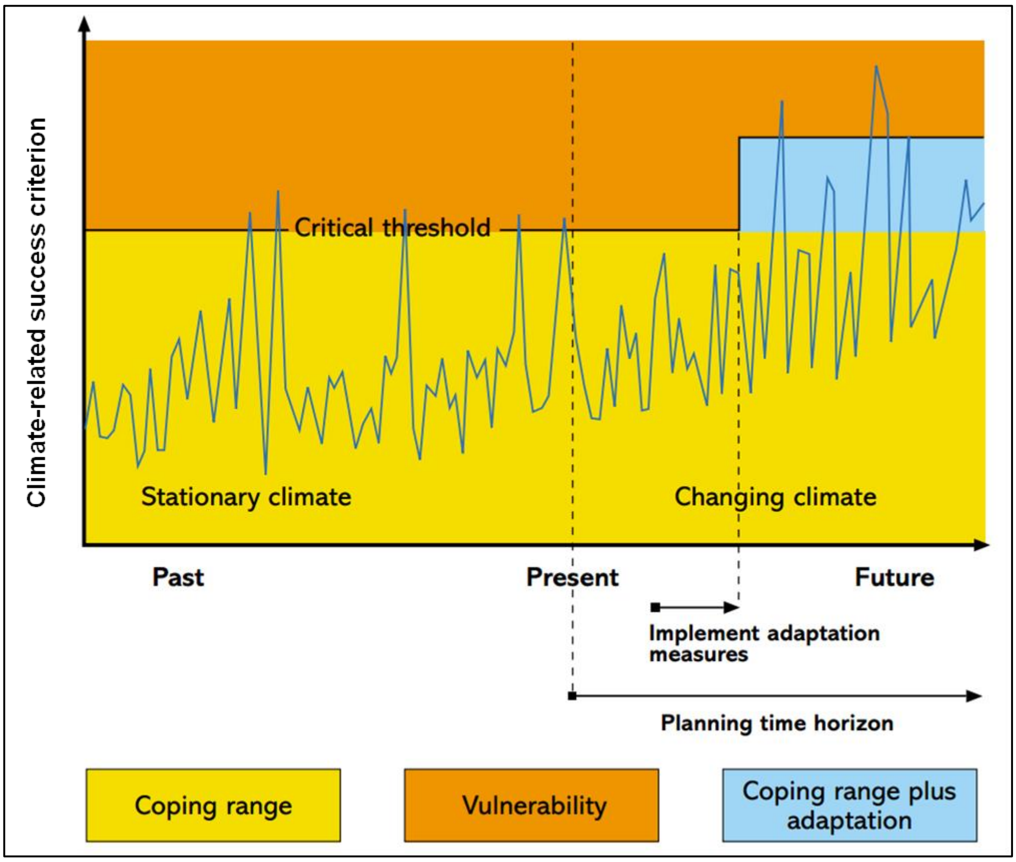


Figure 7-11: The relationship between coping range, critical threshold, vulnerability, and a climate-related success criterion for an asset. (Source: Willows and Connell, 2003[99]).

Climate change will also affect the environmental and social systems around infrastructure assets and their interactions with these systems. For instance, reductions in rainfall may affect the availability and quality of water resources on which assets such as power generation depend. At the same time, local communities' reliance on the same resources may increase in response to a changing climate, for example, leading to additional water demand for irrigation due to rising temperatures and lower rainfall. Where the environment is already under stress, for example during prolonged heatwaves, this may reduce the 'headroom' of environmental systems, with consequences for the operation of infrastructure facilities. For instance, lower river flows and higher river temperatures driven by climate change can lead to environmental authorities requiring power generation facilities to abstract less water or preventing cooling water discharges. Such measures can result in reduced operations by industrial facilities, to ensure they comply with environmental permits.

7.2.3.4. Robust and flexible adaptation

In light of the irreducible uncertainty about future climate change, the focus of decision-makers should be on identifying and implementing risk management measures which perform well under both current and possible future climatic conditions**.** This will have the effect of improving the 'adaptive capacity' of infrastructure projects, which is a key cornerstone of climate resilience.

This method focuses initially on identifying risk management (adaptation) options which reduce vulnerability to past and present climate variability as well as other non-climatic hazards and pressures. Infrastructure designers or operators should identify climate-related thresholds for assets and their critical components and evaluate whether existing climate trends are threatening to exceed them on an unacceptably frequent basis**.**

Having assessed current vulnerability to observed hazards and trends, robust adaptation measures can then be identified that would reduce current vulnerability, whilst being acceptable in other terms (e.g. technically, financially, economically, socially, environmentally). If the lifetime of the infrastructure spans several decades, then future projections from climate models can be used to establish upper and lower bounds for sensitivity testing of the adaptation options. This places the focus on identify adaptation options which perform well (though not necessarily optimally) over a wide range of conditions experienced now and potentially in the future. Examples of types of options that perform well under uncertainty are provided in Section 7.2.4.6).

A further important principle for decision-making in the face of uncertainty is 'adaptive management'. This involved flexible management of assets, by applying strategies which can evolve and adjust to accommodate changing circumstances over time, as well as allowing new scientific evidence about climate change and adaptation technologies to be incorporated.

7.2.4. Risk management options and strategies for critical infrastructure

7.2.4.1. Defining prototypical assets and components

As described earlier, the following CI assets in Çukurova region were shortlisted for the risk assessment:

- **Energy sector:**
  - Sanibey Yedigoze Hydropower Plant (HPP),
  - İsken Sugözü Thermal Power Plant (TPP),
  - Yumurtalik-Kırıkkale Oil Pipeline,

- **Transport / logistics sector:**
  - Mersin International Port,
  - Seyhan Viaduct across the Seyhan River on the E-90 European Highway.

In order to develop risk management options for CI assets in general, which can be applied in the event that an asset could be exposed to a particular type of hazard (see Section 7.2.4.2), a set of representative prototypical assets first needs to be defined. These prototypical assets and their key components are described Annex A6.2 (energy assets) and Annex A6.3 (transport & logistics assets). It should be noted that although they contain in-built assumptions of geographic locations (for example, a sea port will have a coastal location, a thermal power plant needs to be located near to cooling water sources), the prototypical assets do not represent any exact geographic location within the Çukurova Region.

7.2.4.2. Risks from geological and climate hazards

The risk assessment (Section 5) developed a set of hazard scenarios to be used in the simulation of effects on Cis. A summary of the current and future levels of hazards in Çukurova was presented in Section 5.1, Table 5-1 (and in more detail in Annex A3.2). As discussed earlier, for the purposes of developing risk management options for prototypical assets where the exact location and therefore exposure levels to hazards are two unknown parameters, it will be assumed that all prototypical assets are broadly susceptible to the hazards listed in Table 5-1.

7.2.4.3. Non-structural risk assessment and management options

Generic / cross-sectoral

As defined in the risk management framework (see Section 7.2.2 and Table 7-2) non-structural risk management options can contribute significantly to ex-ante resilience, allowing for resilience to be embedded prior to hazardous events occurring. These types of options can be sufficiently generic so as to be valid across different sectors and types of CI assets. Non-structural options can also contribute to wider socio-economic resilience and can thus be considered to provide benefit "beyond the fence line" of any particular CI asset.

Table 7-3 presents generic / cross-sectoral non-structural risk management options. Sector-specific non-structural options are presented in Section 7.2.4.4.

Table 7-3: Generic / cross-sectoral non-structural risk assessment and management options. The icons for hazard types are as follows:  represents geological hazards and  represents climatological hazards. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[100]
Risk prevention			
Planning policies and development control	• Facilitate dialogue on effective coordination of resilience among national and regional authorities, and encourage stakeholders to take ownership of Regional Development Plans. • Examine regional demographic trends to predict future demand for infrastructure and competition for shared resources (e.g. water). • Embed climate resilience and critical infrastructure themes into regional development plans and strategies. • Make use of the physical (spatial) planning hierarchy as an effective tool for better integration of risks posed by natural hazards at various levels of planning. • Use sub-regional Environmental Plans as entry points within which to incorporate information on natural hazards and their future changes		Expert team, CIRIA (2010)
Risk assessment and mapping	• Implement data collection, research and projects on regional climate change and impacts on critical infrastructure. • Establish open-data portals on natural disasters observed in the region, including best available scientific findings on future regional climate change. • Support studies on quantifying direct and indirect economic costs and wider benefits (social and environmental) of building resilience in infrastructure.		Expert team, CIRIA (2010)

Type of option	Key actions	Relevant to hazard type	Source[100]
	• Organize workshops on conducting vulnerability and risk assessments for regional stakeholders. Develop a complete picture of how interruptions and failures could affect their business, services, or lives. • Identify key dependencies / interdependencies of critical infrastructure in the region and map how critical infrastructure assets, system, or networks could impact other components of socio-economic systems; map potential cascading effects from infrastructure disruptions regionally, nationally and transnationally. • Use finer-scale plans such as Urban Master Plans, Urban Implementation Plans and Rural Development Plans to map natural hazards and to zone areas at high risk. • Incorporate consideration of a non-stationary climatic baseline and future changes in environmental impact assessments (EIAs).		
Risk management systems	• Include key actors at different levels of government, private sector and civil society when developing risks management systems. • Link Disaster Risk Management (DRM) with natural hazard risk management incorporating climate change. • Integrate natural hazard risk management within existing processes and standards which cover: ○ supply chain security, ○ business continuity, ○ quality management, ○ environmental management, ○ health & safety, ○ auditing and due diligence.		Expert team, SeDIF (2013)
Stress testing	• Adhere to earthquake design and construction codes and standards. • Use climate model outputs and local disaster profiles to stress test infrastructure design and adaptation options, including different configurations of infrastructure and operation rules/management practices.		Expert team, SeDIF (2013)
Financial protection			
Insurance	• Review insurance policies for Force Majeure/Act of God definitions, exclusions and adequacy of cover. Assess cover for asset		Expert team, CIRIA (2010)

Type of option	Key actions	Relevant to hazard type	Source[100]
	damage, business interruption, public liability, and business interruption and ingress/egress. Analyze past claims triggered by natural hazards and costs to the facility in excesses, lack of cover or outright exclusions. • Monitor insurance industry research on including climate change risks in policies. Determine how these could affect future cover, premiums and exclusions.		
Weather derivatives / index based insurance	• Investigate coverage based upon climate parameters correlated with certain losses. This approach protects from situations where there is a well-defined climate risk that could cause operational reduction / losses.		Expert team, IFoA (undated)
PPP contracts	• Incorporate a changing risk landscape in PPP / BOT legislation and contracts. Force Majeure risk and associated financial loss allocation should be revaluated in the context of a changing climatic baseline and return periods for extreme events. • Ensure investment partners, project designers and operators understand potential changes in the frequency and magnitude of extreme weather-related events.		Expert team, World Bank (2016)
Preparedness			
Contingency / business continuity management	• Develop plans in cooperation with local stakeholders to identify risks associated with: ○ major disasters immediately preventing normal operation, ○ gradually worsening situations (e.g. prolonged high temperatures) that make normal operation difficult, ○ multi-hazard smaller events occurring simultaneously or in sequence. • Plans should include risks to physical assets, equipment failures, transport disruption, supplier impacts, staff availability. • Plans should outline: ○ actions to be taken immediately after an event, ○ actions to allow the service to continue, actions to allow full recovery of operations.		Expert team, CIRIA (2010), SeDIF (2013)
Emergency response / management plan	• Develop plans to reduce vulnerabilities to extreme events, include elements such as purchasing adequate insurance coverage to		Expert team, CIRIA (2010)

Type of option	Key actions	Relevant to hazard type	Source[100]
	cover assets or financial losses, where to evacuate staff in the event of a disaster (preparedness), and seeking financial assistance post-disaster (recovery).		
Desktop incident management exercises	• Apply a multi-agency co-operation approach. Emergency exercises involving multiple agencies and simulated incidents can help individuals and organizations collectively prepare for situations using a real-time approach.		CIRIA (2010)
Forecast / early warning / rapid response systems	• Work closely with meteorological, hydrological and disaster agencies to monitor immediate/short term/seasonal/long-term threats. This allows operational decisions to be made based on forecasts or immediate threats. This is particularly valuable in forecasting extreme events, supporting decision-making such as evacuating facilities and operational shut down. • Implement rapid response systems which allow for automatic control and shut-down of critical infrastructure systems.		Expert team, SeDIF (2013), CIRIA (2010)

Sector specific non-structural options are provided in Annex A6.4.

7.2.4.4. Structural risk management options

This section presents structural risk management options for CI, according to asset type.

Energy assets

Prototypical asset: Hydropower plant (HPP)

Table 7-4 presents structural options for HPPs.

Table 7-4: HPP structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[101]
Risk prevention			
Turbine and generator efficiency	• Replace outdated turbines and generators with more efficient equipment to generate more electricity per unit of water and generate more efficiently across a range of flow conditions.		ADB (2016)
Reduce water losses	• Replace equipment to reduce water losses (e.g. shut-off valves)		World Bank (2009)
Flow rates	• Redesign trash racks to prevent trash / debris build up and prevention of flows.		Expert team, World Bank (2009)

Type of option	Key actions	Relevant to hazard type	Source[101]
Dam integrity	• Asses and improve apron below dams to reduce erosion.		Expert team, World Bank (2009)
Reservoir capacity	• Upgrade sediment bypassing channels / tunnels, sediment flushing and removal methods.		Expert team, World Bank (2009)
Transmission efficiency	• Examine costs and benefits of upgrade of transmission lines to account for lower efficiency in hotter weather, e.g. insulating lines.		World Bank (2009)
Substation efficiency	• Retrofit cooling systems for substations including improved shading.		Expert team
Earthquake protection	• Construct with control effects for ground shaking on buildings, structures, turbines and generators, transmission towers etc. using accelerometric networks, active and passive control systems.		SeDIF (2013)
Resilient reconstruction			
Turbine and generator efficiency	• Source turbines and generators of high efficiency to generate more electricity per unit of water and generate more efficiently across a range of flow conditions and in periods of elevated temperature.		Expert team
Flow rates	• Design new trash racks to prevent trash / debris build up and prevention of flows.		Expert team, World Bank (2009)
Dam integrity	• Construct dam apron to reduce erosion • Design to latest earthquake standards.		Expert team, World Bank (2009)
Reservoir capacity	• Install sediment bypassing and routing channels and sediment removal equipment.		Expert team, World Bank (2009)
Transmission efficiency	• Examine costs and benefits of new transmission lines to account for lower efficiency in hotter weather, e.g. insulated lines.		World Bank (2009)
Substation efficiency	• Construct substations with cooling systems including shading. Consider location.		Expert team
Earthquake protection	• Construct with control effects for ground shaking on buildings, structures, turbines and generators, transmission towers etc. using accelerometric networks, active and passive control systems.		SeDIF (2013)
Thermal comfort of workers	• Apply energy-efficient solutions to reduce thermal discomfort and potential heat stress to workers (e.g. natural ventilation, mechanical air cooling and conventional cooling systems).		Expert team

Prototypical asset: Thermal power plant (TPP)

Table 7-5 presents structural options for TPPs.

Table 7-5: TPP structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[102]
Risk prevention			
Turbine and generator efficiency	• Replace outdated turbines and generators with more efficient equipment to generate more electricity per unit of fossil fuel. • Consider installation of turbine inlet cooling for periods of elevated air temperature.		Expert team, ADB (2016)
Cooling water	• Consider using energy-efficient cooling technology (e.g. closed loop systems) for water intake when abstraction sources are at elevated temperatures. • Use enlarged condensers to accommodate periods of elevated air temperature.		Expert team
Flood protection	• Retrofit flood protection measure (e.g. bunding) • Move critical services above ground level.		Expert team
Materials storage	• Construct fire, heat and flood resistant storage facilities for coal stockpiles. • Provide anchorage points and strengthening against earthquakes.	 	Expert team
Substation efficiency	• Retrofit cooling systems for substations including improved shading. Consider location.		Expert team
Transmission efficiency	• Examine costs and benefits of upgrade of transmission lines to account for lower efficiency in hotter weather, e.g. insulating lines.		World Bank (2009)
Earthquake protection	• Control effects of ground shaking on buildings, structures, turbines and generators, transmission towers etc. using accelerometric networks, active and passive control systems.		SeDIF (2013)
Resilient reconstruction			
Turbine and generator efficiency	• Source turbines and generators with more efficient equipment to generate more electricity per unit of fossil fuel.		Expert team
Cooling water	• Incorporate energy-efficient cooling technology for water-intake (e.g. closed loop systems) when abstraction sources are at elevated temperatures. • Install enlarged condensers to accommodate periods of elevated air temperature.		Expert team

Type of option	Key actions	Relevant to hazard type	Source[102]
Flood protection	• Construct with flood protection measure (e.g. bunding) that include allowances for climate change. • Locate all critical services above ground level.		Expert team
Wind load	• Minimize vertical height of walls • Arrange buildings to maximize shelter • Avoid variations in height of buildings.		Expert team
Materials storage	• Construct fire, heat and flood resistant storage facilities for coal stockpiles. • Construct storage areas with anchorage points and strengthened against earthquakes.		Expert team
Substation efficiency	• Construct substations with cooling systems including shading. Consider location.		Expert team
Transmission efficiency	• Examine costs and benefits of new transmission lines to account for lower efficiency in hotter weather, e.g. insulated lines.		World Bank, (2009)
Earthquake protection	• Construct with monitoring and control of effects of ground shaking for buildings, structures, turbines and generators, transmission towers etc. using accelerometric networks, active and passive control systems.		SeDIF (2013)
Thermal comfort of workers	• Apply energy-efficient solutions to reduce thermal discomfort and potential heat stress to workers (e.g. natural ventilation, mechanical air cooling and conventional cooling systems).		Expert team

Prototypical asset: Pipeline storage and pumping

Table 7-6 presents structural options for pipeline storage and pumping.

Table 7-6: Pipeline storage and pumping structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[103]
Risk prevention			
Flood protection	• Retrofit storage tanks flood protection measure (e.g. bunding) • Move critical services above ground level.		Expert team
Pump efficiency	• Replace outdated pumps with more energy efficient units. • Consider additional cooling during periods of elevated temperature.		Expert team
Earthquake protection	• Control effects of ground shaking on storage tanks, pumps and pipes etc. using		SeDIF (2013)

Type of option	Key actions	Relevant to hazard type	Source[103]
	accelerometric networks, active and passive control systems. • Replace outdated pipeline sections with flexible high-density polyethylene pipes and geofoam / geo membrane protection. • Provide anchorage points and strengthen storage tanks against earthquakes. • Install rupture control valves, seismic actuated gas shut-off valves and remote controlled valves which do not corrode, have a high strain allowance, and are available in many different sizes.		
Resilient reconstruction			
Flood protection	• Construct storage tanks with flood protection measure (e.g. bunding) that include allowances for climate change. • Locate all critical services above ground level.		Expert team
Pump efficiency	• Construct using pumps with more energy efficient units and higher operational efficiencies during elevated air temperature		Expert team
Earthquake protection	• Construct with monitoring and control of effects of ground shaking on storage tanks, pumps and pipes etc. using accelerometric networks, active and passive control systems. • Provide anchorage points and strengthen storage tanks against earthquakes. • Construct pipelines with flexible high-density polyethylene pipes and geofoam / geo membrane protection, seismic actuated gas shut-off valves and remote controlled valves.		Expert team, SeDIF (2013)

Transport & Logistics assets

Prototypical asset: Port

Table 7-7 presents structural options for ports.

Table 7-7: Port structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[104]
Risk prevention			
Flood protection	• Upgrade drainage systems inside ports to increase maximum capacity and manage increased flow. • Retrofit buildings and storage areas vulnerable to flooding, in particular critical components (e.g. insulate electrical equipment, use water resistant materials).		IDB (2015)

Type of option	Key actions	Relevant to hazard type	Source[104]
	• Review options for using sustainable drainage systems (SUDS).		
Quays	• Raise quay heights to prevent flooding and account for future sea level rise and storm surges.		IDB (2015)
Dredging and disposal	• Support maintenance of sediment and water quality within harbors provided by natural ecosystems.		IDB (2015)
Sedimentation	• Upgrade and improve sediment traps.		IDB (2015)
Road integrity	• Replace road surfaces with materials resistant to prolonged elevated temperature.		Expert team
Refrigeration and cooling	• Increase efficiency of cooling / freezing equipment. • Isolate electrical connections to reduce exposure to water and dust, reducing incidents of loss of power to reefers and consequent extra energy for re-cooling/re-freezing.		IDB (2015)
Storage areas	• Retrofit handling areas with covers to protect from heavy rainfall events.		IDB (2015)
Earthquake protection	• Control effects of ground shaking on storage tanks and cranes etc. using accelerometric networks, active and passive control systems.		SeDIF (2013)
Resilient reconstruction			
Flood protection	• Construct sustainable drainage systems (SUDS) inside ports with a climate change allowance to manage increased flow. • Fit new buildings and storage areas with insulated electrical equipment and water resistant materials.		IDB (2015)
Quays	• Construct quay heights to prevent flooding and account for future sea level rise and storm surges.		IDB (2015)
Dredging and disposal	• Support introduction of, or increase in, natural ecosystems to help manage sediment and maintain water quality within harbors.		IDB (2015)
Sedimentation	• Use sediment traps designed to manage future changes in rainfall and sediment / pollutant mobilization from surfaces.		IDB (2015)
Road integrity	• Construct road surfaces with materials resistant to prolonged elevated temperature.		Expert team
Refrigeration and cooling	• Implement best available technology for efficient cooling / freezing equipment.		IDB (2015)

Type of option	Key actions	Relevant to hazard type	Source[104]
	• Construct using isolated electrical connections to reduce exposure to water and dust.		
Storage areas	• Construct handling areas with covers to protect from future increases in heavy rainfall events.		IDB (2015)
Earthquake protection	• Construct with monitoring and control of effects of ground shaking on storage tanks and cranes using accelerometric networks, active and passive control systems.		SeDIF (2013)
Thermal comfort of workers	• Apply energy-efficient solutions to reduce thermal discomfort and potential heat stress to workers (e.g. natural ventilation, mechanical air cooling and conventional cooling systems).		Expert team

Prototypical asset: Viaduct / road bridge

Table 7-8 presents structural options for viaducts / road bridges.

Table 7-8: Viaduct / road bridge risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[105]
Risk prevention			
Flood protection	• Upgrade drainage systems to increase maximum capacity and manage increased flow.		IDB (2015)
Road integrity	• Replace road deck surfaces with materials resistant to prolonged elevated temperature.		Expert team
Prevention of scour	• Use riprap (large rocks and rubble) to stabilize bridge foundations. • Use of additional concrete to strengthen bridge piers and abutments.		Expert team
Earthquake protection	• Control effects of ground shaking on bridge structure, foundations, road deck and expansion joints etc. using accelerometric networks, active and passive control systems.		Expert team
Resilient reconstruction			
Flood protection	• Upgrade drainage systems to increase maximum capacity and manage increased flow.		IDB (2015)
Road integrity	• Construct road deck surfaces with materials resistant to prolonged elevated temperature. Look to design standards in countries with higher temperatures.		Expert team
Prevention of scour	• Use riprap (large rocks and rubble) to stabilize bridge foundations.		Expert team

Type of option	Key actions	Relevant to hazard type	Source[105]
Earthquake protection	• Use of additional concrete to strengthen bridge piers and abutments. • Construct with control and monitoring of effects of ground shaking on bridge structure, foundations, road deck and expansion joints using accelerometric networks, active and passive control systems.		Expert team

7.2.4.5. Methods for appraising risk management options

Several approaches exist to assess the costs and benefits of risk management options. Figure 7-12 presents a decision tree schematic of approaches, depending on decision-makers' objectives and information available for analysis. This represents an important step for ÇKA and infrastructure developers when appraising and selecting hard or soft resilience measures.

However, a changing risk landscape does in itself present methodological issues for conventional cost benefit analyses, related to the themes of uncertainty, valuation and equity (see Box 7-4)[106].

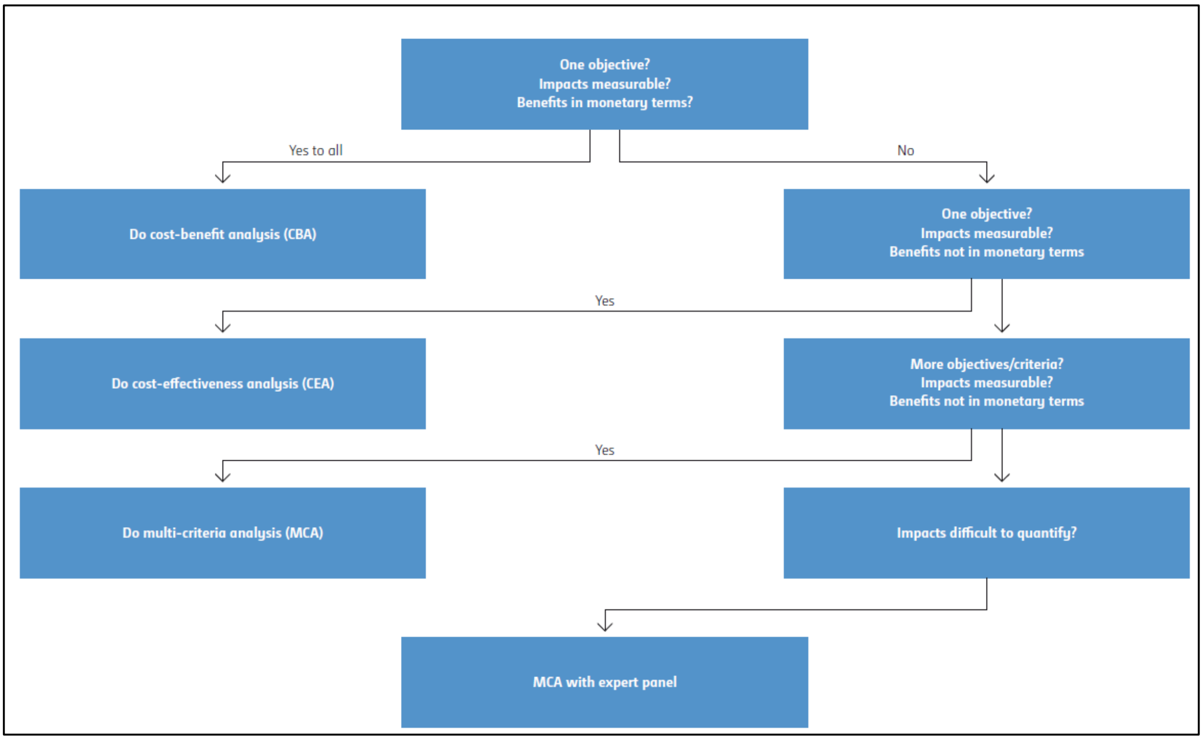


Figure 7-12. Decision tree of possible approaches for assessing the costs and benefits of adaptation options. (Source: UNFCCC, 2011[107]).

Box 7-4. Methodological themes concerning costs and benefits of climate change adaptation (adapted from UNFCCC[108]).

Uncertainty

Uncertainty surrounding future climate change impacts and future socio-economic development constrains the identification of 'optimal' adaptation options. Even under a specific scenario of future greenhouse gas emissions, the range of possible impacts is large.

Adaptation measures should therefore be designed in a flexible manner so that they can be adjusted or reversed as new information becomes available. This is particularly important for adaptation options that have long-term implications. Another aspect of uncertainty relates to data/measurement uncertainty, which can be addressed through adequate sample size and measurement approach so that results are sufficiently robust for decision making.

Valuation

Assessing the costs and benefits of adaptation options can be undertaken narrowly through financial assessments or more comprehensively through economic assessments. Financial assessments are usually undertaken within the budgetary framework of the adaptation option under consideration and consider financial costs and benefits only.

Economic assessments consider the wider costs and benefits to the national economy as a whole, and social and environmental costs and benefits may also form part of the assessment.

For adaptation options, it is important to not only consider quantifiable market costs and benefits, but also non-market costs and benefits, i.e. difficult to quantify in monetary terms (e.g. human health and ecosystem services).

Defining a ***baseline*** is an important, but also difficult, step in estimating the costs and benefits of adaptation options. The baseline should define what would happen to the main variables in the absence of climate change. Significant challenges exist because climate risk assessments look into the future and analyses has to predict levels of development and social changes up to 2030 and beyond. When defining the baseline, it is important to remember that outcomes may vary and not all plans will always be fully implemented. Given the number of uncertainties, multiple baselines may be a relevant approach.

Discount rates are commonly used to estimate the present values of the costs and benefits of adaptation options because the costs of an option occur earlier in time than when the benefits may be realized. Present values are sensitive to the choice of discount rate and to any assumptions about the consistency of the rate over time. Some studies have applied existing discount rates relevant to the country or organization. Many studies undertake sensitivity analyses to test to what extent the result of the assessment is affected by changes in key variables such as the discount rate. Applying a range of discount rates allows testing of the validity of results and ensure that the discount rate is not chosen close to a tipping point that reverses the decision. In such a case, further analysis should be applied.

The ***time-horizon*** of the evaluation is directly linked to the discount rate. The horizon depends on the desired lifespan of the options under consideration. When assessing these options, the totality of costs, including investment and maintenance costs, benefits and expected impacts of climate change over the entire period should be accounted for.

Equity (distributional impacts)

Climate change impacts can disproportionately affect vulnerable populations. It is therefore important for adaptation planners not only to consider net benefits but also to consider the distribution of the costs and benefits of adaptation options. One approach is to give weights to different costs and benefits according to who receives the benefits and who bears the cost, for example, doubling the benefits for vulnerable people, and reducing the benefits for others. In practice, applying weights can be very subjective when choosing where the thresholds should lie and the weighting coefficients to be used. An alternative and more popular approach is presenting distributional impacts of adaptation options alongside aggregate costs and benefits and leaving the decision to be taken by policymakers.

Cost Benefit Analysis (CBA)

CBA is used where all costs and benefits can be expressed in monetary terms. Referring to Figure 7-12, CBA should be used when the following all apply:

- There is a single decision objective, e.g. maximizing economic return,
- Impacts are measurable and quantifiable,
- Benefits are required to be expressed in monetary terms.

Conventional cost benefit analysis (CBA) is used to select efficient and 'optimal' options, i.e. ones which are considered to maximize net benefits. In the context of a changing climate, the focus has to widen to select options which are efficient as well as performing robustly in the context of future climate uncertainties. Defining an option selection strategy in turn becomes as much about climate change risk management as it is about efficiency objectives.

The CBA methodology described in detail in Annex A6.5 builds on the standard CBA methodology to include uncertainty, and is adapted from UNFCCC and EC guidance[109].

Cost Effectiveness Analysis (CEA)

Referring to Figure 7-12, CEA should be used when the following apply:

- There is a single decision objective,
- Impacts are measurable and quantifiable,
- Benefits are not required in monetary terms.

CEA is used to find the least costly risk management option for a pre-defined single objective. Since the CEA is performed after the objective has been defined, it does not evaluate whether the measure is justified, e.g. through benefit-cost ratio (BCR) or Internal Rate of Return (IRR). CEA is applied in assessing options where benefits are difficult to monetize, but where costs can be quantified.

Using a CEA is considered appropriate in cases where only one risk management option will be implemented, which would be the option with the lowest cost-effectiveness ratio, i.e. least cost per unit of effectiveness. In cases where a single risk management option may not be sufficient, use of an incremental CEA become more appropriate.

The CEA methodology for climate vulnerability and risk management purposes is detailed in Annex A6.6.

Multi-criteria Analysis (MCA)

Referring to Figure 7-12, MCA should be used when the following apply:

- The decision has multiple objectives
- Impacts are measurable and quantifiable*
- Benefits are not required in monetary terms.

  * If impacts are difficult to quantify, then MCA with an expert panel is recommended.

MCA allows the assessment of different risk management options against a number of objectives / criteria. Each criterion is given a weighting, and this weighting is used to generate an overall score for each option. The risk management option with the highest score is the preferred one for selection. MCA offers an alternative for the assessment of options when only partial data are available, when cultural and ecological considerations are difficult to quantify and when the monetary benefit or effectiveness are only two of many criteria. MCA involves defining a framework to integrate different decision criteria in a quantitative analysis without assigning monetary values to all factors.

The robustness of an MCA result depends on the certainty or uncertainty of the information regarding the selected criteria, the relative priorities given to various criteria (the weights or scores) and the extent to which there is agreement on the weightings. The result can be tested in a sensitivity analysis to check the robustness of the result to changes in scores and/or weights.

The MCA methodology for climate vulnerability and risk management purposes is detailed in Annex A6.7.

7.2.4.6. Strategic approaches to risk management

The following sections describe types of options that perform well under future climate uncertainty and the decision rules that can be applied when selecting options. As such, these are governing factors which ÇKA will need to incorporate into their CI decision-making processes to assist with selection of structural vs non-structural options, or options which may not be necessarily optimal, but represent a robust approach in the face of uncertainty.

Types of risk management options that perform well under uncertainty

When identifying and appraising risk management actions, particularly for climate-related risks, it is prudent to consider principles of good adaptation and participatory decision making to inform the options selection process. These include[110]:

- Having a balanced approach to managing climate and non-climate risks – i.e. assessing and implementing the approach to adaptation within the overall risk context for the project,
- Focusing on identifying actions that respond to project objectives and help to manage priority climate vulnerabilities and risks,
- Identifying options which perform well in the face of future uncertainties, as described in Box 7-5.
- Working in partnerships with stakeholders and communities to ensure actions will not have unintended negative consequences (termed 'maladaptation').

Box 7-5: Types of options which perform well under future uncertainty.

No regret adaptation: measures that are worthwhile now, delivering net socio-economic benefits which exceed their costs, and that continue to be worthwhile irrespective of the nature of future climate. A sub-set of no-regret measures are so-called 'soft' measures that support understanding, capacity building and improved governance on adaptation.

Low regret adaptation: measures for which the associated costs are relatively low and for which, bearing in mind the uncertainties in future climate change, the benefits under future climate change may potentially be large.

'Win-win' adaptation: measures that have other environmental, social or economic benefits as well as treating climate change.

Flexible or **adaptive management:** measures that can be implemented incrementally, rather than through the adoption of 'one-off' costly adaptation solutions. For example, delaying measures while exploring options and working with other stakeholders to find the most appropriate solutions may be a viable approach to ensure that the appropriate level of climate resilience is reached when needed. Keeping options flexible and open-ended allows them to be adjusted, following monitoring and evaluation and systematic appraisal of their performance.

Evaluation of the costs and benefits of either a single option or a combination of options must be considered integral to any wider strategy of setting future investment targets and spending prioritization. Combining alternatives that perform well under different scenarios then becomes the preferred strategy, rather than finding one optimal outcome. Figure 7-13 presents examples of various flood management options, showing no regret options such as early warning systems providing both high benefits relative to costs as well as a high level of robustness to future uncertainties. This approach lends itself to the preference for flexible, no regret approaches that include options which are cost effective regardless of changes in future hazard risk.

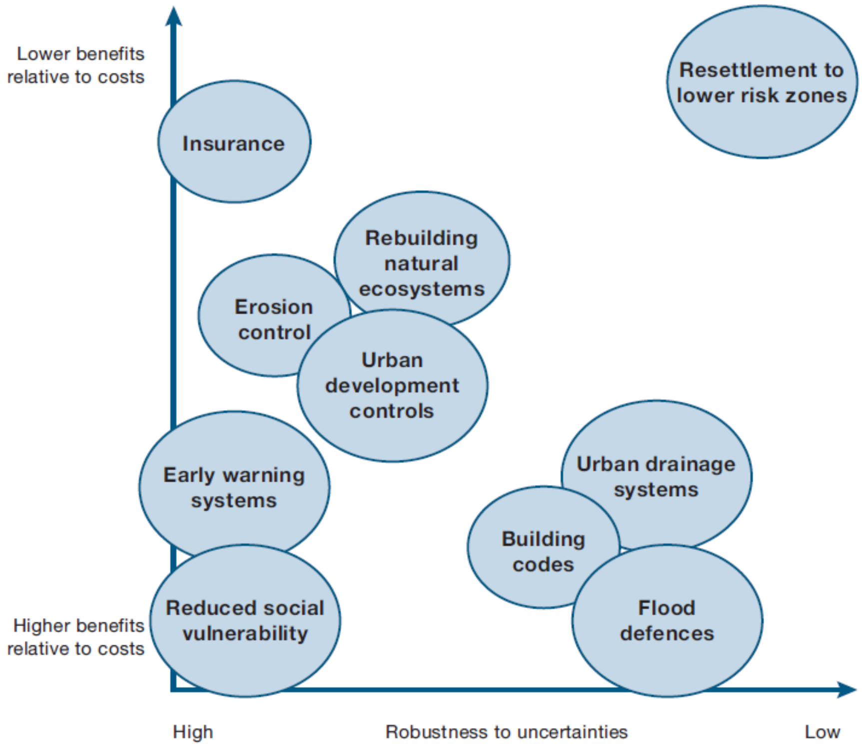


Figure 7-13: Relative costs and benefits of flood management options. (Source: World Bank, 2011[111].)

An internationally cited best practice case of flexible and adaptive management is the Thames Estuary 2100 (TE2100) Plan. The Plan was developed to manage the UK's Thames Estuary tidal flood risk to the end of the century and beyond, and sets out how to provide continued protection to 1.3 million people and £275 billion worth of property. The Plan is an example of a flexible approach to adaptation with options dependent on changes in key hazard risk components (e.g. sea level rise, tidal surge and riverine flooding). As such, TE2100 has three phases split into short, medium and long-term time periods:

- Short term (2010 -2034): Maintaining and improving existing defenses; safeguarding space for future flood management,
- Medium term (2035 -2070): renewal / replacement of existing tidal defenses,
- Long term (>2070): continued maintenance of existing system or construct new tidal defense barrier.

Flexibility is delivered through:

- Interventions that can be brought forward in time,
- Alternative pathways that can be used depending on how hazards do change in the future,
- Design of structures in a manner that allows modifications through time,
- Securing and safeguarding land for new defenses.

The Plan will monitor ten change factors. If rapid change is detected (for example sea level rise), the Plan will be adjusted accordingly and a new adaptation pathway followed (see Figure 7-14).

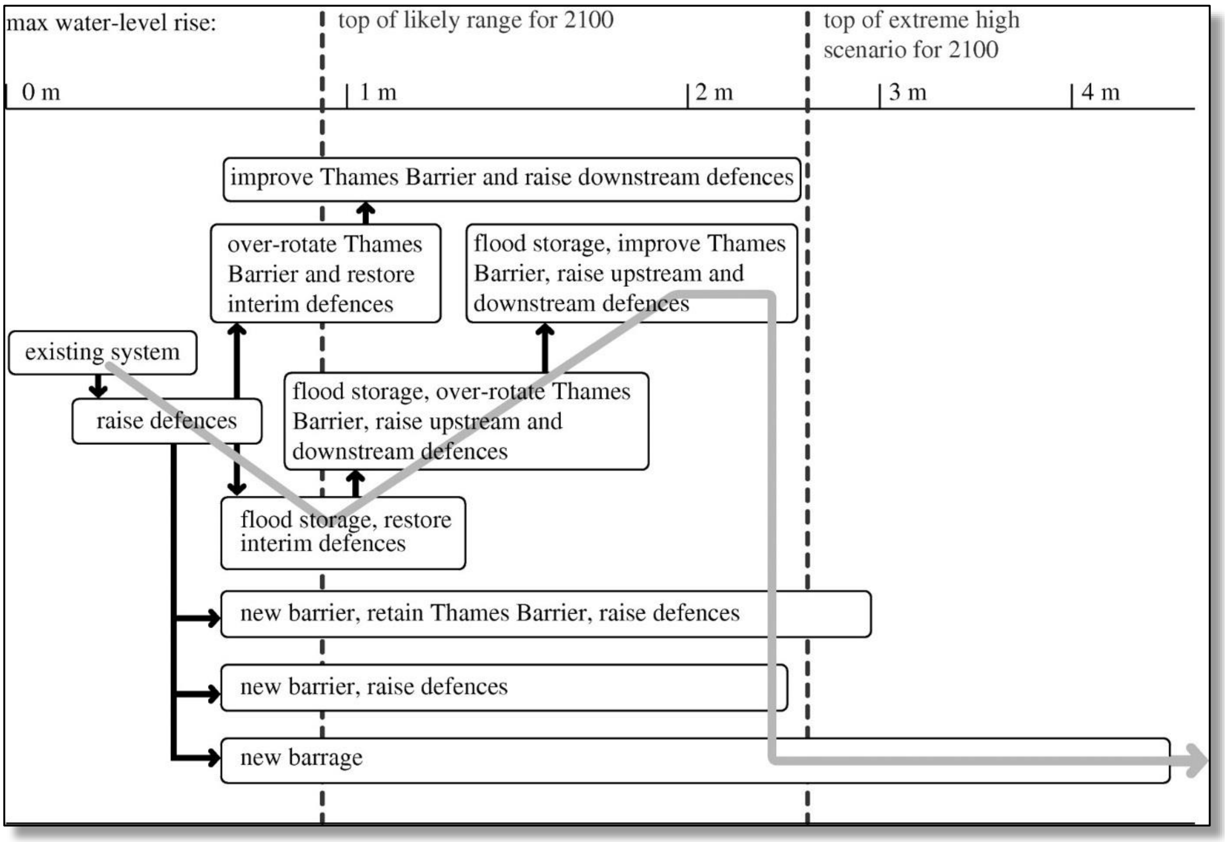


Figure 7-14: Thames Estuary 2100 (TE2100) adaptation options and potential pathways (grey line is one possible pathway). (Source: Stafford Smith et al, 2011[112]).

Selecting adaptation options involves decision-making within the uncertainty of how climate-related hazards may change in the future. Decisions rules will:

- depend on the lifetime of assets; the longer the lifetime the higher the uncertainty about future climate conditions;
- need to reflect the risk appetite and risk tolerance of the decision-makers - who may be risk takers, risk neutral, risk averse or all of these.

Annex A6.8 presents further information on how decisions can be influenced by objectives and level of risk tolerance or aversion.

8. Catalogue of international sources of climate finance for critical infrastructure resilience in Turkey

Summary of key points

- International sources of climate finance are available which can help to build critical infrastructure resilience in Turkey.
- Flows of climate finance globally reached a record high of $437 billion dollars in 2015, followed by a 12% drop in 2016 to $383 billion.
- Within Çukurova Region, such funding sources can potentially be accessed by owners and operators of critical infrastructure, local (municipal) planning authorities and ÇKA, to build resilience into energy and transport & logistics.
- A review of international funding options has identified 21 international climate funds (15 multilateral and 6 bilateral funds) which could potentially fund the resilience-building measures highlighted in this report.
- A ranking of these funds was undertaken according to 4 criteria: Relevance of the fund for the climate resilience-building activities highlighted in this report; compliance with the funds' eligibility criteria; ease of access to the fund; and previous experience in accessing the fund by Turkey.
- Based on the prioritisation and ranking undertaken, a set of 11 highest scoring climate funds are recommended for further discussions as potential viable funding options for the implementation of the resilience building measures for energy and transport & logistics in Çukurova.

8.1. Introduction

Section 7 identifies a range of resilience building options, including structural and non-structural risk management options which contribute to overall resilience. At the 2nd CIRA workshop, held in Adana, Turkey, on 31 May and 1 June 2017, ÇKA and other stakeholders from the energy, transport and logistics sectors requested guidance on international sources of climate finance available for critical infrastructure resilience building in Turkey. This section presents a catalogue of international funding options for the resilience-building actions identified in Section 7, that are available to owners and operators of critical infrastructure, local (municipal) planning authorities and ÇKA, focusing on energy and transport and logistics.

A recent report from the Climate Policy Initiative (CPI) has shown that climate finance flows reached a record high of $437 billion dollars in 2015, followed by a 12% drop in 2016 to $383 billion.[113] It should be noted that the overall increase in finance in 2015 was not due to a major scale up of public finance, but rather to an increase in private finance. While private climate finance averaged $270 billion/year during 2015 and 2016, public finance actors and intermediaries committed an average of $139 billion/year for the same period. In addition, CPI estimates that 79% was raised domestically. International flows from the member countries of the Organisation for Economic Co-operation and Development (OECD) to non-OECD countries account for 12% or $48 billion/year on average during 2015/2016. According to the same source, multilateral climate funds contributed to a record amount of climate finance grants and loans in 2016, reaching $2.45 billion; 40% more than 2015. This is mostly due to the Green Climate Fund (GCF) becoming operational in 2015. In its first full year of operation, the GCF commitments accounted for 54% of the total flows from climate funds.

In terms of comparing financial flows directed at climate change adaptation vs. climate change mitigation, preliminary estimates show that adaptation has received only a small share of public climate finance, corresponding to an average 16% for 2015/2016. Among the sectors targeted by adaptation finance, water and wastewater management captured the largest share: 51% of public finance, on average, during 2015/2016. Land use adaptation including agriculture and forest management received 19%; while disaster risk management interventions had only 11%. For the energy sector, including energy use in power, transportation, and buildings, the needs amount to "$1 trillion per year through 2050" according to CPI's Global Landscape of Climate Finance 2017. While in 2016 the International Energy Agency (IEA) estimated that "*decarbonising the power sector in the 2˚C scenario would cost about USD 9 trillion between 2016 and 2050 (equivalent to 0.1% of the cumulative global gross domestic product [GDP] over the same period)*"[114]. To meet the needs of developing nations, adaptation finance will need to increase significantly.

In light of this, it is important that owners and operators of critical infrastructure, local (municipal) planning authorities and ÇKA take action now to exploit emerging international financing opportunities. With this in mind, this section aims to:

- Map international climate funds (including UNFCCC, multilateral and bilateral sources) available to fund climate resilience building activities for critical infrastructure projects in Turkey,
- Propose prioritisation criteria of the international climate funds identified with a view to inform the local (municipal) planning authorities and ÇKA on which fund(s) they can approach to submit a funding application for the resilience building options identified in Section 7,
- For each climate fund identified, provide an overview of the application requirements, possible application fees, average decision period and similar projects funded,
- Present the prioritised funds, based on the relevance of the fund for the climate resilience-building activities highlighted in Section 7, the alignment of these activities with the fund's eligibility criteria, ease of access to the fund and previous experience in accessing the fund by Turkey.

8.2. Methodological approach to identifying and prioritising international climate funds for CI resilience in Turkey

Figure 8-1 provides an overview of the methodological approach to identify and prioritise the international climate funds.

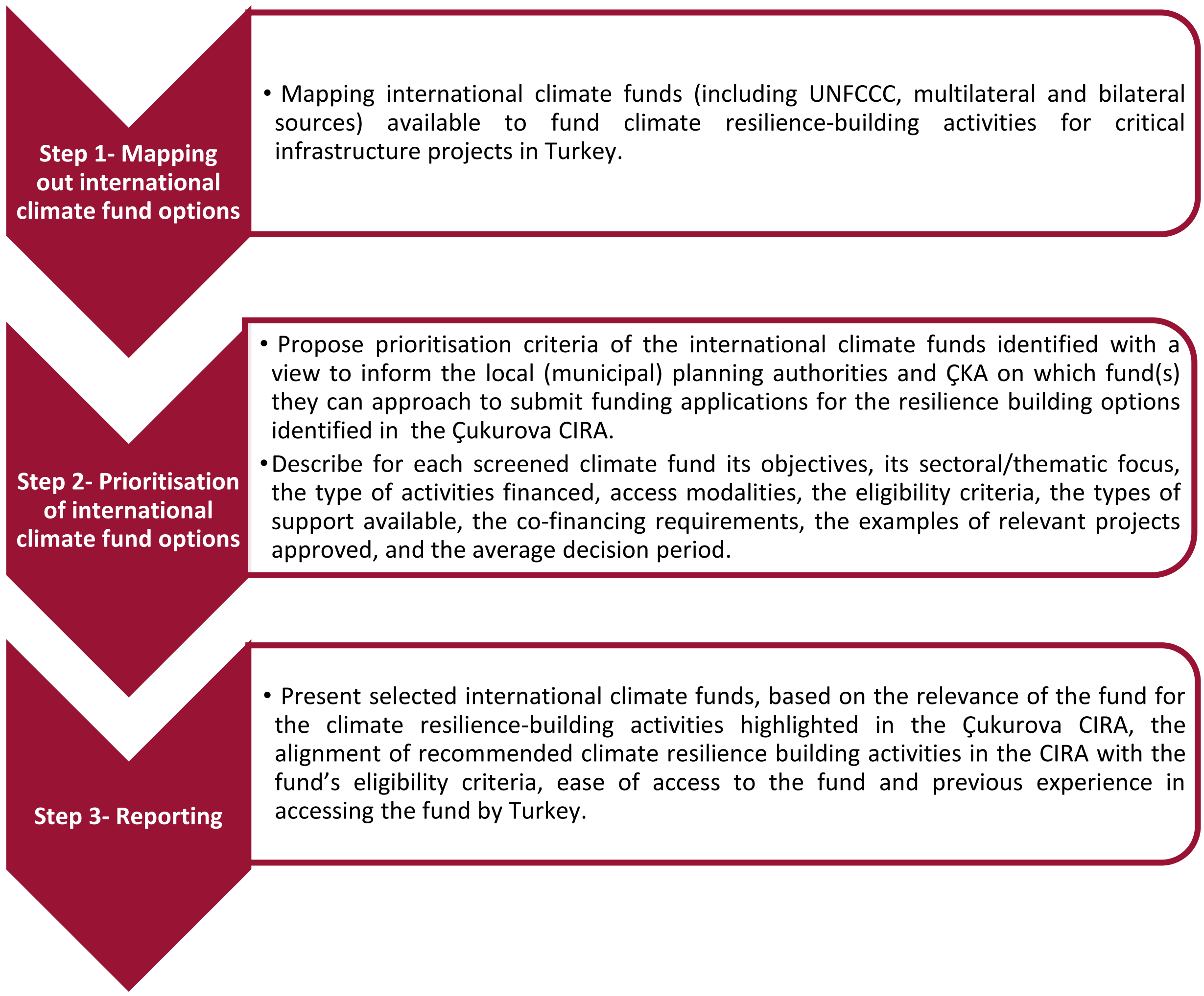


Figure 8-1: Overview of the methodological approach to identifying and prioritising international climate funds for CI resilience in Turkey. (Source: Report authors).

Step 1. Mapping out international climate fund options. This involved undertaking a review of international climate funds available for resilience-building actions identified through the Çukurova CIRA and for which Turkey is eligible. Following this review, 11 climate funds were ruled out, namely: Global Climate Change Alliance + (GCCA+), Pilot Pogram for Climate Resilience (PPCR), Global Environmental Facility (GEF) Trust Fund, United States Agency for International Development (USAID), Canadian International Development Agency (CIDA), Australian Government's Department of Foreign Affairs and Trade and the European Structural and Investment (ESI) Funds, including European regional development fund (ERDF), European Social Fund (ESF), Cohesion Fund (CF), European Agricultural Fund for Rural Development (EAFRD) and European Maritime and Fisheries fund (EMFF).

The review covered information publicly available through existing clearing houses and websites on climate-related finance. It should be noted that the focus of this review was on sources of finance for which Turkey is eligible and that directly support adaptation and climate resilience programmes or projects (i.e. excluding funds that only finance climate change mitigation or REDD+ (Reducing emissions from deforestation and forest degradation) activities). It should also be noted that domestic climate funds are not included in this review, nor private climate finance.

Box 8-1: Climate funds databases consulted

Climate funds update database: http://www.climatefundsupdate.org/
OECD Climate Fund Inventory Database: http://qdd.oecd.org/data/climatefundinventory/.1+5.3
Pacific Climate Change Portal, Donors and Funds: https://www.pacificclimatechange.net/donor-database?search_api_views_fulltext=&page=1
Climate ADAPT: http://climate-adapt.eea.europa.eu/

Step 2. Prioritisation and ranking of international climate fund options. Based on the review undertaken under step 1, each funding option was scored using a set of four prioritisation criteria. These criteria were defined as follows:

- **C1** Relevance of the fund for the climate resilience-building activities highlighted in the Çukurova CIRA,
- **C2** Alignment of recommended climate resilience building activities in the CIRA with the funds' eligibility criteria,
- **C3** Ease of access to the fund, and
- **C4** Previous experience in accessing the fund by Turkey.

Each of the mapped funding options were scored from 0 to 3 (with 0 = not applicable, 1 = low, 2 = medium and 3 = high) for each of the above criteria, using expert judgement. Equal weighting was assigned to all criteria.

C3 "Ease of access to the fund" was assessed based on the complexity and time requirements of the application process, and scored using expert judgement and understanding of the funding application process of the relevant funds. In assessing the ease of access for each fund, three possible answers were available: 3 = Easy to access (defined as a single-stage proposal process, generally going straight to full proposal development); 2 = Complex (long lasting application process); and 1 = Very complex (defined as a multi-stage proposal process, including two review stages for a concept note and full proposal with budget and timeframe).

The highest possible score for a funding option is therefore 12. The values of all criteria were then summed up for each fund. This enables ranking and prioritisation of all funding options.

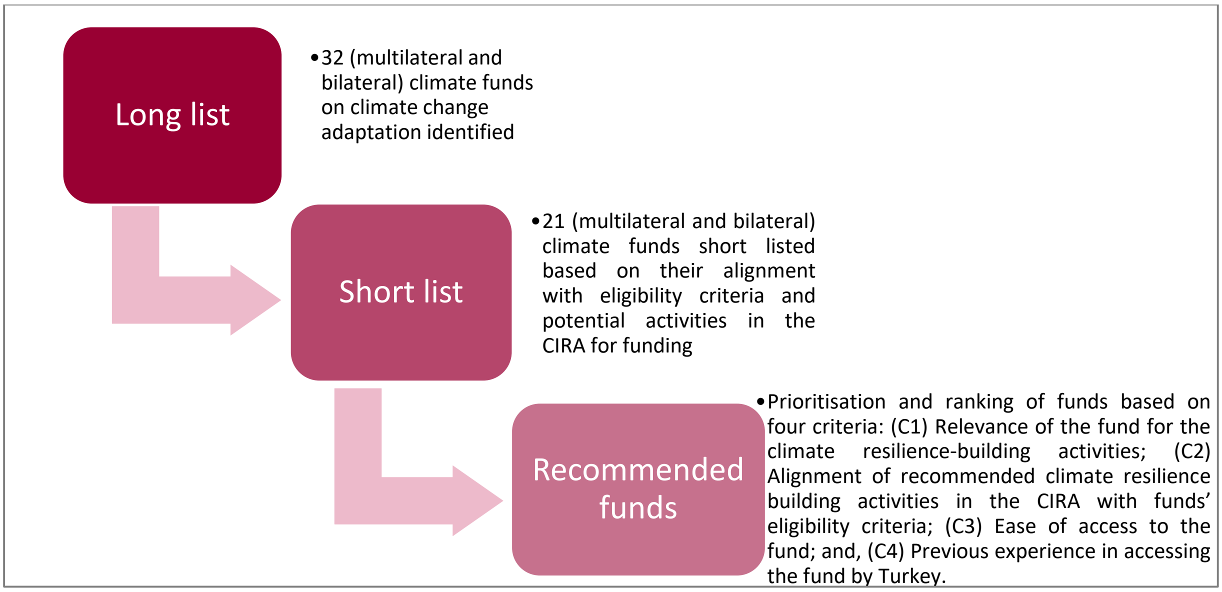


Figure 8-2: Moving from a long-list of climate funds to a set of recommended funds for CI resilience in Turkey. (Source: Report authors).

Step 3. Reporting and recommendations. Based on the prioritisation and ranking undertaken, a set of climate funds were recommended for financing the implementation of the resilience building actions identified in the Çukurova CIRA, through the identification of the highest scoring funding options.

8.2.1. Limitations of this review

The limitations of this review include:

- **Publicly available information**: The review is based solely on information made publicly available through existing clearing houses and websites on climate-related finance,[115] alongside the climate funds. Although this is complemented by expert knowledge where possible, this may mean that certain gaps remain because of the paucity of information made available by certain climate funds, in particular bilateral funds.
- **Focus on international climate funds, including bilateral and multilateral:** It should be noted that domestic climate funds were not included, nor private climate finance.
- **Focus on climate funds that finance climate adaptation and resilience building activities:** The focus of this review was on sources of finance for which Turkey is eligible, and that directly support adaptation and climate resilience programmes or projects (i.e. excluding funds that only finance climate change mitigation or REDD+ activities).
- **Accessibility by Turkish organisations to the Adaptation Fund (AF), GCF and Global Environment Facility Special Climate Change Fund (GEF-SCCF) would depend on the successful re-classification of Turkey as a non-Annex 1 country within the UNFCCC system**: Turkey cannot currently access the GCF, however the country has started to negotiate its eligibility during COP22. A decision on this matter has not yet been made. "*At the invitation of the COP President, the Co-Chairs attended a meeting during COP22 in Marrakech with the*

COP Presidency and Turkey in relation to Turkey's eligibility to access support from the GCF and the CTCN under the Paris Agreement. As per Article 11, paragraph 3(b), of the Convention and paragraph 6(a) of the Governing Instrument, guidance on matters relating to eligibility to receive GCF resources fall within the mandate of the COP. The meeting was convened by the COP Presidency in the context of the consultations it was undertaking in relation to the matter of country Parties whose special circumstances have been recognized by the Convention, particularly in the context of eligibility to receive support under the Convention and related agreements. These consultations were not concluded at COP22 and, accordingly, the COP did not take a decision on this matter. The consultations will continue during 2017 and the matter could be taken up by the Board following the outcome of such consultations".[116]

- **Examples of similar approved projects**: Examples of similar projects approved by international climate funds in the energy, and transport & logistics sectors were not easily found in Turkey or similar countries (such as the Middle East North African region or upper middle income countries). As such, the project examples included are mostly focused on building climate resilience in infrastructure (regardless of the type of infrastructure and socio-econonomic level of the country).
- **Average decision time**: For most climate funds information on the average decision time is not publicly available. Only for selected multilateral climate funds, namely the GCF, the SCCF, and the AF, can information about the average decision time be found.[117] In addition, it should be noted that where this information is provided, the timeline should be considered as indicative, as it is dependent on a number of factors such as: the climate fund workload and existing pipeline, the level of complexity and due diligence requirements for the project, and the level of baseline information available on the project, such as technical studies (e.g. feasibility studies). For these reasons, the average decision period was not used as a prioritisation criterion.
- **Application fee:** Application fee was not used as a specific prioritisation criterion for the climate funds, given that for most funds, there are no application fees for submitting proposals (noting fees may apply for accreditation to the GCF and AF).

8.3. Catalogue of international climate funds

This section provides an overview of international funding options for resilience-building actions identified through the Çukurova CIRA, that are available to owners and operators of critical infrastructure, local (municipal) planning authorities and Çukurova Development Agency (ÇKA) in the energy and transport & logistics sectors. A total of 21 international climate funds were identified, of which 15 were multilateral and 6 were bilateral funds.

The multilateral and bilateral climate funds are presented in Sections 8.3.1 and 8.3.2 respectively. In each section, two tables are provided, with information about:

- The fund objectives, sectoral/thematic focus, access modalities and eligibility criteria; and
- The type of support available, co-financing requirements, examples of relevant projects approved and average decision time.

8.3.1. Multilateral climate funds

Table 8-1: Objectives of the fund, sectoral/thematic focus, access modalities and eligibility criteria of selected multilateral funds. (Source: Report authors).

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
Adaptation Fund (AF)[118]	The AF aims to support concrete adaptation activities that reduce the adverse effects of climate change facing communities, countries, and sectors.	Climate Change Adaptation Resilience Disaster Risk Management Natural Resources and the Environment	Activities supported include: - Water resources management, land management, agriculture, health, infrastructure development, fragile ecosystems; - Improving the monitoring of diseases and vectors affected by climate change, and related forecasting and early-warning systems, and in this context improving disease control and prevention; - Supporting capacity building, including institutional capacity, for preventive measures, planning, preparedness and management of disasters relating to climate change; - Strengthening existing or establishing national and regional centres	The Adaptation Fund's financial resources can be accessed by submitting a project/programme proposal through accredited National, Regional, or Multilateral Implementing Entities. Projects/programmes proposals are considered by the Adaptation Fund Board three times a year. The Fund can be accessed via Direct Access modality, through National and regional implementing entities. This enables entities to directly access financing and manage all aspects their projects, including design, implementation, monitoring and evaluation. The application documents can be found here: https://www.adaptation-fund.org/apply-funding/project-funding/project-proposal-materials/	Accredited institutions from developing countries Parties to the Kyoto Protocol. There are three categories of accredited institutions: - National Implementing Entities (NIEs) - Regional Implementing Entities (RIEs) - Multilateral Implementing Entities (MIEs) The accreditation process is described here: https://www.adaptation-fund.org/apply-funding/accreditation/ Average of 17 and 27 months to accredit national/regional, and multilateral implementing entities, respectively, in the last four years.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
			and information networks for rapid response to extreme weather events, utilising information technology as much as possible.		
Asian Infrastructure Investment Bank (AIIB)[119]	AIIB is a multilateral financial institution founded to bring countries together to address the daunting infrastructure needs across Asia. By furthering interconnectivity and economic development in the region through advancements in infrastructure and other productive sectors, we can help stimulate growth and improve access to basic services.	Rural Infrastructure and Agriculture; Development Energy and Power; Environmental Protection; Transportation and Telecommunications; Water Supply and Sanitation; Urban Development and Logistics	**Sustainable Infrastructure:** green infrastructure and supporting countries to meet their environmental and development goals. **Cross-country Connectivity:** cross-border infrastructure, ranging from roads and rail, to ports, energy pipelines and telecoms **Private Capital Mobilization:** innovative solutions that catalyze private capital, in partnership with other Multilateral Development Banks (MDBs), governments, private financiers and other partners.	**Six steps to access funding for projects:** **1. Strategic Programming** AIIB reviews project ideas and proposals from clients, partners and other stakeholders. If the project meets the preliminary screening criteria, it is included in the rolling investment program to be discussed and approved by the Executive Committee on a regular basis. **2. Project identification** The prospective borrower submits to AIIB the relevant documentation on proposed project, including a brief project summary and/or a preliminary or final feasibility report. Following a review of the information received, AIIB may request that additional research is conducted. Based on the assessment, AIIB will work with the borrower to develop a project concept document. **3. Project preparation** AIIB's project team and the borrower's designated agency/agencies will work closely together on the project design. Following the project appraisal, the AIIB project team will prepare a Project Document. Afterwards, draft loan agreements and project agreements will be shared with the borrower for loan negotiations. **4. Board approval** After negotiations, the Project Document is submitted to the AIIB Board for approval. After the Board's approval, the Borrower and AIIB sign the loan and project agreements. The loan becomes effective after fulfilling the respective loan effectiveness conditions and the legal requirements. **5. Project implementation** In order to avoid delaying in the implementation of the project, AIIB focuses on project readiness. This phase includes: (1) Procurement readiness (advance procurement actions for recruiting consultants and selecting contractors/suppliers);	**N/A**

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
				(2) Implementation readiness (setting-up fully functional project implementation offices with qualified key staff). **6. Project completion and evaluation** AIIB prepares a Project Completion Report (PCR) within 6-12 months after project completion, to assess the Project's results, the performance of the Project Participants and AIIB, and the degree of achievement of the Project's development objectives. More information is available at: https://www.aiib.org/en/projects/process/index.html	
EU Instrument for Pre-accession Assistance (IPA)[120]	Through IPA the EU supports reforms in the 'enlargement countries' with financial and technical help. The IPA funds build up the capacities of the countries throughout the accession process, resulting in progressive, positive developments in the region.	Economic development, transport, energy and environment; Agriculture and sustainable rural development; Public administration; Reform and good governance; Investment in rule of law; Social development, human resources and inclusion.	Specific areas of focus for Turkey as per its Country Strategic Paper 2014-2020. Include: 1.Democracy and governance; 2.Rule of law and fundamental rights; 3.Environment and climate action; 4.Transport; 5.Energy; 6.Competitiveness and innovation; 7.Education, employment and social policies.	IPA funds are implemented in Turkey through three multi-annual operational programmes as illustrated below. **1.Environment Operational Programme (EOP):** supports the improvement of the environment, via investments in the water management cycle and solid waste management. EOP aims also to improve the capacity of the Operating Structure (Ministry of Environment and Forestry) to manage the programme via technical assistance. **2.Transport Operational Programme (TOP):** supports the improvement of transport sector particularly targeting rail infrastructure and ports. It also aims to strengthen the implementation capacity of the Operating Structure (Ministry of Transport) via technical assistance. **3. Regional Competitiveness Operational Programme (RCOP):** aims to increase the competitiveness of the Turkish economy and reducing the regional socio-economic disparities. RCOP provides also technical assistance to strengthen the capacity of the Operating Structure (Ministry of Science, Industry and Technology) and beneficiaries to develop and implement sound projects. More information on the EOP is available at: http://ec.europa.eu/regional_policy/ en/funding/ipa/turkey/environment/ The authority managing these funds in the country should be contacted for further information. In Turkey, this is the Ministry of Environment and Urbanization (Operating Structure and Contracting Authority for the Environment Operational Programme). www.ipa.gov.tr	Public bodies, some private sector organisations (especially small businesses), universities, associations, NGOs and voluntary organisations. Foreign firms with a base in the region covered by the relevant operational programme can also apply, if they meet European public procurement rules.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
				More details on the Environment operational programmes available at: http://ec.europa.eu/regional_policy/en/funding/ipa/ turkey/transport/	
European Bank for Reconstruction and Development (EBRD)[121]	ERBD is committed to furthering progress towards 'market-oriented economies and the promotion of private and entrepreneurial initiative'.	Supports investments in the following sectors: - Agribusiness; - Equity funds; - Financial institutions; - Information and communication technologies; - Legal reform; - Manufacturing services; - Municipal infrastructure; - Natural resources; - Nuclear safety; - Power and energy; - Property and Tourism; - Transport.	Projects may be considered for EBRD assistance if they: - are located in a country where the EBRD works; - have good prospects of being profitable; - have significant equity contributions in cash or in kind from the project sponsor; - benefit the local economy; - satisfy the EBRD's environmental standards as well as those of the host country.	The terms and conditions to ask for loans are available at: https://goo.gl/MWSEBj The terms and conditions for equity investments are available at: https://goo.gl/vp5Z5q The terms and conditions for guarantees are available at: https://goo.gl/BtHFcL The EBRD provides also assistance through financial intermediaries. It aims at supporting the development of micro, small and medium-sized enterprises (SMEs) by making equity and loan financing available to SMEs through a range of intermediaries. Financial intermediaries include banks in which the EBRD has an equity stake or with which has signed a loan, an investment or venture capital funds in which the EBRD has made an investment. The EBRD provides also direct financing and support for SMEs through a number of loan and equity facilities.	Provides project financing for banks, industries and businesses, both new ventures and investments in existing companies. It also works with publicly owned companies, to support privatisation, restructuring state-owned firms and improving municipal services.
European Investment Bank (EIB)[122]	EIB is the European Union (EU)'s bank. It represents the interests of the EU Member States. It works closely with other EU institutions to implement EU policy. It provides	Innovation and skills Access to finance for smaller businesses Infrastructure Climate and environment	•Promotion of economic and social cohesion in the EU; •Improvement of EU transport and telecommunications infrastructure; •Secure energy supplies, production, transfer and distribution, more efficient energy use,	To access EIB financial resources, project proponents are required to submit to the Bank's Operations Directorate a detailed description of their capital investment together with the prospective financing arrangements. Further information on the required documentation is available at: http://www.eib.org/infocentre/publications/all/application-document-for-an-eib-loan.htm The project proponent can make initial contacts with the EIB to discuss a proposed and should provide sufficient information to allow the EIB to assess whether the project adheres to EIB lending objectives and has a well-developed business plan. Proponents must provide a detailed description of their capital investment and prospective financing arrangements.	Eligible project proponents include public and private sector entities. Any project promoted must be in line with the EIB's eligibility criteria and be financially and economically sound. EIB lends directly to large individual projects. The eligibility criteria for blended finance can be found here: https://goo.gl/GqKgku

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
	finance and expertise for sustainable investment projects that contribute to EU policy objectives.		alternative energy supplies; •Development of a competitive, innovative and knowledge-based EU economy; •Investment in human capital; •Natural and urban environment schemes; •Development of small and medium sized enterprises; •Industrial projects improving EU competitiveness; • Support EU's external co-operation and development policies.	Information regarding the application procedure for "enlargement countries", including Turkey, can be found here: https://goo.gl/iJe5zH	
GEF-Special Climate Change Fund (SCCF)[123]	The SCCF was established to finance activities, programs and measures related to climate change that are complementary to those funded through the climate change focal area of the GEF, under its financing windows: i) Adaptation to Climate Change,	Adaptation and mitigation	The SCCF has two active windows (1) Adaptation and (2) Transfer of technologies. Its governing instrument also allows it to support (3) projects on energy, transport, industry, agriculture, forestry, and waste management; and (4) activities to support developing countries whose economies are	The project proponent can submit a project concept to the GEF Secretariat through one of the GEF implementing agencies, with a letter of endorsement from the country's government (provided by the appointed GEF Operational Focal Point in the country). While for medium-sized projects (smaller than or up to $1M), a the CEO Endorsement request is not required, for full-sized projects (larger than $1m), the implementing agency must submit a CEO Endorsement request after the project has been approved by the Council. Once the GEF CEO endorses the project, the funding is released to the Implementing Agency.	All Non-Annex 1 countries are eligible to apply for GEF Funding. However GEF priorities the most vulnerable countries in Africa, Asia, and the Small Island Developing States (SIDS). It should be noted that funding is only provided to address impacts of climate change in addition to basic development needs in vulnerable socio-economic sectors. Projects do not need to generate global environmental benefits as long as additionality can be demonstrated.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
	ii) Technology Transfer, iii) Mitigation in selected sectors, and iv) Economic diversification.		highly dependent on income generated from the production, processing, and export or on consumption of fossil fuels and associated energy-intensive products in diversifying their economies.		
Global Facility for Disaster Reduction and Recovery (GFDRR)[124]	The GFDRR aims to reduce developing countries' vulnerability to natural hazards and assist them to adapt to climate change.	Climate Change Resilience Disaster Risk Management Disaster management Disaster relief Disaster risk reduction	- Open access to risk information - Resilient infrastructure - Resilient cities - Hydromet services - Financial protection - Community resilience - Resilience to Climate Change - Resilient recovery - Gender	The GFDRR funding can be accessed by submitting a project proposal to the GFDRR Secretariat through the GFDRR website. The request is assessed against the following review criteria: • **Consistency with the GFDRR Mission:** The proposed project must be in line with the GFDRR's objective of mainstreaming DRM and supporting sustainable development. • **Government commitment:** Country ownership of the specific activities should be clearly demonstrated. • **Donor Coordination:** The project must promote effective coordination with the activities of GFDRR Partners. Country specific activities must not conflict with World Bank programs and other donors. Evaluation: • Proponents that meet the eligibility and evaluation criteria are notified by the GFDRR Secretariat to prepare a detailed proposal. • The GFDRR Secretariat evaluates the detailed proposals. • The proposal is submitted to the relevant donor for their no-objection, if the proposal is to be funded out of non-core funds. • If the proposal is to be funded out of core funds, the proposal is submitted to the Consultative Group for no-objection. Once an activity is approved, the GFDRR Secretariat and the proponents sign a Grant Agreement/Memorandum of Understanding.	All IBRD borrowers (national governments) can access the multi-donor trust fund.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
GCF[125]	GCF promotes a paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change, considering the needs of those developing countries particularly vulnerable to the adverse effects of climate change.	Adaptation and Mitigation Adaptation sectors: - Health, food and water security; - Livelihoods of people and communities; - Ecosystems and ecosystem services; - infrastructure and built environment. Mitigation sectors: - Low-emission energy access and power generation; - Low-emission transport; - Energy efficient buildings, cities and industries; - Sustainable land use and forest management.	The GCF finances activities to both enable and support adaptation, mitigation (including REDD+), technology development and transfer, capacity-building and the preparation of national reports.	Project proponents can submit a funding proposal through National Designated Authorities (NDAs). Eligible countries are allowed direct access through accredited sub-national, national and regional entities. GCF funds can also be accessed through international accredited entities, such as multilateral development banks and UN agencies. The GCF has a private sector facility (PSF) been established to maximise private sector engagement. The PSF aims to mobilise funding at scale from institutional investors such as commercial banks, investment funds, insurance companies, pensions and wealth funds; and to work with local micro, small and medium enterprises and unlock innovative solutions to address climate change impacts.	Public and private entities are eligible as long as they meet the requirements for accreditation. These may include: national ministries or government agencies, national development banks, national climate funds, commercial banks, financial institutions etc.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
Horizon 2020[126]	Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness.	Focus areas: - Health, demographic change and wellbeing; - Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy; - Secure, clean and efficient energy; - Smart, green and integrated transport; - Climate action, environment, resource efficiency and raw materials; - Europe in a changing world - inclusive, innovative and reflective societies; - Secure societies - protecting freedom and security of Europe and its citizens.	Horizon 2020 finances activities in its focus areas and that will contribute to: - ensuring that Europe produces world-class science; - removing barriers to innovation; - making it easier for public and private sectors to innovate together.	Funding opportunities under Horizon 2020 are set under its two-year work programme. This can be found on the online Participant Portal and can be used as a calendar for the calls for proposals to be published during the year. Each call gives more precise information on the questions that the Commission would like proponents to address in the funding proposals. All calls can be found in the EU's Official Journal and on the Participant Portal. More information is available at: https://ec.europa.eu/programmes/horizon2020/en/background-material	For most calls any consortia, must have at least three participant organisations from at least three EU member states and/or associated countries. Eligible organisations include: - registered business; - charities; partnership or research organisation that have legal standing.
International Bank for Reconstruction and Development (IBRD)[127]	The IBRD aims at achieving the following goals by 2030: - Ending extreme poverty by decreasing the percentage of people living on	Adaptation and Mitigation	The IBRD finances projects in the following sectors: -Agriculture; -Education; -Energy & extractives; -Financial sector; -Health;	The IBRD works with a borrowing country's government and other stakeholders to design a strategy, called Country Partnership Framework, which identifies the country's highest priorities for reducing poverty and improving living standards. This Frameworks defines how financial and other assistance can be used in the country to have the largest impact. The IBRD and the government prepare an initial project concept and the IBRD 's project team defines the basic elements in a	IBRD works primarily with governments.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
	less than $1.90 a day to no more than 3%; and - Promoting shared prosperity by fostering the income growth of the bottom 40% for every country.		- Industry & Trade; -Info & communication; -Public Admin; -Social protection; -Transportation; -Water/ Sanitation/Waste.	Project Concept Note. At this stage two other documents are required: the Project Information Document, which describes the scope of the project; and Integrated Safeguards Data Sheet, which identifies key issues related to the IBRD's safeguard policies for environmental and social issues.	
International Finance Corporation (IFC)[128]	IFC's objective is to assist economic development by encouraging the growth of productive private enterprise in its member nations, particularly in the underdeveloped areas.	Adaptation and Mitigation	IFC's Priorities in Europe and Central Asia: -Financial Markets -Infrastructure -Energy and Climate Business -Agribusiness -Opportunities for women	Investment proposals can be submitted to the IFC following the guideline available at: http://www.ifc.org/wps/wcm/connect/corp_ext_content/ ifc_external_corporate_site/solutions/investment-proposals After this initial contact, the IFC reviews the investment proposals and may request the proponent to provide a detailed feasibility study or business plan to determine whether or not to appraise the project.	A project to be eligible must: - Be in a developing country that is a member of the IFC; - Be in the private sector; - Have good prospects of being profitable; - Benefit the local economy; and - Be environmentally and socially sound, satisfying our environmental and social standards as well as those of the host country. It should be noted that the IFC does not lend directly to micro, small, and medium enterprises or individual entrepreneurs, but several IFC's investment clients are financial intermediaries that on-lend to smaller businesses.
Islamic Development Bank (ISDB)[129]	ISDB is an international Islamic financial institution, established to support the promotion of foreign trade especially in capital goods,	ISDB extends loans to its member countries to finance infrastructural and agricultural projects such as roads, canals, dams, schools, hospitals, housing, rural development, etc. both in the public	Development projects in the agricultural, industrial, agro-industrial and infrastructural sectors, among others.	The project cycle includes 6 steps: **1. Project Identification** The project is identified taking into account the country development plan and the Bank priorities. Several parties can contribute to the identification of the project, including the Government, ISDB missions, other development finance institutions, UN agencies, and private sponsors. In order to submit a proposal, the proponent needs to have official Government endorsement and must also meet a prima facie test of feasibility. In certain instances, Governments have allowed project proposals	Information on eligibility to the various financial products is available here: http://www.isdb.org/flipbooks/ MoF/mobile/index.html#p=30

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
	among member countries; providing technical assistance to member countries; and extending training facilities for personnel engaged in development activities in Muslim countries to conform to the Sharia.	and private sectors, which have an impact on the economic and social development of the member countries concerned and are accorded priority by the Governments concerned. In line with the Sharia, such loans are interest-free and the Bank recovers its administrative expenses by levying a service fee.		to be submitted without such endorsement if the project is submitted by the Private Sector. **2. Preparation** The project idea is transformed into a full proposal that covers the full range of technical, economic, financial, social, institutional and environmental aspects. This is done through close collaboration between the Bank and the beneficiary/executing agency. The feasibility study is the major aspect in the preparation process and aims at defining the best method to achieve the project's objectives, by comparing alternatives considering their relative costs and benefits. →It should be noted the Bank can provide financial and technical assistance for project preparation. **3. Appraisal/Negotiation** The Bank reviews the proposal and undertakes a full-scale project appraisal. The appraisal process covers the technical, economic, social, financial and institutional aspects as well as the environmental aspects of the project proposal and sets the foundation for implementing the project and evaluating it once completed. If successful, the Bank prepares a draft project financing agreement to be negotiated with the beneficiary. At the end of the process, a Memorandum of Understanding (MOU)/Minutes of Meeting reflecting the discussions and understanding reached by the parties is signed. **4. Approval and Signing** A Staff Appraisal Report (SAR) and Report and Recommendation of the President (RRP) are prepared that outline findings and recommend the level and terms and conditions of ISDB financing. These reports reflect the agreements reached during appraisal. They are reviewed and cleared according to ISDB's internal processes and procedures. **5. Implementation and Follow-up and** The beneficiary is the primarily responsible for the implementation of the project. The Bank will follow-up on the implementation and procurement processes. Follow-up concerns mostly matters related to the construction of physical components, purchase and installation of equipment, services rendered and new institutions, programs, and policies put in place. 6. **Post-Evaluation After Completion**	

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
				Upon completion, projects are subjected to post-evaluation. Within-5 years of completion, the Operations Evaluation Office (OEO), prepares an independent evaluation report. More information is available at: https://goo.gl/p3ZCee	
EU-LIFE[130]	LIFE is the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU.	Resource efficiency Biodiversity loss Climate adaptation and mitigation.	Type of activities that can be financed by EU-LIFE include: (a) pilot projects; (b) demonstration projects; (c) best practice projects; (d) integrated projects; (e) technical assistance projects; (f) capacity-building projects; (g) preparatory projects; (h) information, awareness, and dissemination projects; (i) any other projects needed to achieve the general objectives.	There are two phases of the application process: 1. submission of the proposal with a financial plan; and 2. submission of a letter of intent indicating the extent to which other relevant Union, national or private funding sources are to be mobilised, and specifying such sources of funding. 8.3.1.1. All projects will be screened against the following criteria: "(a) being of Union interest by making a significant contribution to the achievement of one of the general objectives of the LIFE Programme set out in Article 3 as well as the specific objectives for the priority areas listed in Article 9, the thematic priorities set out in Annex III, or the specific objectives for the priority areas listed in Article 13; (b) ensuring a cost-effective approach and being technically and financially coherent; and (c) being sound in the proposed implementation."[131]	The EU Life funding can be accessed by public and private entities. The Fund can be accessed by EU members, candidate countries and the Western Balkan countries involved in the Stabilisation and Association Process, as well as countries to which the European Neighbourhood Policy applies and overseas countries and territories. Turkey is a candidate country and is therefore eligible.
OPEC Fund for International Development (OFID)[132]	Development finance institution established by the Member States of OPEC as a collective channel of aid to the developing countries. OFID works to stimulate	Climate Change Adaptation Mitigation Economics and Finance Economic development Social Development Poverty	Projects in the following area: - Energy - Transportation - Financial - Agriculture - Water and Sanitation - Industry - Health - Communication - Education	To access OFID funding, applicants must submit a grant application form and their organisation's registration certificate. Applicants will receive notification in due course. To access funding dedicated to the private sector, applicants should submit a proposal including: i) a project description outlining the objectives; ii) an outline of the market environment, the sectors involved and future prospects; iii) an overview of the organizational and managerial structure of the proposed project, as well as information on project sponsors, promoters and other relevant parties; iv) background information on the economic and regulatory environment within which the proposed project will be	International, national, regional and non-governmental organisations are eligible for funding as long as they provide proof of their financial and legal status.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
	economic growth and alleviate poverty in all disadvantaged regions of the world.			implemented; and v) financial information on the proposed project, including level, type and justification of funding required.	
Public-Private Infrastructure Advisory Facility (PPIAF)[133]	Strengthening the policy, regulatory and institutional underpinnings of private sector investment in infrastructure in emerging markets and developing countries. By building institutions, reducing policy, regulatory and institutional risks, and building the capacity of counterparties, PPIAF allows governments to generate a pipeline of bankable projects.	Adaptation Capacity-building	Supports a range of eligible infrastructure sectors: Information and telecommunication technologies ICT, transport, water & sanitation, and power. Additional project priority areas include: - Creditworthiness - Energy efficiency - PPP institution building - Regional integration	Grant proposals must be in line with PPIAF's mandate to support governments in creating and strengthening an enabling environment for private participation in infrastructure, focusing on the following activities: - Framing infrastructure development strategies - Designing and implementing policy, regulatory, and institutional reforms - Organizing stakeholder consultation workshops - Building government institutional capacity - Designing and implementing pioneering projects. Applicants make initial contact with the PPIAF team member(s) to assess whether the activity to be funded is eligible and a good strategic fit. Applicants with eligible proposals can be helped to find a "sponsor" task team in the World Bank to implement their activity. Applicants submit a brief concept note that outlines the activity's objectives, scope, budget, implementation plan and time-frame. PPIAF reviews the concept notes and undertakes a preliminary screening. Successful concept notes will be sent to PPIAF's donors to flag potential issues affecting a go/no go decision. Valid concept notes that are not selected only because of funding constraints can be re-considered in the next round of review. Successful applicants are requested to submit a revised concept note that incorporates PPIAF's feedback. This is then submitted to PPIAF's donors for no-objection before proceeding to the next stage. After approval of the concept note, a detailed application package is then prepared. It comprises an application form, a detailed budget, terms of reference for any procurement, an official	National governments and regional institution are eligible. Sub-national entities can also apply for funding, including: - Special-purpose government entities delivering infrastructure services (such as utilities, authorities, and state-owned enterprises); - General-purpose sub-national government entities (such as municipalities, provinces and states); and - Financial intermediaries and entities (e.g., banks; funds and facilities; country development banks; and municipal funds), with a primary focus on sub-national infrastructure lending.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed	Access modalities (including access through accredited entities e.g. for GCF)	Eligibility (what type of organization/institution is eligible)
				government request letter, and a clearance note from the World Bank country director/manager. The processing of grants is usually completed within two to three weeks after the award letter is sent. Information on the application process is available at: https://ppiaf.org/documents/4181/download	

Table 8-2: Type of support available, co-financing requirements, examples of relevant projects approved and average decision time of selected multilateral funds. (Source: Report authors).

Fund(er)	Types of support available	Co-financing required?	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
AF	Grants	No	Promoting climate change resilient infrastructure development in San Salvador Metropolitan Area. Description of the project is available here: https://goo.gl/Zrw9o3	Once an entity is accredited, the AF takes an average of 8 - 12 months to approve one-step and 12 – 17 months for two-step projects, respectively.[134]	The relevance of this fund for Turkey depends on whether the country will be re-classified as Non-Annex 1 country under the UNFCCC system.
AIIB	Loan, equity investment	No	None of the projects approved so far has addressed climate change concerns. However, there is potential for climate change action under the sustainable infrastructure focus area.	N/A	**AIIB Project Preparation Special Fund is Open to Proposals:** AIIB provides grants to support and facilitate the preparation of projects in eligible member countries (including International Development Association recipients, including International Development Association Blend countries). In exceptional circumstances, AIIB resources may be used for financing innovative/complex projects, regional/cross-border projects that have significant regional impact. More info can be found here: https://www.aiib.org/en/projects/preparation-special-fund/index.html
EU IPA	Grants and loans	No	N/A	N/A	More details on financial assistance available for Turkey under IPA II is available at: https://ec.europa.eu/neighbourhood-enlargement/instruments/funding-by-country/turkey_en
EBRD	Loans, equity investments, guarantees for trade (depending on the sector)*	Yes	EBRD investments in resilient infrastructure: http://www.ebrd.com/downloads/sector/eecc/sei-adaptation.pdf	N/A	- It should be noted that the EBRD funds up to 35% of the total project cost for a greenfield project or 35% of the long-term capitalisation of an established

Fund(er)	Types of support available	Co-financing required?	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
	"EBRD financing for private sector projects generally ranges from $5 million to $250 million, in the form of loans or equity. The average EBRD investment is $25 million. Smaller projects may be financed through financial intermediaries or through special programmes for smaller direct investments in the less advanced countries."[135]		More info here as well: http://www.ebrd.com/infrastructure/infrastructure-matters.com The EBRD Green economy Transition Approach states that *"Climate change mitigation and, to a lesser extent, climate change adaptation and wider environmental considerations already underpin a range of Bank operations. This progressive reorientation is also visible in the launch of specific initiatives and the selection of key priorities for sectoral and country strategies. This is noticeably the case in the Sustainable Resource Initiative (BDS 13-052 (Final)), the environmental strategic initiative of the Bank which includes the Sustainable Energy Initiative. Sector strategies also reflect an increased focus on the environmental dimension as in the case of the Municipal and Environmental Infrastructure Sector Strategy (BDS12-126) and of other sectoral strategies including Transport, Agribusiness and Energy."* The project description can be found here: https://goo.gl/vQPgHz		company - Additional funding must be provided by sponsors and other co-financiers. - Typical private sector projects are based on at least one-third equity investment. - Significant equity contributions are required from the sponsors. Sponsors should have a majority shareholding or adequate operational control. In-kind equity contributions are accepted.
EIB	**Lending:** project loans, intermediated loans, venture capital, microfinance, equity and fund investment **Blending:** structured finance, guarantees, project bonds, EU finance for innovators, trust fund, transport infrastructure, flexible SME funding, ESIF	Yes. The EIB's contribution to a project's cost is limited to 50% of the overall amount established during appraisal. The EIB works with other banks,	N/A	An EIB appraisal procedure can take anywhere between six weeks and 18 months depending on the project scope, the degree of complication	Over 25% of EIB lending goes to climate action projects.

Fund(er)	Types of support available	Co-financing required?	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
	financial instrument, supporting urban development, Mutual Reliance Initiative, Private Finance for Energy Efficiency, Natural Capital Financing Facility, Risk Capital Facility. **Advising**: InnovFin advisory, Public-private partnerships, European Local Energy Assistance, Sustainable solutions for cities, Green-tech support.	either co-financing projects or in security structures.		of an operation, and the efficiency of the appraisal process on the part of both the EIB itself and the project promoter.	
GEF-SCCF	Grant.	Yes	N/A	Averages 19-20 months.	Any Non-Annex I country who is party to the UNFCCC is eligible for project funding under the SCCF[136]. Annex II countries of the UNFCCC provide the funding for the SCCF along with some Annex I countries as well as any non-Annex I that may wish to voluntarily contribute to the Fund.
GFDRR	Co-finance, grant, technical assistance.	Yes	The GFDRR provides technical assistance to governments to improve the design and resilience of new and rehabilitated infrastructure. It aims to bring together governments, the private sector, and civil society. The GFDRR finances technology and data analytics to quantify the level of risk and prioritize actions to guide risk-reduction investments. Resilient infrastructure projects are presented at: https://www.gfdrr.org/resilient-infrastructure	N/A	Building resilience to climate change is one of the thematic priorities of GFDRR, with focus on helping countries formulate enabling policies and investment programs for integrating climate and disaster risk into development strategies. Information on GFDRR activities to build resilience in Turkey can be found at: https://www.gfdrr.org/building-resilience-in-turkey-bank-executed-
GCF	Grants, loans, equity, guarantees.	The GCF has no clear requirements in terms of co-financing ratio required in a	FP004: Climate-Resilient Infrastructure Mainstreaming in Bangladesh. Full funding proposal available here: https://goo.gl/uYt47j	The GCF can take anywhere between 6 months to 3 years.	Turkey cannot currently access the GCF, however the country has started to negotiate its eligibility during COP 22. A decision on this matter has not yet been made. Extract below is from the 15th GCF Board: *"At the invitation of the COP President, the Co-Chairs*

Fund(er)	Types of support available	Co-financing required?	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
		project or programme, however securing co-financing is highly recommended to encourage crowding in, that is stimulating long-term investments beyond the GCF resources and up-front commitments.	FP008: Fiji Urban Water Supply and Wastewater Management Project. Full funding proposal available here: https://goo.gl/ZYJZBz FP040: Tajikistan: Scaling Up Hydropower Sector Climate Resilience Full funding proposal available here: https://goo.gl/T6BXXL		*attended a meeting during COP22 in Marrakech with the COP Presidency and Turkey in relation to Turkey's eligibility to access support from the GCF and the CTCN under the Paris Agreement. As per Article 11, paragraph 3(b), of the Convention and paragraph 6(a) of the Governing Instrument, guidance on matters relating to eligibility to receive GCF resources fall within the mandate of the COP. The meeting was convened by the COP Presidency in the context of the consultations it was undertaking in relation to the matter of country Parties whose special circumstances have been recognized by the Convention, particularly in the context of eligibility to receive support under the Convention and related agreements. These consultations were not concluded at COP22 and, accordingly, the COP did not take a decision on this matter. The consultations will continue during 2017 and the matter could be taken up by the Board following the outcome of such consultations."*[137]
Horizon 2020	Grants and technical assistance	Not for all projects[xxvi]	N/A	N/A	"The dedicated funding for climate action and resource efficiency will be complemented through the other objectives of Horizon 2020 with the result that at least 60 % of the total Horizon 2020 budget will be related to sustainable development, the vast majority of this expenditure contributing to mutually reinforcing climate and environmental objectives. It is expected that around 35% of the Horizon 2020 budget will be climate related expenditure. The EU Commission, as part of the implementation of the Adaptation Strategy, is working in refining key knowledge gaps with regards to adaptation. The findings will be fed into the programming of Horizon 2020."[138]

[xxvi] For research and development projects the share of the EU contribution can be up to 100% of the total eligible costs. For innovation projects up to 70% of the costs, with the exception of non-profit legal entities which can also receive up to 100 % in these actions. In all cases indirect costs will be covered by a flat rate of 25% of the direct costs. More details available at: http://ec.europa.eu/research/horizon2020/pdf/press/fact_sheet_on_rules_under_horizon_2020.pdf

Fund(er)	Types of support available	Co-financing required?	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
IBRD	Low-interest loans, zero to low-interest credits, and grants to developing countries. These support a wide array of investments in such areas as education, health, public administration, infrastructure, financial and private sector development, agriculture, and environmental and natural resource management.	Some projects are co-financed by governments, other multilateral institutions, commercial banks, export credit agencies, and private sector investors.	Strengthening Critical Infrastructure in Tajikistan against Natural Hazards. The description of the project can be found here: http://projects.worldbank.org/P158298?lang=en	N/A	**"Turkey is the IBRD sixth-largest borrower in terms of debt outstanding.** The investment portfolio and pipeline support the energy sector, financial and private sector development, urban development, and health care. Under the current Country Partnership Strategy (CPS) (FY12–16), total IBRD lending has reached US$4.3 billion."[139]
IFC	Grants, loans, equity, trade & supply chain finance, blended finance, advisory, syndications, treasury client solutions, venture capital, asset management	Yes	N/A	N/A	The country has already accessed IFC. Information on IFC activities in Turkey can be found here: https://goo.gl/qxGjtT
ISDB	-Grants -Loans -Leasing -Istisna'a -Instalment Sale -Mudarabah/ Restricted -Mudarabah -Equity Participation -Technical assistance	No	N/A	N/A	
EU-LIFE	Grant and Technical Assistance.	Yes	No similar project found; however financing resilient infrastructure is one of the priority actions under the climate adaptation funding area.	N/A	

Fund(er)	Types of support available	Co-financing required?	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
OFID	Grant; Trade finance; Public and Private sector lending.	Yes	No similar project found.	N/A	OFID already financed projects in Turkey, including: • Sivas-Erzincan Development Project, Agriculture, 2003 • Develi Environmental and Irrigation Project, Agriculture, 2004 • Samsun Light Rail System Project, Transport, 2006 • Zonguldak Waste Water Treatment Plant Project, Water & Sanitation, 2008 • Ankara-Istanbul High Speed Train Project, Transport, 2009 •ATM Saglik Manisa Yatirim ve, Health, Private Sector Debt,2017 • Fibabanka A. S. (Fibabanka), Financial, Trade, 2015 • Odea Bank A.S. (OB), Financial, Trade, 2016 • Sekerbank, Financial, Trade, 2015 • Tiryaki Agro Gida Sanayi ve Ticaret A.S. (TAGST) Agriculture, Trade, 2015 • Tiryaki Agro Gida Sanayi ve Ticaret A.S. (TAGST) Agriculture, Trade, 2014 • Turkiy Petrol Refinerileri A.S., Mining, Trade, 2012
PPIAF	Grant Technical Assistance	No	Relevant info here: https://ppiaf.org/pillar/energy-efficiency	N/A	PPIAF already financed two projects in Turkey: 1. City Creditworthiness Initiative Technical Assistance for 5 Municipalities in Turkey, Transport (2017) 2. Technical Assistance Program for Sub-National Financing (2017)

8.3.2. **Bilateral climate funds**

Table 8-3: Objectives of the fund, sectoral/thematic focus and access modalities of selected bilateral funds. (Source: Report authors).

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed (climate resilience investments in hard infrastructure, enabling environment etc.)	Access modalities (including access through accredited entities)
Agence Française de Développement (AFD)[140]	AFD is France's public development bank. It provides financing and technical assistance to projects in developing and emerging countries and in the French overseas provinces. AFD promotes the transition of these countries to sustainable development.	Climate Change Adaptation and Disaster Risk Management	Rural development, food security, water and sanitation, urban infrastructure, transportation, agriculture, education, banking and microfinance, energy, sustainable cities, sustainable resource management, climate change, ocean, biodiversity, forests, peace and justice, gender equality, international partnerships.	Proposals must be submitted by the local contracting authorities to the AFD offices. Proponents should also provide a feasibility study, including a technical study, marketing survey and financial projections.
Kreditanstalt für Wiederaufbau (KfW)[141]	Provides financial support for projects in the areas of climate change, sustainable economic development, energy and water supply, infrastructure, urban development, solid waste management, transport, protection of forests and biodiversity, agriculture and forestry.	Agriculture, Forestry and Fishing Climate Change Adaptation Mitigation Human Settlements Land use Natural Resources and the Environment Water	- Poverty and empowerment - Education - Biodiversity - Energy - Financial system development - Peace - Health - Governance - International development cooperation - Climate - Rural development - Social protection - Urban development - Transport - Environment and sustainability - Insurance - Economic growth - Water	KfW financial resources can be accessed by developing an agreement between partner countries and the German federal government. Such agreement would define the specific programmes to be financed and would form the basis of the funding provided by KfW. KfW supports and advises its partners throughout the entire project cycle, including before and after execution.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed (climate resilience investments in hard infrastructure, enabling environment etc.)	Access modalities (including access through accredited entities)
German International Climate Initiative (IKI)[142]	IKI finances international projects in the areas of climate change mitigation, adaptation, REDD+ and biodiversity conservation. IKI seeks to ensure its investments can catalyse other funding streams and encourage private sector participation.	Climate Change Adaptation Mitigation Natural Resources and the Environment	Mitigation activities: - Low emissions development strategies and nationally appropriate mitigation actions; - Monitoring of greenhouse gas emissions and mitigation actions; - Promoting cooperation with the private sector. Adaptation activities: - EbA - Ecosystem-based Adaptation; - Risk management instruments; - Innovative solutions for insuring against weather risks; - Development and implementation of national adaptation strategies; - Monitoring and reporting of adaptation. REDD+ activities: - REDD+ mechanism - keeping forests intact for climate change mitigation; - Ecological and social standards and additional benefits of carbon sequestration; - Bonn Challenge: restoring forest landscapes; - Monitoring, reporting and verifying REDD+. Biodiversity activities: - Mechanisms for planning and managing biological diversity; - Protected areas and ecosystem services.	Project proponents must submit their proposals using the form provided on the IKI website. The first phase requires the submission of only a project outline. The German Environment Ministry (BMUB) evaluates the outlines received and undertakes a preliminary screening. This takes into account foreign and development policy criteria and available budget funds. Applicants will be informed in writing of the results of the evaluation. Proponents, whose project outlines are shortlisted, are then invited to submit a full application in the second phase[143]. The template to be used is provided with the invitation for submission. The decision on funding by BMUB is based on the final appraisal of each funding application.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed (climate resilience investments in hard infrastructure, enabling environment etc.)	Access modalities (including access through accredited entities)
Japan International Cooperation Agency (JICA)[144]	Assists and supports developing countries as the executing agency of Japanese's Official Development Assistance (ODA). In accordance with its vision of "Inclusive and Dynamic Development," JICA supports the resolution of issues of developing countries by using the most suitable tools of various assistance methods and a combined regional-, country- and issue-oriented approach.	Climate Change Adaptation Resilience Meteorology and Weather	Education, Health, Disaster Risk Reduction, Governance, Natural Resources and Energy, Private Sector Development, Rural Development, Natural Environment Conservation, Fisheries, Sustainable Development based on safe and resilient society, Gender and Development, Urban/Regional Development, Environmental Management, Poverty Reduction. In particular, for climate change adaptation priorities are: Mainstreaming of disaster risk management; Infrastructure Rehabilitation project; Improving the Weather forecasting system and meteorological warning facilities improving risk literacy.	**Project application process for grants:** • The country fills a **preparatory survey** for cooperation as part of 'project preparation' phase. JICA assesses the project and develops a workplan with the government of the partner country. • The country submits an '**official request**' to JICA for examination and appraisal. • If appraisal is successful, the Japanese government provides the '**approval by the Cabinet**'. • The partner country signs the '**Exchange of Notes**' with the Japanese government, then signs a '**Grant Agreement**' with JICA. • During implementation, **JICA monitors progress of the project** and gives advice to stakeholders including the government of the partner country, while respecting country ownership of the project. • After completion of the project**,** JICA prepares an **'ex-post evaluation**', and where necessary, provides '**Follow-Up Cooperation**' in the form of materials and equipment procurement, emergency repair work, etc. The application process for loans is similar to the one described above for grants. More information is available at: https://goo.gl/ULwzLx
Swedish International Development Cooperation Agency (SIDA)[145]	The objective of SIDA is to create opportunities for people living in poverty and under oppression to improve their living conditions. SIDA provides both humanitarian aid and long-term development cooperation.	- Democracy, human rights and freedom of expression - Gender equality - Environment and climate - Health - Market development - Agriculture and food security	The details of activities financed by SIDA under each priority area are available at: http://www.sida.se/English/how-we-work/our-fields-of-work/	Different type of organisations can access SIDA funding in different ways. **Civil society organisations (CSOs):** - CSOs can apply for funding by developing a framework agreement with SIDA. - CSOs can apply for humanitarian aid and to receive support for innovation. - SIDA provides funding for CSOs that work to influence the private sector to take greater responsibility for sustainable development and responsible business conduct.

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed (climate resilience investments in hard infrastructure, enabling environment etc.)	Access modalities (including access through accredited entities)
		- Education - Sustainable societal development - Conflict, peace and security - Humanitarian aid		**Private sector:** - SIDA finances entrepreneurs that have a strong commitment to drive sustainable development via the 'Challenge Funds'. - SIDA provides support for the development of PPPs to pro-actively engage the private sector in the development of sustainable societies in low income countries. - SIDA uses its guarantee instrument to mobilise capital for developmental purposes. - Through the Swedish Leadership for Sustainable Development, SIDA provides financial resources to: 1) Reduce negative impacts on environment and promoting efficient use of resources; 2) Create decent jobs, productive employment and development opportunities; 3) Fight corruption and unethical behaviour. **Public Sector:** - SIDA provides funding to prepare a 'Twinning Project Proposal': EU Twinning and TAIEX are EU-funded programmes aiming to establish contacts and support mutual exchange between EU Member States. Research institutions: - SIDA provides funding for capacity building activities, as well as to support global, regional and national research and innovation. More information is available at: http://www.sida.se/English/partners/our-partners/

Fund(er)	Objectives of the fund	Sectoral/thematic focus	Type of activities financed (climate resilience investments in hard infrastructure, enabling environment etc.)	Access modalities (including access through accredited entities)
UK International Climate Fund (ICF)[146]	UK ICF supports developing countries addressing the challenges presented by climate change and benefit from the opportunities.	Climate Change Adaptation Mitigation Energy Energy efficiency Renewable energy Natural Resources and the Environment Water	Promotes sustainable economic growth and poverty reduction in three key areas: - Supporting sustainable and inclusive economic growth; - Building resilience to manage risks; and - Improving stewardship of natural resources.	Funding requests should be developed in partnership with a DFID country office or UK government department. The ICF Secretariat can be contacted through the DFID public enquiry point or via DFID country offices or UK Embassies/High Commissions overseas.

Table 8-4: Eligibility criteria, sectoral/thematic focus, co-financing requirements, examples of relevant projects approved and average decision time of selected bilateral funds. (Source: Report authors).

Fund	Who can apply? (what type of organization/ institution is eligible)	Types of support available	Co-financing requirements	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
AFD	LDCs, middle income countries, emerging markets and overseas territories of France can apply for AFD funding. To LDCs, AFD mostly provides grants. To middle income countries, AFD lends at favourable conditions and strengthen cooperation. In emerging markets, it mostly provides market-based loans to finance projects to combat climate change or to promote growth that respects men and the environment. Finally, in the overseas territories of France, advises and provides loans for local public and private sector entities.	Grant Loan Technical Assistance	no	AFD activities in the infrastructure sector are described here: https://goo.gl/aVNRFp	N/A	Turkey already accessed AFD. The description of projects funded is available at: https://www.afd.fr/sites/afd/files/2017-09/Turquie-plaquette.pdf In 2009, the AFD Group launched its program Turkey-Climate in partnership with five local banks which pulled together 350 million euros for projects of energy efficiency and renewable energy. "AFD supported 168 projects, 36 of them in renewable energies (solar, hydroelectric, wind, biomass), i.e. over 2.5 million tons of CO2 equivalent avoided per year."[147]
KfW	Public and private entities	Grant Loan ODA Structural Financing	no	Improvement in the water supply for one million people in Jordan: Project description here: https://goo.gl/DLYKZ1	N/A	Turkey already received KfW support: https://goo.gl/L3TY4v The areas of focus in Turkey are: - Renewable energy and energy efficiency - Sustainable economic development - Municipal infrastructure - Refugee crisis Focus on climate change and resilient infrastructure are presented at: https://goo.gl/XzbsPp

Fund	Who can apply? (what type of organization/ institution is eligible)	Types of support available	Co-financing requirements	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
IKI	IKI funds can be accessed by federal implementing agencies, NGOs, business enterprises, universities and research institutes, and by international and multinational organisations and institutions, e.g. development banks and United Nations bodies and programmes. More details on the selection process can be found here: https://goo.gl/oF6xod	Grant Loan ODA	no		N/A	Several projects already financed in Turkey.
JICA	Governments, NGOs, Institutions.	Grants Loans Technical Assistance	no	Training Program for Human Resources Development in the Mining Sector (Kizuna Program) - Fostering Kizuna (Bonds of Friendship) between Japan and the World through Human Resources Development The project description can be found here: https://goo.gl/GXALGA	N/A	Turkey already accessed JICA.
SIDA	Loans, guarantees, partnerships, EU blending, and innovative financing.	N/A	N/A	N/A	N/A	

Fund	Who can apply? (what type of organization/ institution is eligible)	Types of support available	Co-financing requirements	Examples of projects approved which are similar to the recommended climate resilience building activities in the CIRA	Average decision period for proposals submitted to the fund	Notes
UK ICF	ODA recipients	Grant Loan ODA	no	N/A	N/A	Engaging with the private sector is a key part of the ICF's Strategy to increase private finance to tackle climate change. "A range of programmes financed through the ICF are involved in working with the private sector. These include the World Bank's Carbon Initiative for Development (Ci-Dev) and the Results Based Financing Facility (for energy access) being delivered through the Energising Development (EnDev) programme."[148]

8.4. Climate finance project highlights in Turkey or similar locations

This section presents selected projects funded by international climate funds (respectively the GCF and IBRD) which involve financing of climate resilient infrastructure in Turkey and similar locations.

Table 8-5: Project highlight 1: Scaling up hydropower sector climate resilience in Tajikistan. (Source: Report authors).

Fund	GCF (co-financed by EBRD and EIB)
Implementing entity/agency	EBRD
Executing entity	Ministry of Finance
Thematic Focus	Cross-cutting (adaptation & mitigation)
Sector	Infrastructure
Implementation start and end dates	Start: 2017 End: 2023
Beneficiaries	The entire population of Sughd region, 2,400,000 will directly benefit from more secure and reliable electricity supply. This is based on the fact that Qairokkum HPP is the only major electricity generation asset in the northern Sughd region and thus responsible for secure and reliable supply to all households in the region.
Financial instrument	Senior loan and grant
Total requested funding	USD 133 million
Co-financing	USD 83 million
Project description	**This project aims at scaling up the adoption of climate resilience practices and technologies in the Tajik hydropower sector**. Enhanced institutional capacities, modern climate resilience technologies and adequate technical skills are urgently needed in Tajikistan to address the risks associated with climate change in the fragile and highly climate-vulnerable hydropower system. It will support the transfer of knowledge and technologies for achieving these targets and will be delivered through a structured approach comprising of technical assistance, policy dialogue and facility upgrades in close partnership with the Tajik authorities.
Project objective	The objective of the project is to build the climate resilience of a critical but climate-vulnerable sector (hydropower) and introducing best international practices on climate risk management in hydropower operations. Specific benefits include: • The modernisation of a major hydropower facility taking into account projected future climate conditions • The population of Sughd region (approx. 2,400,000 people), in particular women, will benefit from a more secure and climate-resilient electricity supply.
Project outputs	**Output 1:** Increasing the adoption of international best practices in climate risk management in the hydropower sector; **Output 2:** Develop institutional capacities and structures for effective transboundary management of hydropower cascades; **Output 3:** Scale up the integration of climate resilience measures into a strategic hydropower facility (Qairokkum HPP) with high demonstration impact across the sector.

Table 8-6: Project highlight 2: Strengthening critical infrastructure against natural hazards in Tajikistan. (Source: Report authors).

Fund	IBRD
Implementing entity/agency	Ministry of Finance, Republic of Tajikistan
Executing entity	Ministry of Finance
Thematic Focus	Cross-cutting (adaptation & mitigation)
Sector	Infrastructure
Implementation start and end dates	Start: 2017 End: 2023
Beneficiaries	People who live in the disaster prone areas of Tajikistan covered under the project.
Financial instrument	Credit: US$ 25 million - Maturity 38 years; Grace 6 years Grant: US$ 25 million
Total project cost	USD 50 million
Co-financing	N/A
Project description	**The project aims at strengthening the disaster risk management capacities in Tajikistan, enhance the resilience of its critical infrastructure against natural hazards, and improve its capacity to respond to disasters**. It will be achieved by attaining a better understanding of disaster risks, improving disaster risk–informed planning, designing and reconstruction of critical infrastructure (including bridges and flood protection and riverbank erosion–prevention infrastructure), and improving the Government of Tajikistan's (GoT) capacity to respond promptly and effectively in emergencies.
Project objectives	**The project is structured around four components:** 1. Strengthening disaster risk management capacity. This component is intended to strengthen the GoT's capacity for DRM through selected activities that focus on disaster risk identification, disaster preparedness, and financial protection against disasters. It will be implemented in coordination with UNDP, which has been continuously strengthening the capacities of the Committee of Emergency Situations and Civil Defense (CoESCD) at the national and regional levels, while building regional mechanisms for disaster risk management and mainstreaming disaster risk reduction into state policy at the national and subnational levels. 2. Making critical infrastructure resilient against natural hazards. This component will finance capital works and contingency planning (for example, equipment for emergency situations) for the transportation network in Gorno-Badakhshan Autonomous Oblast (GBAO), which suffered the most significant damage in July 2015, as well as the flood protection infrastructure that has repeatedly been damaged in the Khatlon Oblast. 3. Contingent emergency response component. The objective of this component is to enhance Tajikistan's capacity to respond to disasters. An emergency eligible for financing is an event that has caused, or is likely imminently to cause, a major adverse economic and/or social impact to the Borrower, associated with a disaster. Finally, the fourth component is the project management.
Project outputs	N/A

Table 8-7: Project highlight 3: Climate resilience in the power sector: Turkey - risk assessment and investment needs. (Source: Report authors).

Fund	EBRD
Implementing entity/agency	EBRD
Executing entity	N/A
Thematic Focus	Cross-cutting
Sector	Sustainable Resources and Climate Change, Power and energy
Implementation start and end dates	N/A
Beneficiaries	N/A
Financial instrument	N/A
Total project cost	EUR 310,000
Co-financing	N/A
Project description	This project aims at understanding and quantifying the potential effects of climate change on the power generation and transmission assets in Turkey as well as provide an initial assessment of the most technically-robust and economically-viable solutions for mitigating the effects.
Project objectives	The project is structured around three components: 1. Country Level Assessment – (i) Review and identify the potential high-level impact of climate change and associated shifts in mean and peak climatic conditions on the power sector (both generation and transmission), (ii) Develop and pilot a methodology for calculating water consumption by energy generation facilities that will enable meaningful comparisons and the establishment of benchmarks at both the facility-level and country-level; and (iii) Prepare a high-level action-plan for mitigating the potential impacts, in terms of technologies available. 2. Preparation Case Studies – (i) Review and identify the potential impact of climate change on a number of specific power plant, energy storage or transmission assets in terms of type and probability of disruptions, gradual loss of capacity and efficiency due to rising temperatures and water stress, risk of out of services, etc.; and (ii) For each facility, prepare a priority investment plan of technically available and economically viable retrofit solutions which could help reduce the potential impact of climate change on the asset. 3. National Workshop - Organise and manage a national workshop in Turkey for disseminating the findings of the assignment. It is anticipated that the workshop will target all the major stakeholders of the power sector in the country, policymakers, regulators, operators and others to facilitate a broader application of the developed tools and methodologies and initiate a proactive discussion on risks, priorities, suitable technologies and implementation/financing approaches for mitigating the anticipated impacts of climate change.
Project ouputs	N/A

Table 8-8: Additional project examples. (Source: Report authors).

Fund	Project title	Implementing entity	Executing entity	Funding requested	Objective
AF	Promoting climate change resilient infrastructure development in San Salvador Metropolitan Area	United Nations Development Programme (UNDP)	Ministry of Public Works, Transport, Housing and Urban Development (MOP)	Grant $ 5,425,000	To reduce the vulnerability of urban areas to flooding, erosion, and landslides created by extreme precipitation associated with climate variability and climate change. Full project description available at: https://goo.gl/qc7CG3
GEF- SCCF	Climate-resilient Infrastructure in Northern Mountain Province of Vietnam	Asian Development Bank (ADB)	Government of Viet Nam	GEF Grant $ 3,400,000	To increase the resilience and reduce vulnerability of local, critical economic infrastructure in the northern mountains areas of Vietnam to the adverse impacts of climate change and to support a policy framework conducive to promoting resilient northern mountains zone development. Full description available at: https://goo.gl/PbMqLy
GEF- SCCF	Strengthening the Resilience of Small Scale Rural Infrastructure and Local Government Systems to Climatic Variability and Risk in Timor Leste	UNDP	Ministry of Economy and Development; Ministry of State Administration and Territorial Management; Ministry of Infrastructure	GEF Grant $ 4,600,000	To design climate resilient critical small scale rural infrastructure and strengthen local governance systems, reflecting the needs of communities vulnerable to increasing climate risks. Full description available at: https://goo.gl/ikS961
GFDRR	Increasing Climate Resilience of Georgia's Road Network	N/A	GFDRR	Grant $200,000	To build an effective strategy to manage climate risks in Georgia’s road network by assessing the vulnerability of the country's roads to climate change and improving the Roads Department (RD) of the Ministry of Regional Development and Infrastructure (RDMRDI)'s climate resilience planning. Full description available at: https://goo.gl/WZhzAx

Fund	Project title	Implementing entity	Executing entity	Funding requested	Objective
GFDRR	Mainstreaming Natural Hazard and Climate Risk Information and Community Driven Development in Afghanistan	N/A	N/A	Grant $1,300,000	To integrate natural hazard and climate change risk information into planning and decision making for select sectors in Afghanistan, and promote risk informed community-driven development (CDD). To achieve this objective, the project will support: (i) knowledge management and dissemination of hazard risk profiles; (ii) development of an exposure model for Kabul City to increase urban resilience; and (iii) development and piloting resilient infrastructure designs for inclusive and community resilience. Full description available at: https://goo.gl/5Aa3bJ
GCF	Climate-Resilient Infrastructure Mainstreaming in Bangladesh	KfW	Local Government Engineering Department of Bangladesh	Grant $ 40 million	To integrate climate change adaptation systematically into decision-making for infrastructure planning, supervision and maintenance of the Local Government Engineering Department (LGED), responsible for local infrastructure throughout Bangladesh. Full description available at: https://goo.gl/uYt47j
Horizon 2020	Extreme Weather impacts on European Networks of Transport	N/A	Consortium led by Teknologian Tutkimuskeskus VTT, Finland	Grant € 1,478,981	To assess the EU policies and strategies on climate change with particular focus on extreme weather impacts on EU transportation system. The goal of EWENT is to estimate and monetise the disruptive effects of extreme weather events on the operation and performance of the EU transportation system. Full description available at: https://goo.gl/6VmrNy
Horizon 2020	INTACT: Impact of Extreme Weather on Critical Infrastructures)	N/A	Consortium including Dragados SA (Spain), Stiftelsen Norges Geotekniske Institutt (Norway),	Grant € 3,445,518.92	To offer decision support to critical infrastructure (CI) operators and policy makers regarding Critical Infrastructure Protection (CIP) against changing extreme weather events' risks caused by climate change.

Fund	Project title	Implementing entity	Executing entity	Funding requested	Objective
			United Nations University (Japan), Teknologian tutkimuskeskus VTT Oy (Finland)		Full description available at: https://goo.gl/Z3cHWm
Horizon 2020	CIPRNET: Critical Infrastructure Preparedness and Resilience Research Network	N/A	Consortium including Universita Campus Bio Medico di Roma (Italy), University of British Columbia (Canada) Acris GMBH (Switzerland)	Grant € 6,569,842.50	To enhance the resilience of CI by improving the understanding, preparation and mitigation of the consequences of CI disruptions following an all hazards approach. To develop a Network of Excellence in CIP R&D for a wide range of stakeholders including (multi)national emergency management, critical infrastructure (CI) operators, policy makers, and the society.
IBRD	Climate Resilient Infrastructure in Belize	Belize Social Investment Fund	Ministry of Finance of Belize	Loan $ 30 million	To enhance the resilience of road infrastructure against flood risk and impacts of climate change; and To build the government's capacity toto mainstream climate resilience considerations into core physical and investment planning and asset maintenance Full description available at: https://goo.gl/fUxmxU

8.5. Prioritised list of climate funds for resilience-building actions in the CIRA

Based on the prioritisation and ranking undertaken, a set of eleven highest scoring climate funds are recommended for further discussions as potential viable funding options for the implementation of the resilience building actions from the Çukurova CIRA. The results of this analysis are presented in Table 8-9 below.

Table 8-9: Ranking and prioritisation of multilateral and bilateral climate funds to which proposals could be submitted for climate resilience-building measures identified in the CIRA. (Source: Report authors).

Fund	C1: Relevance of the fund for the climate resilience-building activities highlighted in the Çukurova CIRA	C2: Compliance with funds' eligibility criteria	C3: Ease of access to the fund	C4: Previous experience in accessing the fund by Turkey	Total	Ranking
JICA	3	3	3	3	12	1
KfW	3	3	3	3	12	1
EU-IPA	3	3	3	3	12	1
AFD	3	2	3	3	11	2
EBRD	3	3	2	3	11	2
IBRD	3	3	2	3	11	2
EU-LIFE	3	3	2	3	11	2
OFID	2	3	3	3	11	2
ISDB	2	3	3	3	11	2
Horizon 2020	3	3	3	2	11	2
SIDA	3	3	3	2	11	2
IKI	2	3	2	3	10	3
UK ICF	3	3	2	2	10	3
GFDRR	2	3	2	3	10	3
PPIAF	2	3	2	2	9	4
EIB	2	2	2	3	9	4
IFC	2	1	2	3	8	5
AIIB	3	3	2	0	8	5
SCCF	3	1	2	0	6	6
AF	3	1	1	0	5	7
GCF	3	1	1	0	5	7

9. Concluding remarks

Successful growth aspirations and drive for competitiveness in the Çukurova region requires support from measures to strengthen the resilience of its critical infrastructure (CI). This itself can only be achieved through a united approach by infrastructure designers, developers and operators and the ÇKA. Critical infrastructure plays a fundamental role in the economic and social development of local, regional and national economies. The current state-of-play is that the legislative, planning and design and operation processes driving and supporting infrastructure investments are yet to fully address the issue of a changing risk landscape. This places at risk the economic and financial models which underpin large scale infrastructure investments and their economic benefits.

ÇKA should consider its existing planning processes and assess where and how it can integrate climate resilience measures in the planning process – a good starting point is to use existing considerations for geological hazards as entry points. Development planning at all scales – local, regional, national and across national borders – has a critical role to play in integrating multi-hazard resilience into infrastructure. This report has demonstrated that a broad suite of measures can be implemented by infrastructure developers to build resilience into their assets. It has shown that non-structural risk management measures, such as management and operational changes, can contribute significantly to ex-ante resilience, and they are often less costly than structural measures. Furthermore, they are inherently flexible, contributing to adaptive management in the face of future uncertainties.

ÇKA should look to the factors which can govern selection of options for CI resilience in the region, in the first instance aiming these at non-structural and low regret options which help build resilience, strengthen instructional capacity and reduce overall vulnerability of the region and its socio-economic populations. With respect to CI assets, structural measures should be considered at the early stages of design and planning for new investments, or during rehabilitation or renovation of existing facilities, to minimize costs.

A range of methods are available to appraise risk management options, depending on the decision-makers' objectives and information available for the analysis. The methods emphasize the need to consider the costs and benefits of the options not only for the infrastructure developer, but also for wider stakeholders who will be affected by the decision. The methods for appraising options needs to be considered by ÇKA, depending on whether ÇKA wants to fulfill a single economic objective, , or whether ÇKA wants multiple objectives to be considered that may not always be expressed in monetary terms. ÇKA also needs to consider its own attitude to risk, and how this should be represented for the region in its own capacity as an agent for change. ÇKA should begin by looking at its internal methods of financial or economic appraisal, with a view to adapting these to include the concept of appraising options in an uncertain climate.

ÇKA could also drive forward the development of a central knowledge base to support resilience activities within this nationally important region. This can range from awareness raising workshops, to providing international best practice case studies on how this challenge is being addressed by others today, and on provision of finer scale data targeted to the individual needs of types of infrastructure that are considered critical in the region.

The following recommendations are provided as next steps for the region to access climate finance:

- Build the capacity of local (municipal) planning authorities and ÇKA, working closely with national government authorities and owners / operators of energy and transport & logistics infrastructure, to access and plan effective and efficient uses of international climate finance.
- Start discussions with the relevant multilateral and bilateral climate funds presented in Section 8.5, with a view to generate interest in developing a specific project and programme proposal for

the implementation of the resilience building actions identified through the Çukurova CIRA and identify most viable funding options based on the preliminary assessment provided in this section.

- Carry out further assessment of the most viable funding options and undertake further engagement with relevant stakeholders, including national government authorities and owners / operators of energy and transport & logistics infrastructure.
- Identify appropriate access modalities to the most viable funding option identified, by engaging with relevant multilateral implementing entities to submit potential funding applications on their behalf.
- Develop a project and programme proposal, working closely with the relevant multilateral implementing entity for submission to the most viable funding options.

A1 Critical Infrastructure definition & criteria - further information

A1.1 Definitions used by international organisations

A1.1.1 Introduction

A brief literature review was undertaken to identify definitions of critical infrastructure from international organizations (OECD, NATO, UNISDR) and governmental bodies. Governmental bodies were identified by the project team, based on knowledge of governmental bodies that have made progress on defining critical infrastructure including:

- Countries / jurisdictions that are in close proximity to Turkey, namely the EU and certain EU Member States that are more advanced on critical infrastructure assessment (UK, Germany),
- Countries that are technical leaders on critical infrastructure assessment i.e. USA and Australia,
- Countries that have similar socio-economic dynamics and infrastructure investments to Turkey, namely Mexico and the Philippines.

The literature review was not intended to be comprehensive, and it is worth noting that other countries are also developing approaches to defining and identifying critical infrastructure.

A1.1.2 Understanding country drivers

To understand the drivers behind each country's approach to defining and assessing critical infrastructure, it is helpful to know their exposure to natural hazards. A new web-based tool developed by GFDRR, ThinkHazard![149] allows users to assess the level of natural hazards, including river flood, earthquake, drought, cyclone, coastal flood, tsunami, volcano, and landslide within a user-defined area. ThinkHazard! has been developed for a wide range of applications and users. The hazard level is calculated within ThinkHazard! according to the frequency at which that hazard is expected to occur with a damaging level of intensity. For each hazard, ThinkHazard! has set an intensity threshold, above which the intensity parameter is considered to be able to cause damage to a development project of undefined type. The ThinkHazard! country-level hazard ratings for the countries included in this review are presented in Table A 1-1. This reveals that many of the countries are exposed to high or medium exposure to natural hazards, which may partly explain their interest in assessing and managing risks to critical infrastructure.

In addition, some countries have been driven to protect critical infrastructure due to concerns about other hazards or threats, such as terrorism or cyber attack. Understanding these drivers is useful for evaluating their definitions of critical infrastructure and the associated criteria (discussed in Annex A1.3) for their relevance to the Çukurova CIRA. Where information is publicly available on these drivers, it is discussed further below in the country-specific sections.

Table A 1-1: Country level of exposure to natural hazards based on ThinkHazard!. (Source: Report authors; adapted from GFDRR[150]).

Country	Earthquake	Landslide	Volcano	Water scarcity	River flood	Coastal flood	Cyclone
Turkey	High	High	High	High	High	No data available	No data available

UK	Low	Low	Very low	Low	High	No data available	No data available
Germany	Medium	Low	Medium	Medium	High	No data available	No data available
USA	High	High	High	High	High	High	High
Australia	High	Low	Medium	Low	High	High	High
Mexico	High	High	High	High	High	Medium	High
Philippines	High	High	High	High	High	High	High

Definitions and any additional drivers for action identified from governments/supra-national government organisations are presented below.

A1.1.3 Organisation for Economic Co-operation and Development (OECD)

Critical infrastructure: '*Those interconnected information systems and networks, the disruption or destruction of which would have a serious impact on the health, safety, security, or economic well-being of citizens, or on the effective functioning of government or the economy.'*[151]

Critical infrastructure (networks): *'…e.g.* ***energy****,* ***transportation****, telecommunications and information systems.'*[152]

A1.1.4 North Atlantic Treaty Organization (NATO)

Critical infrastructure: '*Physical or virtual systems and assets under the jurisdiction of a State that are so vital that their incapacitation or destruction may debilitate a State's security, economy, public health or safety, or the environment.'*[153]

A1.1.5 United Nations International Strategy for Disaster Reduction (UNISDR)

Critical facilities: '*The primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency.'*

'Critical facilities are elements of the infrastructure that support essential services in a society. They include such things as ***transport*** *systems,* ***air*** *and* ***sea ports****,* ***electricity****, water and communications systems, hospitals and health clinics, and centres for fire, police and public administration services.'*[xxvii]

[xxvii] UNISDR website: https://www.unisdr.org/we/inform/terminology

A1.1.6 European Union

The initial driver for assessing and managing critical infrastructure risk in the EU was the threat of **terrorism**, though this was extended to cover '**all hazards**' in 2005 as explained below:

"In June 2004 the European Council asked for the preparation of an overall strategy to protect critical infrastructures. In response, on 20 October 2004, the Commission adopted a Communication on critical infrastructure protection ***in the fight against terrorism*** *which put forward suggestions as to what would enhance European prevention of, preparedness for and response to terrorist attacks involving critical infrastructures.*

"In December 2005 the Justice and Home Affairs Council called upon the Commission to make a proposal for a European programme for critical infrastructure protection ('EPCIP') and decided that it should be based on an ***all hazards approach while countering threats from terrorism as a priority****. Under this approach, man-made, technological threats and natural disasters should be taken into account in the critical infrastructure protection process, but the threat of terrorism should be given priority."*[154]

Definitions of critical infrastructure are:

Critical infrastructure: '*An asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions*';

'***European critical infrastructure' or 'ECI'*** *means critical infrastructure located in Member States the disruption or destruction of which would have a significant impact on at least two Member States. The significance of the impact shall be assessed in terms of cross-cutting criteria. This includes effects resulting from cross-sector dependencies on other types of infrastructure.'* [154]

Sector	Subsector	
I Energy	1. Electricity	Infrastructures and facilities for generation and transmission of electricity in respect of supply electricity
	2. Oil	Oil production, refining, treatment, storage and transmission by pipelines
	3. Gas	Gas production, refining, treatment, storage and transmission by pipelines LNG terminals
II Transport	4. Road transport	
	5. Rail transport	
	6. Air transport	
	7. Inland waterways transport	
	8. Ocean and short-sea shipping and ports	

Figure A 1-1: Critical infrastructure sectors in the European Union (only transport and energy). (Source: Official Journal of the European Union, 2008 [155])

A1.2 Definitions used by countries

A1.2.1 United Kingdom

The initial driver for protecting critical infrastructure in the UK was the experience of disruption caused by major flooding in 2007, and this was extended to cover '**natural events' more generally,** as explained below:

*"Sir Michael Pitt identified during the **review of the summer 2007 floods**, a gap in the Government's policy-making and delivery towards the protection of critical infrastructure from severe disruption caused by natural hazards. In his Interim Report, Sir Michael concluded "that the Government should establish a systematic, coordinated, cross-sector campaign to reduce the disruption caused by natural events to critical infrastructure and essential services." This Strategic Framework and Policy Statement (the Framework) sets out proposals for a cross-sector systematic programme to improve the resilience of critical infrastructure and essential services to severe disruption by **natural hazards** (the Programme)."*[156]

Definitions of critical infrastructure are:

'*Those infrastructure assets (physical or electronic) that are vital to the continued delivery and integrity of the essential services upon which the UK relies, the loss or compromise of which would lead to severe economic or social consequences or to loss of life'*. [156]

The Cabinet Office does not identify a list of critical infrastructure, but rather provides a broad list of national infrastructure and states that some of the assets within those sectors are deemed as critical.

A1.2.2 USA

Action to protect critical infrastructure in the USA has been driven by terrorist attacks which have been experienced in the USA and elsewhere, together with disruption caused by extreme climatic events, as highlighted below:

*"….the level 1 consequence-based criteria and thresholds were initially established at the beginning of the program at the discretion of the Assistant Secretary for Infrastructure Protection, who sought to identify infrastructure that the destruction of which could be expected to cause impacts similar to those caused by the **attacks of September 11 and Hurricane Katrina**."*

*"In October 2012, the remnants of **Hurricane Sandy** caused widespread damage across multiple states and affected millions of people. Damage included flooding in the nation's financial center that affected major transportation systems and caused widespread and prolonged power outages. The damage and resulting chaos disrupted government and business functions alike, producing cascading effects far beyond the location of these events. Threats against critical infrastructure are not limited to natural disasters, as demonstrated by the **terrorist attacks of September 11, 2001, and the 2005 suicide bombings in London,** where terrorists disrupted the city's transportation system, which resulted in a breakdown of its mobile telecommunication infrastructure."*[157]

Definitions of critical infrastructure are:

'Systems and assets, whether physical or virtual, considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof'.[158]

Table A 1-2: Critical infrastructure sectors, USA. (Source: Report authors; adapted from US Department of Homeland Security[159]).

USA Critical Infrastructure Sectors	
Chemical	Commercial Facilities
Communications	Critical Manufacturing
Dams	Defense Industrial Base
Emergency Services	**Energy**
Financial Services	Food and agriculture
Government Facilities	Healthcare and public health
Information technology	**Nuclear** reactors, materials and waste
Transportation systems	Water and wastewater systems

A1.2.3 Australia

The Australian Government was driven to develop a strategy to protect critical infrastructure following terrorist attacks abroad:

"In the wake of the 11 September 2001 ***terrorist attacks*** *in the United States and the 2002 Bali Bombings, the Australian Government established a national Critical Infrastructure Strategy for Australia. This* ***'all hazards'*** *Strategy provided a strong foundation on which critical infrastructure owners and operators and governments could prepare for, and respond to, a range of significant disruptive events."*[160]

While the development of the strategy was initially spurred by these terrorist attacks, it aims to ensure the continued operation of critical infrastructure in the face of 'all hazards' which includes "*natural disasters, pandemics, negligence, accidents, criminal activity, or computer network attack*."

The Australian, State and Territory governments define critical infrastructure as:

"those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of the nation or affect Australia's ability to conduct national defence and ensure national security."

"In this context, significant means an event or incident that puts at risk public safety and confidence, threatens our economic security, harms Australia's international competitiveness, or impedes the continuity of government and its services."[160]

A1.2.4 Mexico

The *U.S.-Mexico Border Partnership Declaration*, signed in March 2002, in Monterrey, Mexico, provided both countries with the basis to develop the *Framework of Cooperation for Critical Infrastructure Protection (CIP)*. This framework covered a broader set of threats to infrastructure:

"Under this framework, the governments of Mexico and the United States share the commitment to protect their populations and critical infrastructure from ***terrorist attacks, natural disasters and any another eventuality that may compromise their integrity and operation****. The protection of the critical infrastructure network on the border - taking into consideration the interdependency between the two countries, and vulnerabilities - represents challenges and opportunities for both countries."*[161]

According to one citation, "*Mexico's national security law establishes the government's obligation to protect the country's critical infrastructure, such as* ***ports****,* ***airports*** *and* ***energy*** *installations*."[162] However, a review of Mexico's National Security Legislation, "*Ley de Seguridad Nacional*" did not identify a definition of critical infrastructure[163].

Historically, the Security and Prosperity Partnership (SPP) of North America was a collaborative North American approach, emphasizing and supporting critical infrastructure planning, preparedness, response and recovery processes within and across borders during a pandemic. It recognized major interdependencies among Mexico, Canada and the United States. According to an SPP report, Mexico defined critical infrastructure as:

"*those assets, services and networks that are indispensable to the support and maintenance of the well-being of the Mexican population*. *Following the concept stated by the U.S.-Mexico CIP, Mexico has established sectoral working groups to evaluate and improve the protection of critical infrastructure within its territory. In this context, Mexico's approach includes eight sectoral working groups:* ***Energy****, Telecommunications,* ***Transportation****, Water and Dams, Public Health, Food & Agriculture, Cyber Security and Strategic Facilities."'*[164, 165]

A1.2.5 Philippines

No official or widely-accepted definition of critical infrastructure was identified for the Philippines. However, the World Bank report, *"Safe and Resilient Infrastructure in the Philippines"*, links the critical nature of infrastructure to post-disaster needs, whereby:

'*[i]n the aftermath of disasters, hospitals, as well as* ***transportation****,* ***power****, water systems, and telecommunications network infrastructure, are functionally critical; swift resumption of public services and hospital operations helps to normalize the situation in affected areas and mitigate a secondary wave of human and economic losses.'*[166]

A1.2.6 Turkey

The Turkish Republic Prime Ministry Disaster and Emergency Management Authority's (AFAD's) Roadmap for Protection of Critical Infrastructure 2014-2023 (RPCI)[167] was prepared by the Directorate General for Planning and Disaster Risk Reduction, Technological Risks Risk Reduction Working Group in close collaboration with relevant government stakeholders. The RPCI explains that the Military Zones Protection Regulation was the first legal regulation in Turkey that touched upon physical protection of critical infrastructure. The only legal regulation (as of the date of the RPCI publication) is the Cabinet Decree on Coordination and Execution of National Cyber Information Security (20 October 2012). Subsequently an action plan has been adopted by another Cabinet Decree dated 20 June 2013. The RPCI notes that an increasing trend of the **threat of terrorism** for Turkey is leading to an intensification of efforts to protection of critical infrastructure.

There is no official and widely accepted definition of CI used in Turkey. Instead, a brief literature review reveals that the EU and US definitions are often used by authors/experts.

The focus on identification and risk management for critical infrastructure is a relatively new phenomenon in Turkey. Therefore, the number of projects/initiatives finalised to date is very limited. AFAD's RPCI defines critical infrastructure as:

Critical Infrastructure (CI): *Combination of networks, assets, systems and structures which can have serious impacts on health, security, and economy of citizens due to adverse impacts on environment, society order and public services that occur as a result of partial or complete loss of functionality of such networks, assets, systems and structures*.

The document also defines **European Critical Infrastructure (ECI):** *A critical infrastructure that can have impacts on at least two member states due to partial loss or complete loss of functionality*.

The document notes that an action plan has been adopted by a Cabinet Decree (20 June 2013) which prioritizes the following sectors: **transportation, energy,** electronic communication, finance, water management and critical public services.

A1.3 Criteria applied by international organisations and countries

A1.3.1 European Union

The identification of critical infrastructure in the European Union is carried out by the Member States that identify potential CIs that satisfy the **cross-cutting and sectoral criteria** listed below, and meet the EC definition of CI.

Member states are responsible for implementing a methodology to identify critical infrastructure that works within their national context. The thresholds are developed by each member state, taking into account qualitative and quantitative effects of the disruption and destruction of a particular infrastructure.[168]

Sectoral Criteria

These criteria do not consider the potential impact of disruption or destruction of the infrastructure on society, but just its nature.

The specific sectoral criteria for the energy and transport sectors are classified information and therefore could not be found through an open-source literature search. The process by which critical infrastructure is to be identified by Member States is as follows:

1. **Prescribe specific properties**: for example, dimensions, capacities, and distances which an infrastructure should have, in order for the criteria to be met; thresholds for the specific properties may be decided by the concerned Member States. In general, a Member State will work within the sectors to identify all infrastructures that meet the properties set out by the criteria.
2. **Identify networks of which the key elements must be determined**. Identification of these key elements needs to take place by analysing the system as a whole and identifying those elements that can potentially cause large disruptions of the system, which could lead to significant losses in Member States.
3. **Allow a Member State to identify an asset directly.**

Cross-cutting criteria

a. **'Casualties'** - assessed in terms of the potential number of fatalities or injuries,
b. **'Economic effects'** - assessed in terms of the significance of economic loss and/or degradation of products or services, including potential environmental effects,
c. **'Public effects'** - assessed in terms of the impact on public confidence, physical suffering and disruption of daily life, including the loss of essential services.

'The cross-cutting criteria thresholds shall be based on the severity of the impact of the disruption or destruction of a particular infrastructure. The precise thresholds applicable to the cross-cutting criteria shall be determined on a case-by-case basis by the Member States concerned by a particular critical infrastructure'. [169]

a. Further details on the 'Casualties' criterion

Guidelines for the application of the casualties criteria

In the assessment of casualties the precise number is not required, only an order of magnitude.

Estimation of the exposed population

Estimations can be derived from statistics on the use of a service among a population, on the number of customers provided by the operator, on the population living in the area where the service is delivered, etc.

- How many people are using the service and are impacted by the loss of service?
- How many people are using other services that are dependent on the service that is lost?
- Are there sensitive structures where people could suffer more from the service disruption (e.g. hospitals, retirement houses, schools, etc.)?
- Within these exposed populations, are there sensitive groups?

(Sensitive groups are typically people over 65, children, disabled people, etc. They are considered as more vulnerable to the loss of service)

Evaluation of the vulnerability of the population exposed

This may be done for instance on the basis of lessons learnt taken from past events, where relevant or using existing vulnerability functions when they exist on the basis of expert judgment. This vulnerability assessment should take into account the duration of the service's disruption.

- Is the service disruption more susceptible to causing fatalities or injuries?
- Are there similar events that in the past caused casualties? In which proportion?
- Are there already existing vulnerability functions that are used at national level to assess casualties in case of a service's disruption?

Assessment of the coping capacities and alternatives

- What is the level of coping capacities of the population (stocks of food, water, alternative resources for heating, etc.)?
- Are the rescue services prepared to face this kind of service disruption?

b. Further details on the 'Economic effects' criterion

Definitions

- Economic losses are those losses related to the loss of service

Main Assumptions

- This calculation should take into account whether alternatives or temporary solutions may be found, including the additional costs these incur,
- The environmental impact and related costs should be included in the calculation of economic impact,
- Cascading effects should be counted where it can be demonstrated that they can be reasonably calculated,
- Restoration costs shall be considered on a sectoral basis.

Issues for the application of the economic criteria

Economic losses include

- Loss of production which represents a real impact on the national economy.
- Environmental impact which represents a real impact on the national economy.

Key issues for assessing economic losses in a scenario

The impact of a disruption is assessed in terms of how business is interrupted for the duration of the disruption. The following questions provide further guidance in the assessment of the infrastructure.

Impact

- How is the infrastructure used in the production process?
- What would be the scale of the disruption if the infrastructure fails? (local/regional/national)
- How long will it take before the service is restored, once it has been lost?
- What is the number of end users being affected in the category agriculture?
- What is the number of end users being affected in the category households?
- What is the number of end users being affected in the category industrial producers?
- What is the number of end users being affected in the category service sector?
- What is the normal income received by the previously mentioned categories for a period with a length equal to the duration of the loss of service?

Alternatives

Alternatives are a key issue in assessing the net effect of a disruption in infrastructure. Currently no standard methods exist, however a few rules of thumb or key questions can be identified:

- In the affected area, is there any specialized industry?
- In the affected area is there any unique installation, for which no alternatives exist, that would be interrupted in its normal business in case of a disruption in one of the infrastructures?
- Do sufficient producers exist which can replace the lost production within the geographic limits of the area of interest?
- Is there any cost associated with transferring production and/or using these alternatives?

Net-impact

- When taking into account the issues mentioned under the section "alternatives" above, how much of the lost production under the section "impact" can be made up for in un-affected areas?

Assessing cascading effects

Cascading effects may constitute a significant part of the loss incurred due to a disruption in critical infrastructure. The following provides indications on when to pay special attention to cascading effects.

- Long duration of disruption
- Event affecting significant proportion of the area (region, Member State) of interest
- Impacts on highly concentrated and specialized industry or services
- Nodal points in networks (communications, transport, energy, information) are affected.

c. Further details on the 'Public Effects' criterion

Main Assumptions

For the purpose of the Directive 'public effects' are characterized by:

- Number of people impacted
- Severity of the impact
- Duration of the impact

Public effect is expressed in three separate categories, on which the actual sub criteria is based:

- Physical suffering
- Impact on public confidence
- Disruption to daily life

Only if the criteria 'physical suffering' or 'impact on public confidence' are not met shall the 'disruption of daily life' be considered

- Public effect in each of these three effect categories shall be measured on a severity scale using three categories that express the magnitude of the impact:
  - Low
  - Medium
  - High

Assessment Methods

The assessment relies mainly on expert judgement. With regards to the proposed criteria, the following steps could be followed to assess public effects:

- Estimation of the number of people potentially affected,
- Assessment of the severity of the impact (see Figure A 1-2),
- Final assessment of the public effects on the basis of the number of people impacted and the severity of the impact.

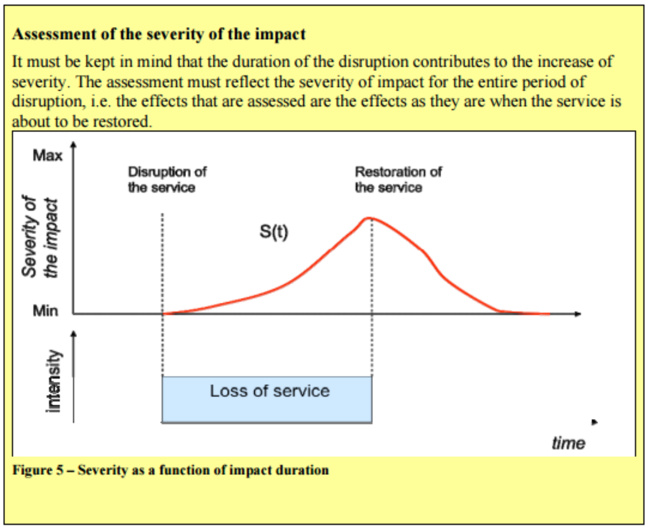


Figure A 1-2: Assessment of Severity of Impact. (Source: European Commission Joint Research Centre, 2008[170])

Key differentiators of the EU criteria

- *Prescribed methodology to guide Member States in identifying critical infrastructure, based on two types of criteria: sectoral (encompassing the nature of the infrastructure); and cross-cutting (encompassing injury / risk to life, economic and public effects).*
- *Cross-cutting criterion on 'economic effects' requires assessment of potential environmental effects and on cascading impacts where they can be reasonably calculated.*
- *Cross-cutting criterion on 'public effects' requires assessment of impact on public confidence.*

A1.3.2 United Kingdom

'Infrastructure is categorised according to its value or "criticality" and the impact of its loss. This categorisation is done using the Government "Criticality Scale", which assigns categories for different degrees of severity of impact. Table A 1-3 provides broad descriptions of the types of infrastructure that would be categorized at the different levels. For example, Category 5 (CAT 5) indicates infrastructure which would have the most severe impact when it is disrupted; CAT 0 indicates infrastructure whose loss would be minimal when considered in the national context.'[171]

Table A 1-3: UK Cabinet Office categorisation of infrastructure criticality and criticality scale. (Source: UK Cabinet Office, 2010[172]).

Criticality Scale	Description
Category 5	This is infrastructure the loss of which would have a catastrophic impact on the UK. These assets will be of unique national importance whose loss would have national long-term effects and may impact across a number of sectors. Relatively few are expected to meet the Category 5 criteria.
Category 4	Infrastructure of the highest importance to the sectors should fall within this category. The impact of the loss of these assets on essential services would be severe and may impact provision of essential services across the UK or to millions of citizens
Category 3	Infrastructure of substantial importance to the sectors and the delivery of essential services, the loss of which could affect a large geographic region or many hundreds of thousands of people

Category 2	Infrastructure whose loss would have a significant impact on the delivery of essential services leading to loss, or disruption, of service to tens of thousands of people or affecting whole counties or equivalents
Category 1	Infrastructure whose loss could cause moderate disruption to service delivery, mostly likely on a localized basis and affecting thousands of citizens
Category 0	Infrastructure the impact of the loss of which would be minor (on a national scale)

'The Criticality Scale includes three impact dimensions:

- ***impact on delivery of the nation's essential services**;*
- ***economic impact** (arising from loss of essential service), and*
- ***impact on life** (arising from loss of essential service).*

These are illustrated in Figure A 1-3. Infrastructure may be classified using any one of these factors of impact. The designation should reflect the highest criticality category reached in either of the impact dimensions.'[171]

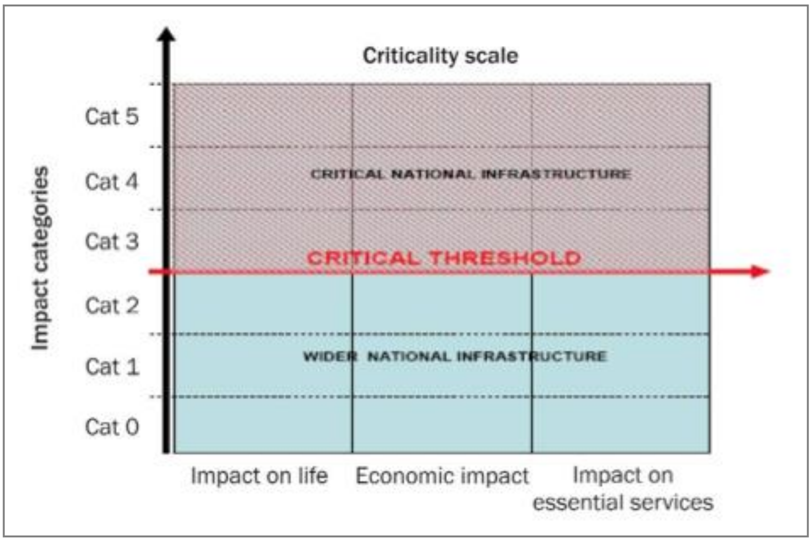


Figure A 1-3: UK Cabinet Office criticality scale and impact categories. (Source: UK Cabinet Office, 2010[173]).

The following factors provide the means to distinguish between different degrees of severity of impact on **essential services**:

- The **degree of disruption** to an essential service
- The **extent of the disruption**, in terms of population impacted or geographical spread
- The **length of time the disruption** persists.

'A critical threshold has been set on the scale and is the level above which the impacts of loss are considered so severe that infrastructure falling into these categories should be considered to form part of the Critical National Infrastructure. The threshold is currently set at CAT 3'.[171]

Key differentiators of the UK criteria

- *Infrastructure is categorised against a quantitative-qualitative six-point "criticality scale" (Category 0 to 5) based on different degrees of* severity of impact*; anything above Category 3 is assigned as critical.*
- *The critical threshold is described as being "currently set" at CAT 3, which implies that infrastructure can be upgraded or downgraded in the event that the UK decides to revise the criticality cut-off threshold.*

A1.3.3 Germany

Germany's Federal Office of Civil Protection and Disaster Assistance (BBK) provides a set of 'Common assumptions of criticality assessments':

> *(1) Only* ***impacts due to infrastructure impairment or failure*** *are considered, not direct impacts of hazards such as staff killed by lightning;*
> *(2)* ***External effects outside the place where the hazard occurs*** *are important. For example, a flood in region x can affect the energy supply in region y; and*
> *(3)* ***Interdependencies and cascading effects*** *leading to different impact entry-points must be evaluated.*

The viewpoint of some national critical infrastructure protection programs (Federal Ministry of the Interior of Germany 2007) requires a focus on the consequences specifically due to the ***service failure*** *of an infrastructure. The focus lies on* ***mortality, economic loss, or other negative outcomes directly related to service interruption of infrastructures.'***[174]

Criticality includes three common criteria:

Critical *proportion*:

- Critical number of elements or nodes of an infrastructure
- Choke points
- Critical number of services
- Size of population
- Magnitude of customers affected
- Moreover, other aspects such as the critical spatial extent, outreach, scope, or population density can be expressed with this criterion

Critical *time*:

- Duration of outage
- Speed of onset, and specific critical time frames, but also notes the capacities before, during, and after a crisis. The latter are, for example,
  - Mean Time to Repair (MTTR),
  - Mean Time to Recovery,
  - Mean Time to Functionality (MTTF), and business continuity or interruption.

Critical time covers not only on/off, yes/no cases but also gradual transitions

Critical *quality*:
'Critical quality summarizes aspects such as the quality of the service delivered (for example water quality), and includes public trust in (water) quality. A lack of quality might seriously disturb the usability of the service delivered by infrastructures. Even when the technical structures, human personnel, and administrative organization are all in place and still delivering the good or service, it might be of no use because of lack of quality—whether that deficiency is real or only perceived. Quality includes identity and ethics and therefore highlights organizational processes that are the baseline for ensuring the integrity and operability of infrastructure services.'[174]

Key differentiators of the German criteria

- *Germany makes a specific point of including "external effects outside the place where the hazard occurs" i.e. to take into account disruptions that may occur due to indirect impacts.*

- *"Criticality" includes the concepts of:*
  - *"critical proportion" which implies a threshold for numbers of elements / nodes after which infrastructure is likely to fail*
  - *"critical quality", the notion of loss in* public trust *for use of service, if the quality of supply is not of the acceptable standard.*

A1.3.4 USA

The Department of Homeland Security's (DHS) National Critical Infrastructure Prioritization Program (NCIPP) uses a tiered approach to identify critical infrastructure based on the consequences associated with the disruption of those critical infrastructures.

Those assets most critical to the nation as a whole are identified, based on the hazards/**threats** to which the asset is exposed, its **vulnerabilities** to those hazards/threats, and the potential **consequences** that might result, including impacts that might **cascade** to other infrastructure assets.
Consequence x **Vulnerability** x **Threat = Risk to CI**

- **Consequence** the overall effects of an incident. Typical examples can include loss of life or injuries, property loss, fear instilled in a population, or impact to government operations.
- **Vulnerability** 'physical feature or operational attribute that renders an entity open to exploitation or susceptible to a given hazard'[175].
- **Threat** 'natural or manmade occurrence, individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment, and/or property'.[175]

The process of prioritizing CI involves combining, aggregating and analysing these results to determine which assets, systems, networks, sectors, or combinations thereof, face the highest risk so that risk management priorities can be established[175].

NCIPP's criteria to prioritize high-risk federal assets, systems or networks as either Level 1 (highest priority) or Level 2, is based on four criteria (see Figure A 1-4):

- fatalities,
- economic consequences,
- mass evacuation length (of time), and
- impact to national security.

In order for an asset, system or network to be included as Level 1 or Level 2, it must meet two of the four consequence thresholds. Depending on which consequence thresholds it meets, it is classified as either Level 1 or Level 2.

Level 1: Consequence-based criteria were established to identify infrastructure the destruction of which could be expected to cause impacts similar to those of Hurricane Katrina.
Level 2: Uses the same consequence-based criteria as Level 1, but with lower thresholds than those used to identify Level 1 assets (see Figure A 1-4).

The overwhelming majority of the assets and systems identified are categorized as Level 2. Only a small subset of assets meets the Level 1 consequence threshold.

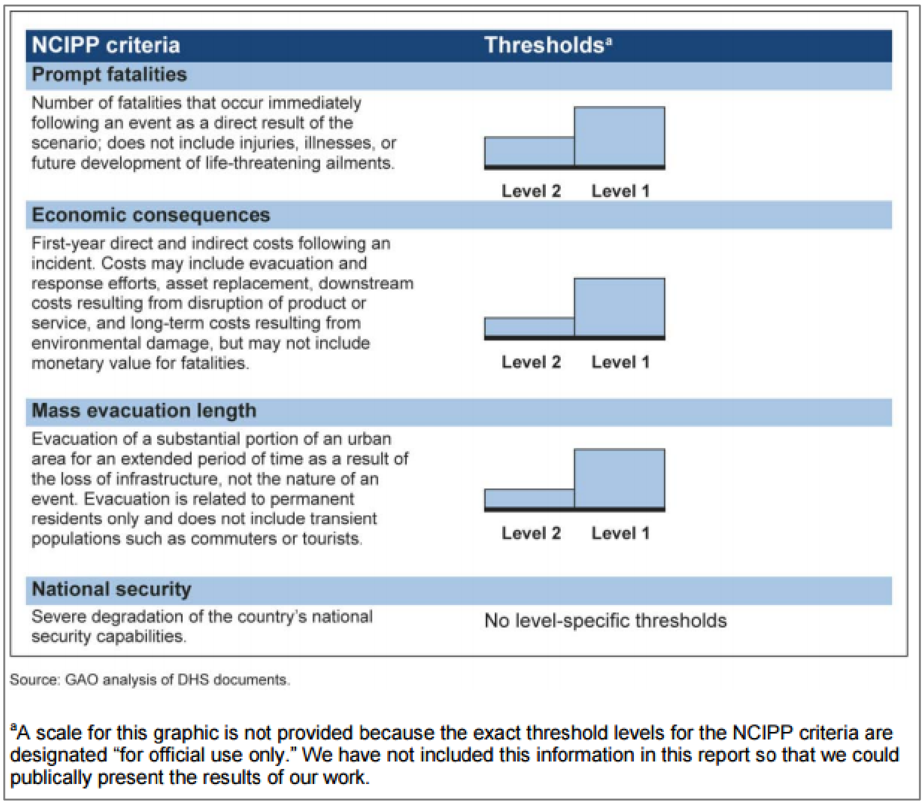


Figure A 1-4: US National Critical Infrastructure Prioritization Program (NCIPP) Criteria. (Source: GAO, 2013[176])

Key differentiators of the US criteria

- *Includes "mass evacuation length (of time) and "impact to national security" as criteria.*
- *It is interesting to note that consequence thresholds for assigning high priority assets refers to destruction that could be expected cause impacts similar to a previous severe weather event, Hurricane Katrina.*

A1.3.5 Australia

The Australian Government is developing a comprehensive approach to identifying key elements of Australia's critical infrastructure that are 'most' important, as well as key dependencies. The aim is to assist owners and operators to prioritise measures to address vulnerabilities and focus risk management efforts where the need, and return, may be greatest. The criteria for identifying critical infrastructure are under development, and the Government is working on a sector-by-sector basis "*with relevant stakeholders in a staged approach to develop and implement sector-led activities to map key dependencies, identify nationally critical systems, networks and assets, and indicatively measure resilience levels.*" The Government's 2015 *"Critical Infrastructure Resilience Strategy: Plan"*[177] details the activities being undertaken, which include developing sector-based guidance (see Table A 1-4).

Table A 1-4: Activities in the Australian Government's "Critical Infrastructure Resilience Strategy: Plan" related to developing sector-based guidance on assessing critical infrastructure. (Source: Australian Government, 2015[178]).

Activities			
2.1	*A clearer understanding of the systems, networks and assets that are most critical at a national level; and of the resilience of our critical infrastructure sectors.*	A	Increase sector-level understanding of nationally vital and significant critical infrastructure assets or networks, by: • developing sector/systems-level guidance for undertaking criticality and dependency assessments, and • implementing a sectoral approach to determining national criticality, utilising TISN Sector Groups with support from the Attorney-General's Department and relevant government agencies.
		B	Develop guidance for indicative measures of resilience at the sectoral level; undertake an initial sector-level resilience benchmarking exercise to determine indicative resilience levels of critical infrastructure sectors in Australia; and identify and agree opportunities for improvement.

The Australian Government places a strong emphasis of collaboration between public and private sector organisations on critical infrastructure risk assessment and resilience, given that most infrastructure is privately owned. In line with Activity 2.1A in Table A 1-4, sector guidance and tools are published via the *'Trusted Information Sharing Network'* (TISN) for Critical Infrastructure Resilience, established by the Australian Government in 2003. TISN is Australia's primary national engagement mechanism for business-government information sharing and resilience building initiatives on critical infrastructure resilience. The TISN provides a secure environment for critical infrastructure owners and operators across seven sector groups (including energy and transport) to share information and cooperate within and across sectors, to address security and business continuity challenges. The suite of tools available to infrastructure owners and operator via the TISN includes the '*Critical Infrastructure Program for Modelling and Analysis'* (CIPMA). CIPMA is an Australian Government capability to assist critical infrastructure owners and operators in understanding network interdependencies and improving resilience. It provides a computer based capability, underpinned by data and information, to model and simulate the behaviour and dependency relationships of critical infrastructure. It is accessible to TISN members.

The TISN provides other guidance and tools, some of which are publicly accessible, such as Excel-based 'Criticality spreadsheets' for use by companies in the energy sector for pandemic influenza planning. The spreadsheets guide the user through a process of the identifying business units that are the most critical to support in the event of pandemic, and the most important functions and persons to protect within those high-importance business units[179].

Interestingly, the Government's 2015 *"Critical Infrastructure Resilience Strategy: Plan"* places an emphasis on measuring the resilience of infrastructure, alongside deciding what infrastructure is most critical:

"The determination of what is most critical will be complemented by an indicative measurement of the resilience of critical infrastructure. This will enable the outcomes of resilience-building initiatives to be compared across time and environments, and further assist in the prioritisation and targeting of mitigation strategies."[177]

Key differentiators of the Australian criteria

- *Criteria are being developed on a sectoral basis in close collaboration with infrastructure owners and operators -many of whom are from the private sector, through the 'Trusted Information Sharing Network' (TISN) for Critical Infrastructure Resilience.*
- *A suite of tools is being developed to assist owners and operators in identifying critical infrastructure.*
- *There is an emphasis on measuring the* resilience *of infrastructure, alongside deciding what infrastructure is most critical.*

A1.3.6 Turkey

The Roadmap for Protection of Critical Infrastructure 2014-2023 (RPCI)[180] developed by AFAD identifies a number of factors which are relevant when evaluating criticality of infrastructure:

- The impact during partial or complete loss of critical infrastructure considering:
  - public impact,
  - physical impact,
  - economic impact,
  - environmental impact, and
  - interdependency with other infrastructure.
- Time impact is also mentioned, i.e. the time required to return from the state of partial/complete loss, back to a fully-functioning state.

Annex A1.4 provides a summary of key points from the RPCI report. AFAD has set out needs and actions in the Roadmap for Protection of Critical Infrastructure 2014-2023. These are summarised in Annex A1.4, Table A 1-6.

Key differentiators of the Turkish criteria

- *Turkey specifically includes two stand-alone criteria which, in other countries, are incorporated as part of other criteria, namely:*
  - *Environmental impact,*
  - *Interdependency.*

A1.4 Summary of key points from AFAD's 'Roadmap for Protection of Critical Infrastructure 2014-2023'

1. Law (#5902) regarding the responsibilities and governance of AFAD orders that the institution is responsible for coordinating all institutions and stakeholders with an overarching task of efficient management of disasters. AFAD was founded in 2009 by order of the same law.

2. The report provides an overview of related EU & EC directives on critical infrastructure protection: EU COM702/2004, EU COM786/2006, and 2008/114/EC.

3. The RPCI underlines that Turkey is in the process of pre-accession to the EU so the definition and policies regarding protection of critical infrastructures are also seen in this context. Turkey needs to comply with the relevant EU directives.

4. There is a reference to Turkey's 10th Development Plan related to: Strengthening disaster risk reduction measures particularly focusing on critical infrastructures in the context of disaster management and response such as hospitals, schools, energy, transportation, communication, public services (e.g. water) etc. Strengthening communication between governmental institutions. Taking measures which aim to strengthen infrastructures and ensure that new constructions are built to be resilient to disasters.

5. The RPCI is among the most recent and comprehensive guidance document put forward in Turkey on critical infrastructure. Its objectives are: to support local, national and regional efforts on disaster risk reduction; enhance cooperation between relevant stakeholders to comply with the EU acquis; promote new projects on critical infrastructure protection; define institutional roles and responsibilities in this context; coordinate institutions that are responsible for identifying critical infrastructure in Turkey; identify cross-border critical infrastructure and build policies for protection; gather data for Critical Infrastructures Warning Information Network (CIWIN).

6. Interestingly, the RPCI looks at the issue through the lens of 'Technological Disasters' and 'Technological Disasters Triggered by Natural Disasters'.

7. Institutional Roles and Responsibilities are summarized in Table A 1-5.

Table A 1-5: Institutional roles and responsibilities identified in AFAD's Roadmap for Protection of Critical Infrastructure 2014-2023'. (Source: AFAD, 2014[181]).

Institution	Main Responsibility
Disaster and Emergency Management Authority (AFAD)	Coordinates all institutions in the context of disaster risk reduction, management and response; Uses relevant budgets; makes action plans and risk maps; trains and builds capacity; coordinating body for EU acquis harmonization in the context of critical infrastructures; identifies indicators for critical infrastructure sectors; makes Operational Security Plan regarding these sectors; develops new projects to protect critical infrastructures in Turkey; works for integration to the EU Critical Infrastructure Warning Information Network; cooperates with international and regional institutions to exchange best practices.
Ministry of Environment and Urbanization	Coordinates Turkey's environmental policy; leads harmonization with the EU environment acquis; identifies critical infrastructures that fall within its area of responsibility; takes measures to protect them.
Ministry of Labour and Social Security	Audits facilities in the context of major industrial accidents and mine disasters.
Ministry of Health	Identifies critical health infrastructures and elements; takes measures to protect them.
Ministry of Internal Affairs	Identifies critical public services and elements; takes measures to protect them.
Ministry of Energy and Natural Resources	Identifies critical energy infrastructures and elements; takes measures to protect them.
Ministry of Finance	Identifies critical finance infrastructures and elements; takes measures to protect them.

Ministry of Transport, Maritime Affairs and Communication	Identifies critical transportation and communication infrastructures and elements; takes measures to protect them.
Ministry of Culture	Identifies critical cultural heritages and elements; takes measures to protect them.
Ministry of Forestry and Water Affairs	Identifies critical water resources, forests, water infrastructures and elements; takes measures to protect them.
Ministry of Science, Technology and Industry	Identifies facilities and infrastructures that have critical importance; takes measures to protect them.
Ministry of Customs and Trade	Identifies critical facilities that achieves high level of production, critical ports, trade related facilities and elements; takes measures to protect them.
Ministry of Food, Agriculture and Livestock	Identifies critical agricultural and livestock areas; takes measures to protect them.

8. The RPCI notes that a number of factors are relevant when evaluating criticality of infrastructures: The impact during partial or complete loss of critical infrastructure (public impact, physical impact, economic impact, environmental impact, and interdependency with other infrastructures): Time impact is also mentioned, indicating the time required from the state of partial/complete loss to return to a fully-functioning state.

9. The RCPI summarizes EU legislation on critical infrastructure protection.

10. The present situation in Turkey is summarized as follows: The topic of critical infrastructure protection has been tackled under the national information security theme between 1990-2006. But it noteworthy to mention that the Military Zones Protection Regulation was the first legal regulation in Turkey that touches upon physical protection of critical infrastructure without giving a clear definition of CI. During the 1990s and early 2000s, the Ministry of Defence coordinated efforts on drafting a National Information Security Law and defined responsibilities. TÜBİTAK (Scientific and Technological Research Council of Turkey) led the "Information Security Management for Critical Infrastructures" project in 2012 with financial support of the Ministry of Development. The only legal regulation (as of the date of the RPCI publication) is the Cabinet Decree on Coordination and Execution of National Cyber Information Security (20 October 2012). Subsequently an action plan has been adopted by another Cabinet Decree dated 20 June 2013. In the context of this action plan, transportation, energy, electronic communication, finance, water management and critical public services have been prioritized. Unfortunately, no clear definition for the term critical infrastructure has been legally made and no legal regulation regarding protection of critical infrastructures against disasters has been drafted yet. With an increasing trend of terror threat, Turkey is intensifying its efforts to fill these gaps.

11. AFAD proposes every ministry in Turkey should appoint at least 2 staff for identifying critical infrastructure that fall under their area of responsibility. AFAD recognizes the need to come up with a clear definition of CI and proposes to organize a workshop with this aim. AFAD also aims to lead a project on drafting a risk assessment methodology for critical infrastructure operators. AFAD plans to organize another workshop for abovementioned ministry staff members to share this methodology. AFAD envisages training critical infrastructure operators on preparing risk assessment reports and risk management plans. On a national level, such plans and reports will be

prepared by AFAD. Lists of critical infrastructure and plans should be assessed by AFAD and AFAD should ensure sustainability.

12. Finally, needs and actions are assessed. These are summarized in Table A 1-6.

Table A 1-6: Needs and actions identified in AFAD's Roadmap for Protection of Critical Infrastructure 2014-2023' (Source: AFAD, 2014[182]).

Needs		
Responsible Institution	**Relevant Stakeholder**	**Expected Date for Completion of Defined Actions**
Need 1: Identification of responsible authorities on sectoral basis (energy, transportation, water management and dams, banking and finance, agriculture and food, culture and tourism, critical production and trade services, critical public services and health)		
All related institutions	AFAD	2016
Need 2: Identification of authorized coordination body & identification of indicators that will be used for defining critical infrastructure sectors		
AFAD	All related institutions	2016
Need 3: Drafting legislation for EU harmonization; identification of critical infrastructure considering scope, scale and time impact factors; enhancing protection measures.		
All related institutions	AFAD	2016
Need 4: Operative protection of critical infrastructure; enhancing communication and coordination at national and European levels.		
AFAD	All related institutions	2017
Need 5: *Drafting operative security plans for critical infrastructure sectors*		
All related institutions	AFAD	2018
Need 6: Appointing security liaison officer (between critical infrastructure operator and governmental coordination body)		
All related institutions	AFAD	2018
Need 7: Development of capacity building training and application of them.		
All related institutions	AFAD	2017
Need 8: Drafting a nationwide "Critical Infrastructure Protection Plan" for CI that has national criticality.		
AFAD	All related institutions	2018
Need 9: Best practice sharing & Integration to Critical Infrastructures Warning Information Network (CIWIN).		
AFAD and sector regulating bodies.	All related institutions	2018
Need 10: Annual Reporting		
AFAD and sector regulating bodies.	All related institutions	2018

A2 Energy and transport & logistics sectors - further information

A2.1 The energy sector in Çukurova

A2.1.1 Power generation

Çukurova has some specific regional characteristics relevant to power generation, namely:

- Plentiful resources for renewable power generation
- Easy access to ports importing coal for power generation
- Suitable characteristics for nuclear power generation

Each of these characteristics is discussed further below. This section then provides a summary of the existing power generation assets, and new generation projects under development in the region.

Plentiful resources for renewable power generation

The region enjoys abundant natural renewable energy resources such as water, sun and wind.

In terms of water resources, the Çukurova Basin is one of the largest plains in Turkey, with a complex interaction of major river basins and groundwater-dominated, low-lying coastal plains. The Ceyhan and Seyhan Rivers, which originate in the Taurus Mountains, flow through the basin and terminate in the Mediterranean Sea. The Seyhan carries substantial flows of water into the basin throughout the year. Some of the riverine water infiltrates into the basin through the distributary channel systems while the remainder flows overland towards its delta.[183,184] Water flows in the rivers are highest between November-December because of the rains and in spring because of snowmelt, and lowest between August-September.

The location and seasonal characteristics of Çukurova Region create a significant advantage in terms of solar energy potential, with Mersin being relatively more advantageous than Adana (Figure A 2-1). Sunshine duration and global radiation in Çukurova Region exceed the average values for Turkey.

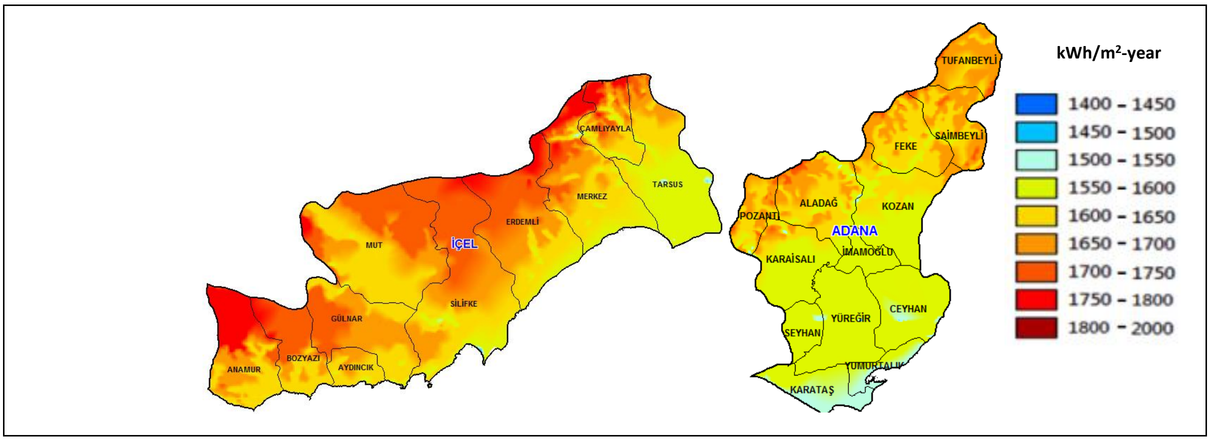


Figure A 2-1: Solar energy potential of Mersin and Adana. (Source: ÇKA, 2015[185])

In terms of wind potential, Adana and Mersin are not known as wind-rich areas but there is still potential at adequately acceptable wind speeds (ca. 8 m/s) (Table A 2-1).

Table A 2-1: Wind potential classification of Adana and Mersin. (Source: General Directorate of Renewable Energy[186]).

	Adana		Mersin	
Wind Speed at 50m height (m/s)	Total Area (km^2)	Total Capacity (MW)	Total Area (km^2)	Total Capacity (MW)
6.8-7.5	100.46	502.32	340.56	1702.8
7.5-8.1	48.99	244.96	191.94	959.68
8.1-8.6	18.19	90.96	138.61	693.04
8.6-9.5	12.1	60.48	35.14	175.68
>9.5	0	0	0	0

Easy access to ports importing coal for power generation

The accessibility of ports in Çukurova Region is one of the key drivers for the development of power generation projects in the region using imported coal as their fuel. Imported coal-fired power plants make up a significant, and growing, proportion of Turkey's energy mix due to their baseload characteristics. In order to guarantee their continuous generation, power plant projects are preferred to be located in regions that have easy access to international ports. Figure A 2-2 shows the concentration of imported coal-fired power plant projects in Yumurtalık District (Adana Province). All of these projects foresee importation of coal through existing ports in the region, or construction of new ports at the project sites. (It should be noted that only some of these projects will be able to materialize, due to constraints posed by port capacity and concerns over their cumulative environmental impacts.)

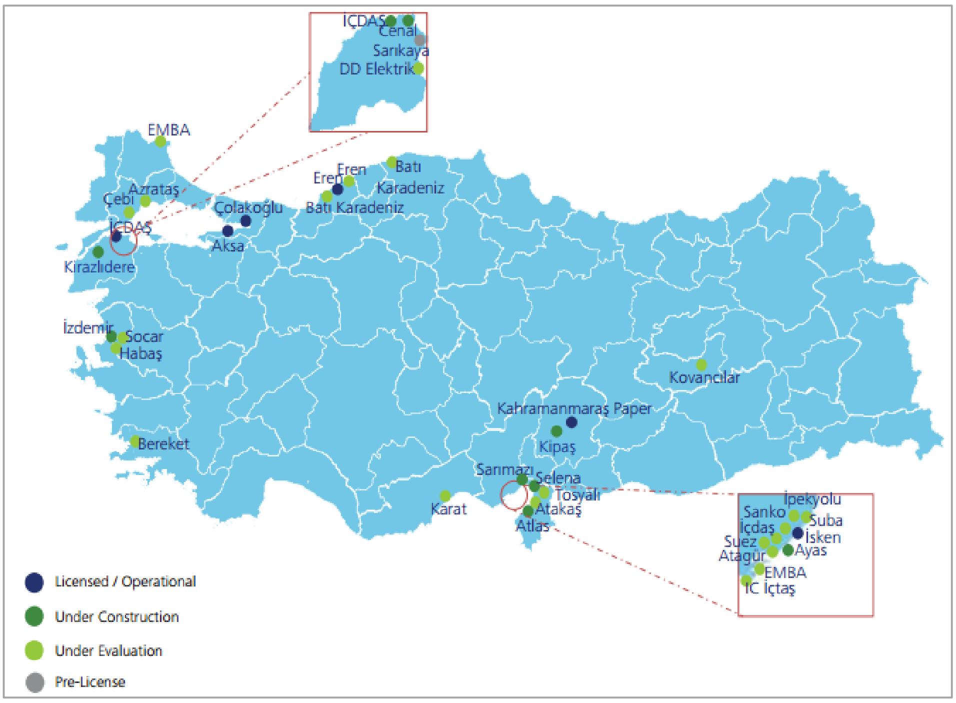


Figure A 2-2: Coal-fired power plants in Turkey at various stages of development, showing the high concentration of projects in Çukurova Region (as of 2013). (Source: Deloitte, 2013[187])

Suitable characteristics for nuclear power generation

Bearing in mind the sensitivity of nuclear power plants, there are various factors that are taken into consideration in selecting suitable locations for their development, namely:

- Easy access by highways and airports,
- Lower earthquake risks identified through seismic studies,
- Limited coastal tourism,
- Suitable hydrology (Mediterranean Sea, river and groundwater) and appropriateness of seawater for reactor cooling requirements,
- Easy transmission line connection to the national grid,
- Considerable power consumption within the region.

Most of these characteristics are valid for the whole of Çukurova Region, which explains why Çukurova was identified as the most suitable candidate for the development of Akkuyu NPP.

Current power generation assets and new projects under development

The current generation assets in Çukurova Region are a diverse mix (Table A 2-2) thanks to the regional characteristics mentioned above, such as plentiful water resources and access to ports for coal import.

Table A 2-2: Installed power generation capacity breakdown by fuel type for Çukurova Region, 2016 (MW). (Source: Enerji Atlasi)[188]

Type	Adana	Mersin	Total installed capacity (MW)
Hydroelectric	1,699.00	569.48	2,268.48
Imported Coal	1,320.00	-	1,320.00
Lignite	450.00	-	450.00
Natural Gas	28.76	257.62	286.38
Wind	-	132.00	132.00
Solar	11.40	29.88	41.28
Biogas	17.60	9.78	27.38
Naphtha	14.74	12.00	26.74
Waste heat recovery	-	9.56	9.56
Total installed capacity (MW)	**3,541.50**	**1,020.32**	**4,561.82**

Adana accommodates 78% of the region's installed capacity with ca. 3,500 MW while Mersin has around 1,000 MW. Bearing in mind the plentiful water resources in the region, hydroelectric power plants form the highest proportion of the total at present. Isken Sugozu imported coal power plant, which is the only coal fired Build-Operate type power plant, is located in the region.

Although the exact generation figures from each source are not publicly available, based on general assumptions, it is estimated that 51% of Çukurova Region's total generation is realized from foreign-originated resources such as imported coal and natural gas (Figure A 2-3), while the remainder of the generation depends on domestic resources, including renewables and fossil fuels. Its domestic resources represent an important advantage for the region, especially when compared to other regions (e.g. Thrace Region, where the majority of power generation is fuelled by foreign-originated resources).

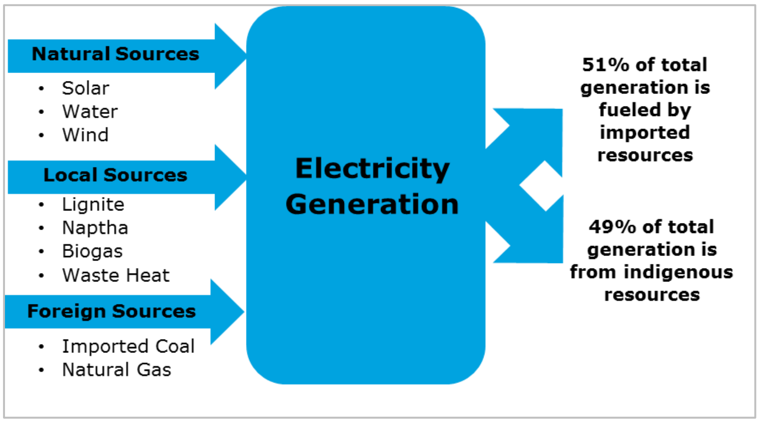


Figure A 2-3: Fuel sources for power generation in Çukurova Region. (Source: Report authors).

The contribution of Çukurova Region to national power generation is 6.2% based on installed capacity and 7.0% based on annual production (Table A 2-3). Unfortunately, data are not available on how Çukurova Region's contribution to national totals have changed over time.

Table A 2-3: Power plant installed capacity (MW) and annual production (GWh) for Çukurova Region and Turkey as a whole, 2016. (Source: Enerji Atlası,2017)[189].

Power generation	Installed capacity (MW)	Annual production (GWh)
TR62 region (Adana and Mersin)	4,562	18, 579
Turkey - import	74,039	264,380
Region as % of Turkey	**6.2%**	**7.0%**

As compared to the region's summer demand peak, with total of ca. 4,500 MW of installed capacity, it can be concluded that the region is capable to generate more than it consumes. However, since the Turkish electricity system is not regional but national, it can be said that region is partially capable to support the whole power system.

Analysis of installed capacity reveals that Çukurova Region consists mainly of base load power plants (Table A 2-4). Peaker plants power (i.e. plants that generally run only when there is high demand for electricity) are mostly composed of hydropower plants with reservoirs and a limited amount of natural gas fired generation capacity that is flexible to ramp up very quickly. When Akkuyu Nuclear Power

Plant is commissioned, baseload capacity in the region will almost be tripled. During the national blackout of 31 March 2015, the eastern region was islanded with higher surplus and frequency increase while western part of Turkey were down because of low voltage. As discussed in further detail in sub-section "*Power transmission and distribution*" below, it can be concluded that transmission network system around the region must be reinforced if the region is hosting a growing base load generation fleet.

Table A 2-4: Installed power generation capacity breakdown according to base load, peaker and intermittent sources for Çukurova Region, 2016 (MW). (Source: EUAS[190] and EMRA [191]).

Type	Base load	Peaker	Intermittent	Total (MW)
Hydroelectric	710.48	1,558.00		2,268.48
Imported Coal	1,320.00			1,320.00
Lignite	450.00			450.00
Natural Gas		286.38		286.38
Wind			132.00	132.00
Solar			41.28	41.28
Biogas	27.38			27.38
Naptha	26.74			26.74
Waste Heat Recovery	9.56			9.56
Total	**2,544.16**	**1,844.38**	**173.28**	**4,561.82**

Note: Reservoir type hydro plants and gas fired plants are assumed to be peaker type plants.

Key examples of large assets and future projects in the region can be summarized as follows (Figure A 2-4):

- *Sugözü Thermal Power Plant* is the first coal-fired power plant in the region, located in Yumurtalık, Adana. It provides 9 billion kWh for the national power grid each year and thereby meets about 4% of the total energy demand of the country, at an installed capacity of 1320 MW.
- The recently commissioned *Tufanbeyli Thermal Power Plant* is a 450 MW lignite-fired plant in the Tufanbeyli district of Adana. It will generate approximately 3 billion kWh for the national power grid each year. The mine mouth plant utilizes locally produced coal from the open pit nearby, therefore creating value for both mining and power generation industries.
- *Ayas Thermal Power Plant* is a proposed 625 MW imported coal-fired power plant in the Yumurtalık district of the Adana province.
- *Mersin (Combined Cycle) Natural Gas Power Plant* is planned to have an installed capacity of 1148 MW.
- In addition to those, there are also *several power plant* license applications in the phase of evaluation, specifically for locations in the Yumurtalık district of Adana.
- *Akkuyu Nuclear Power Plant* is the first of two identified nuclear projects of Turkey. Per agreement, four reactors are planned to be installed, each with 1,200 MW of generation capacity, in the Akkuyu district of Mersin. The power plant company expects to commission the first unit (1,200 MW) in 2020, followed by the other three equal-sized units in subsequent

years. The plant's total annual electricity generation capacity is expected to be 35 billion kWh when all four units are operational in 2023[192, 193]. However, considering the current project development status, some considerable delays may happen on the commissioning of the first unit.

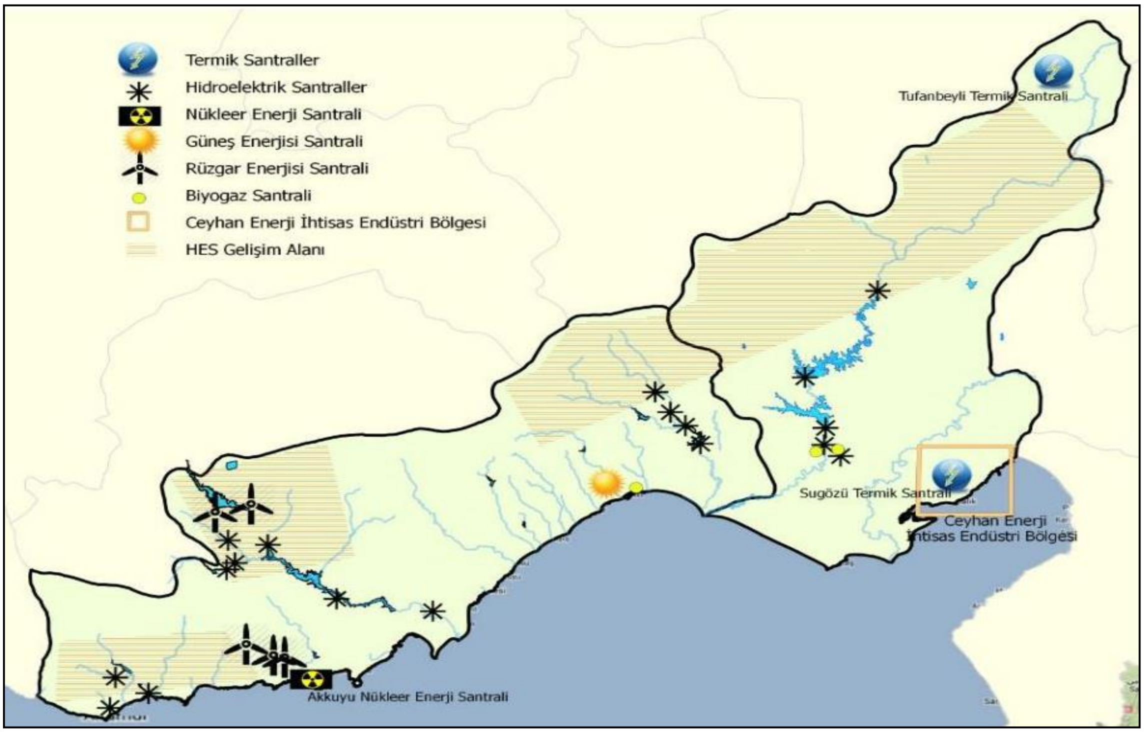


Figure A 2-4: Map of existing and planned power plants in Çukurova Region[194]

There is also large potential for renewable energy in Çukurova Region. The region offers a wide range of renewable options, including hydro, wind, solar, biomass, and biofuels. Hydropower plant investments are spread over the entire northern part of Adana and Mersin.

Regarding the development of new power generation projects in the region, it can be clearly seen that the region is attracting a large amount of new projects using various fuel types, thanks to the region's characteristics and in line with the objectives in the Tenth National Development Plan and the 10-year Çukurova Regional Strategic Plan for 2014-2013. Table A 2-5 summarizes the current project stock.

Table A 2-5: Power sector project stock for Çukurova Region, as of October 2016. (Source: EMRA, 2016[195]).

	Biomass	Hydroelectric	Imported Coal	Naphta	Natural Gas	Nuclear	Waste Heat Recovery	Wind	Grand Total (MW)
License	20.8	2,608.9	3,585.5	27.3	1,468.0		9.6	193.7	**7,913.7**
Adana	18.9	2,027.9	3,585.5	15.1	59.6				**5,707.0**
Approved		52.4							**52.4**
Effective	18.9	1,975.5	3,585.5	15.1	54.4				**5,649.4**
Under Evaluation					5.2				**5.2**
Mersin	1.9	581.0		12.1	1,408.4		9.6	193.7	**2,206.8**
Effective	1.9	581.0		12.1	1,408.4		9.6	193.7	**2,206.8**
Pre-License		70.9	-		24.5	4,800.0		2,205.7	**7,101.1**
Adana		-	-		-			-	**-**
Effective		-	-		-				**-**
Under Evaluation			-					-	**-**
Mersin		70.9			24.5	4,800.0		2,205.7	**7,101.1**
Effective		64.1			24.5	4,800.0		30.0	**4,918.6**
Under Evaluation		6.8						2,175.7	**2,182.5**
Grand Total (MW)	**20.8**	**2,679.8**	**3,585.5**	**27.3**	**1,492.5**	**4,800.0**	**9.6**	**2,399.4**	**15,014.9**

According to the EMRA electricity license database, the project pipeline for Adana and Mersin exceeds 10,000 MW (i.e. the total shown in Table A 2-5 minus existing installed capacity), including licenses and pre-licenses. The striking point here is the total amount of imported coal-fired capacity. As indicated in Section 0, the region is highly suitable for coal import and therefore, as they provide base load generation, imported coal-fired power plant projects are in demand. Moreover, the development of Akkuyu Nuclear Power Plant in the region will adds a further 4,800 MW to the project stock.

Çukurova Region‘s total wind power potential is approximately 4,400 MW. Currently, in Mersin, a total of 30 MW wind capacity is under construction and approximately 144 MW is operating. It is clear from the project stock analysis (Table A 2-5) that the wind potential of Mersin is noticed by investors and a considerable number of wind generation projects are under development. It can be concluded that the region is becoming an important centre for renewable power generation[196, 197]. However, although the region's solar potential is high (see Section 0), solar power generation is a vastly undeveloped area. Similarly, biomass potential is not exploited currently, despite the region having considerable biomass resources because of farming and livestock raising.

A2.1.2 Power transmission and distribution

Electricity transmission system operations and maintenance are controlled by the state-owned Turkish Electricity Transmission Company (TEİAŞ). TEİAŞ comprises 22 separate transmission, facility, and management directorships and ten load dispatch operation directorates located around Turkey. The Çukurova region is one distinct region in that system.

On the distribution side, the Turkish Electricity Distribution Company (TEDAS) has the responsibility for coordination of Turkey's electricity distribution system. Distribution grids are owned by the government but are operated by the private sector on the government's behalf. Distribution grid is divided into 21 separate regions. Each region is controlled by private distribution companies that have distribution operating rights for 30 years. These companies maintain a monopoly for their respective region as an operator and hold a retail sales license.

Transmission

The map below illustrates the electricity transmission grid connecting towns and settlements in the Çukurova Region. Existing power lines of various voltages (highest 380kV, lowest 34.5kV) are mapped indicatively (straight connections) as are planned power lines and the locations of power stations and transformation stations.

Figure A 2-5: Map of electricity transmission assets. (Source: TEİAŞ, 2011[198])

From a transmission infrastructure perspective, the Turkish Electricity Market works as a pool and consequently, load flows between the regions become a crucial factor to analyse, because seasonal characteristics and the generation/consumption structure of the regions mostly determine congestion and load transmission possibilities. A study conducted by TEİAŞ and TUBITAK in 2013 providing a Regional Demand Forecast and Network Analysis for the 2013-2022 period underlines the important dynamics of the transmission network. The project stock with positive connection approval in Çukurova Region is highlighted specifically in the report, as the upcoming generation capacity exceeding the demand in the region is expected to result in an oversupply. Figure A 2-6 shows the relative balance between generation capacity and forecast consumption for the 2013-2022 time horizon.

Substations

Since the above analysis was conducted at the resolution of substations, substation capacity requirements were also analysed, considering winter and summer peak loads. The report underlines the fact that, in the face of increasing winter/summer peak load observed in metropolitan cities, including Mersin and Adana, substation capacities may be insufficient in 2017. Hence, the report points out the need for additional capacity or new substation investment in these locations. For the East Mediterranean National Load Dispatch Region, the substation requirement for the 2022 summer peak is visualized in Figure A 2-7.

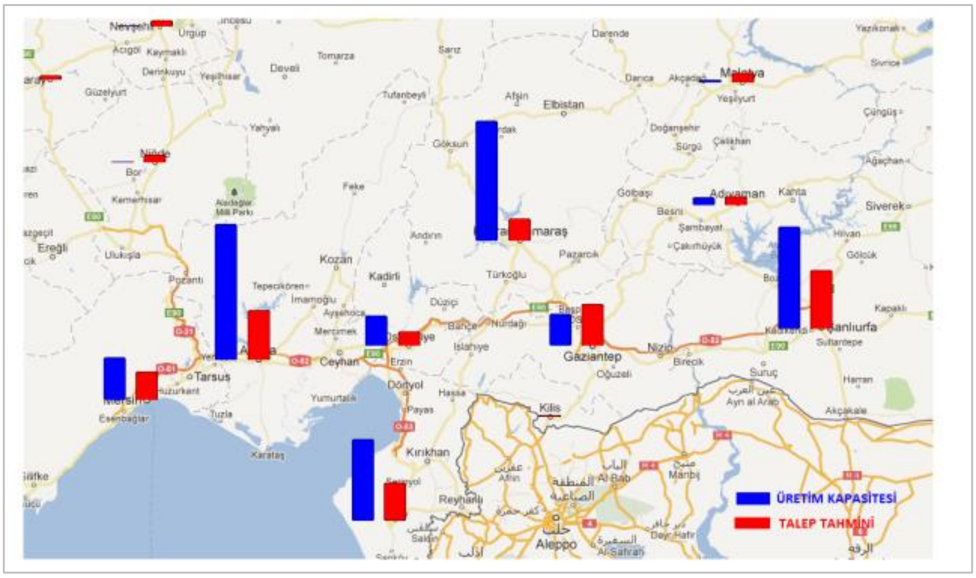


Figure A 2-6: Demand forecasts and generation projection study results for 2013-2022. (Source: TEİAŞ & TUBITAK, 2013[199]).

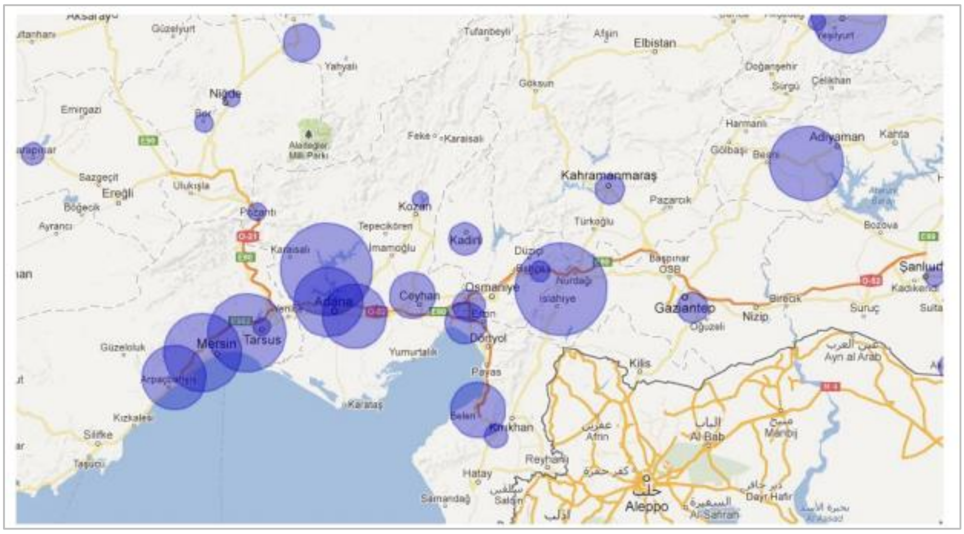


Figure A 2-7: Foreseen seasonal substation capacity needs in 2022 (summer Peak 2022 Season). (Source: TEİAŞ & TUBITAK, 2013[200]).

Regarding the load flows between the regions, the impact of prospective projects in Çukurova Region can be grasped by comparing Figure A 2-8 and Figure A 2-9. The maps clearly show the expected overcapacity in the region, particularly by 2022. Since the project stock of Çukurova Region is mostly composed of baseload power plants, the overcapacity is expected to have a significant impact and will require additional investments in the region. On the other hand, this study assumes the commissioning of Akkuyu Nuclear Power to start as of 2019 with the first unit (1200 MW) and reaching full capacity (4800 MW) as of 2022. As the pace of its development is somewhat slower than planned at present, these commissioning expectations may be optimistic. Therefore, the comments above should be interpreted according to the possible changes in the nuclear power plant project schedule and indeed other baseload power plant project developments.

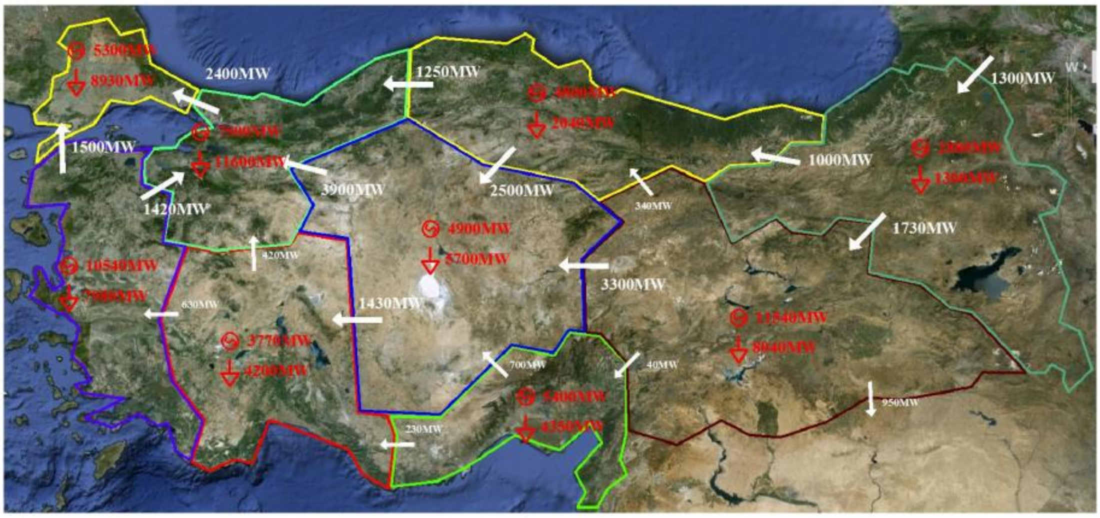


Figure A 2-8: Summer Peak Inter-Regional Projected Load Flows in 2017. (Source: TEİAŞ & TUBITAK, 2013[201]).

Figure A 2-9: Summer Peak Inter-Regional Projected Load Flows in 2022. (Source: TEİAŞ & TUBITAK, 2013[202]).

Distribution

Adana and Mersin are covered under Toroslar Electricity Distribution Company and, as of January 2015, the number of electricity subscribers, including eligible consumers were ca. 920,000 in Adana, and 850,000 in Mersin, out of ca. 35 million subscribers in Turkey as a whole (corresponding to 4.95% of the total within TR62 region).

In Adana, small and medium sized subscribers account for around 97% of the total number of subscribers and in Mersin, due to the concentration of agriculture, irrigation subscribers are considerably high, at 5.9% of the total (Table A 2 6). Altogether TR62 region is covered by a 43,648 km distribution network (Table A 2-7) which realizes approximately 12.5 TWh of electricity distribution.

Table A 2-6: Electricity subscriber breakdown for 2015 in Adana and Mersin. (Source: EMRA,2016[203])

Adana	# of subscribers connected from distribution level	
	Subscriber	# of Eligible consumer
Illumination	5,320	
Residential	766,199	5,529
Industry	1,289	126
Agricultural Irrigation	8,137	14
Commercial	125,092	8,520
Mersin	**# of subscribers connected from distribution level**	
	Subscriber	**# of Eligible consumer**
Illumination	7,163	
Residential	681,443	3,654
Industry	520	85
Agricultural Irrigation	43,200	23
Commercial	107,529	7,782

Distribution network enhancements has been realized by private sector companies after the privatization of distribution regions. Adana and Mersin lie within the top 20 cities in relation to their distribution line investments.

Table A 2-7: Electricity network components analysis for Turkey, showing the importance of Adana and Mersin. (Source: EMRA,2016[204])

Ranking	Cities	Line Length (thousand km)	Substation Capacity (MVA)	Substation Number (units)
1	ANKARA	58,285	9,294	15,767
2	İSTANBUL	53,253	23,544	20,068
3	KONYA	42,011	4,929	26,036
4	ANTALYA	35,122	5,391	12,414
5	İZMİR	30,673	10,169	17,492
6	SAMSUN	26,511	1,801	6,319
7	ADANA	25,838	3,473	10,44
8	BALIKESİR	24,402	2,267	7,258
9	MUĞLA	24,269	2,727	7,415
10	ORDU	23,333	786	4,195
11	MALATYA	22,394	1,209	4,822
12	BURSA	21,730	4,661	11,341
13	MANİSA	21,522	2,786	11,059
14	TRABZON	20,927	1,189	3,512
15	KAYSERİ	20,566	2,250	6,651
16	DENİZLİ	19,623	2,143	5,632
17	ŞANLIURFA	19,576	5,536	24,74
18	AYDIN	19,386	2,147	6,186
19	MERSİN	17,810	2,764	8,169
	Total	**1,070,337**	**143,768**	**417,440**

A2.1.3 Gas transmission and storage

With its convenience and clean nature, natural gas has become an important energy source penetrating into various regions of Turkey. Growing national consumption has already helped initiate development of pipelines to bring natural gas into the country, and while it has little natural gas left for export, new supplies have been contracted and new pipelines are under construction that will increase both Turkey's imports and exports of natural gas[205] (Figure A 2-10). Its use in Turkey is typically concentrated in relatively colder regions, but in the Mediterranean region, the existence of industrial sites using natural gas in manufacturing processes have created a momentum for it in this region as well.

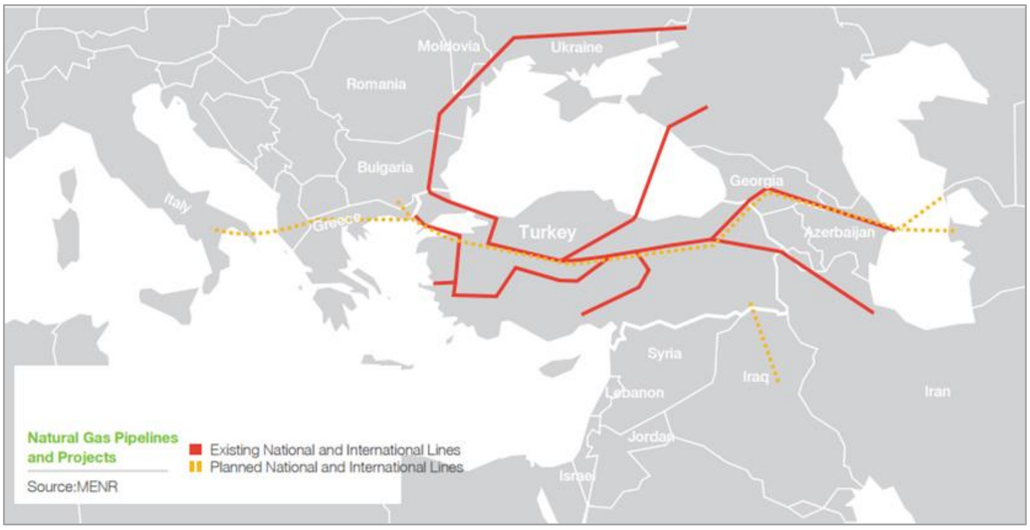


Figure A 2-10: Natural gas pipelines and projects. (Source: MENR, 2014[206]).

The BOTAŞ Transmission Pipeline Map shows the coverage of natural gas and crude oil petroleum pipelines in Çukurova Region (Figure A 2-11). Along with the current gas transmission line to Adana and Mersin, an additional connection from Mersin to the Central Anatolia network is planned. This is a strategic step to ease the compression management of the network, because the current natural gas entry points are located on the Northwest (pipeline and LNG), North (pipeline), East (pipeline) and West (LNG) of Turkey. Therefore, gas transportation to the southern part of Turkey is to be managed by pressure differentiation.

The salt cavern-type underground natural gas storage which will be located in Sultanhanı (Central Anatolia - Tuzgölü Region) does not have a direct connection to the southern part of Turkey. Moreover, a potential pipeline from East Mediterranean gas sources is expected to be connected to the network from this region. In order to transport possible gas from this entry point to northern parts of Turkey, the planned network connection to Central Anatolia is a strategic step. Underground natural gas storage is a necessity for network management in the winter season when residential gas consumption climbs significantly. Besides limited volume of depleted gas fields, Turkey is not rich in terms of suitable geology for underground gas storage. The only candidates are known to be around Tuzgölü Region where construction of the 1 bcm/year capacity BOTAŞ storage construction is ongoing, and Tarsus region where a private company holds licenses for two projects (Toren and Gazdepo) which in total sum up to 4 bcm/year capacity.

In case of realization of these projects, in order to benefit from the flexibility that these projects will provide for the system, the gas transmission network is to be supported in this region. The planned transmission connection to Central Anatolia will also be a network enhancement serving this aim.

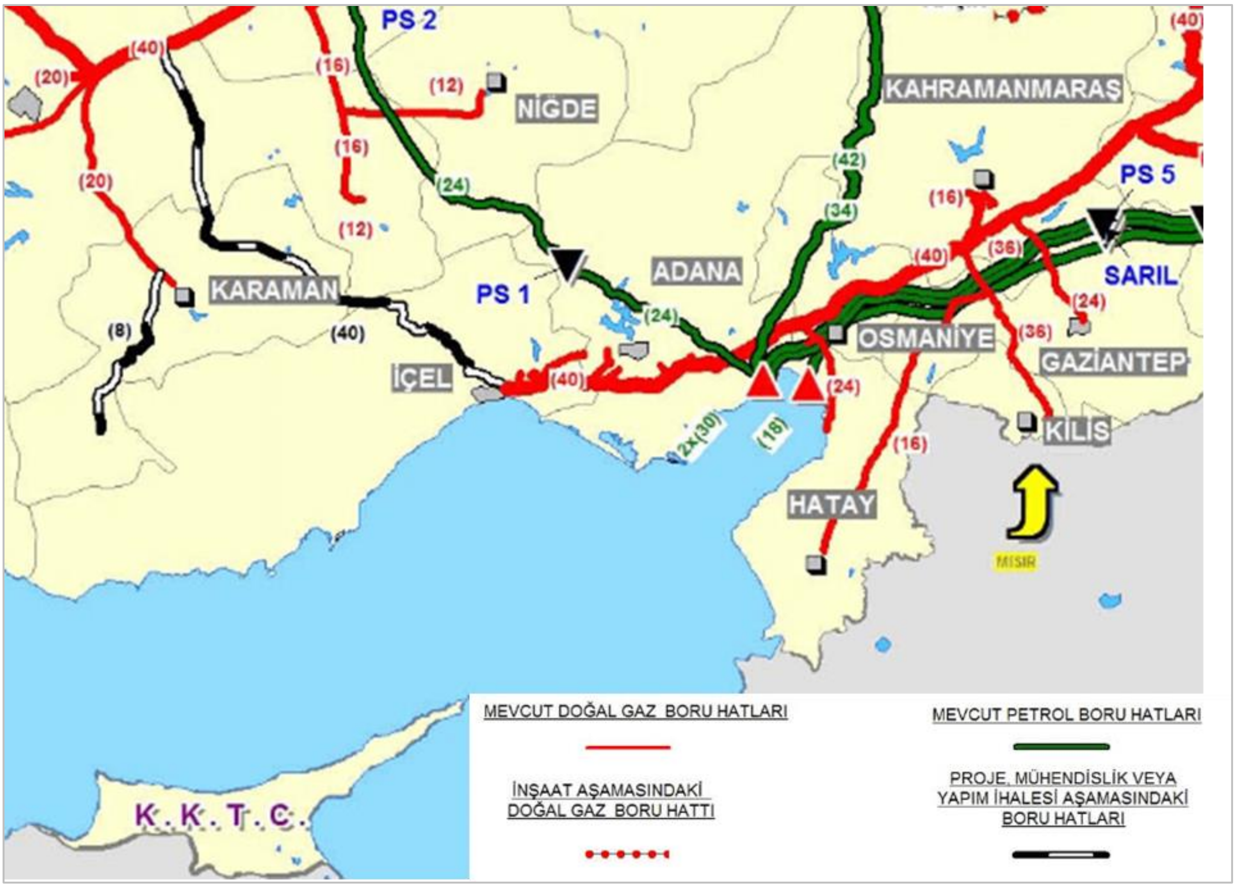


Figure A 2-11: BOTAŞ Natural Gas and Crude Oil Pipeline Map. (Source: ÇKA, 2015[207])

Turkey has a bridging role between energy resources rich Asian (Middle Eastern, Caspian) countries and the significant energy consumption point, Europe. Russia, which has been a reliable supplier to Europe since natural gas penetration became prominent, has seen its reputation damaged in the past decade because of various issues, such as Ukraine transit problems and market dominance etc. These concerns have led to natural gas supply diversification politics and development of various transit gas pipeline projects, namely the Trans Adriatic Pipeline, Nabucco and so on. Turkey has been the main actor not only for these projects, but also all possible concepts involving natural gas transportation towards Europe. The location of Çukurova Region creates a significant opportunity for considering it as a tailor-made candidate for natural gas transportation to domestic and international markets. The following pipeline projects are directly related to Çukurova Region:

- _East Mediterranean Natural Gas Projects_: Offshore natural gas exploration efforts in eastern regions of the Mediterranean Sea resulted in large natural gas field discoveries by Israel and Cyprus. These significant developments in the region keep the natural gas export opportunities at the top of the government's agenda. Even though the current state of sophistication of natural gas transport allows for transportation of gas in liquefied form via onshore or even floating LNG terminals, project economics usually falls behind supporting these significantly capital intensive investments. Therefore, the viable export option appears as onshore pipelines which are highly cost effective compared to deep offshore pipeline or LNG terminal investments. Çukurova Region stands out as the closest region to transport the gas onshore. Therefore, the project plans for Israeli gas from the Leviathan field foresee a connection to Ceyhan transporting 8-10 bcm/year. Export possibilities towards Europe via Turkey have even been considered. Figure A 2-12 visualizes the potential route of the prospective gas pipeline.

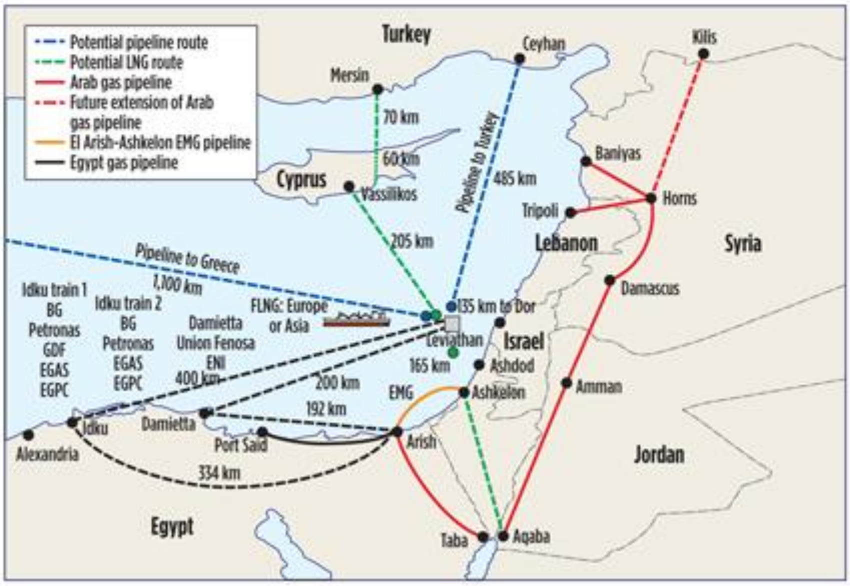


Figure A 2-12: Potential pipeline routes from the Leviathan natural gas field. (Gas Processing News, 2014[208])

Although export opportunities from the Leviathan basin have always kept a pipeline option on the table, Cyprus gas has been targeted to be marketed to Europe via LNG terminal options. However, project economics do not seem to support those plans and underline the need for a cost-effective pipeline alternative. As a result, Çukurova Region stands as a solid candidate for receiving the gas for export opportunities. In case of realization of this project, ca. 20% of current gas demand of Turkey will be supplied from it. In line with increasing gas demand expectations for Turkey and possible expiration of existing gas contracts, this pipeline will become a very important source of natural gas for Turkey.

Besides that, Turkey has deep roots with Cyprus and the northern part of Cyprus is supported by Turkey in various ways. In a recent development, an agreement was signed between Turkey and Northern Cyprus Turkish Republic on the construction of a submarine electricity transmission line between Anamur, Mersin to Kyrenia, Northern Cyprus. Furthermore, previously, another project was developed for Turkey to provide water to Northern Cyprus. This close collaboration between Turkey and Northern Cyprus Turkish Republic serves for Turkey's aims of creating an energy hub in the Mediterranean Region. With the increased harmony with neighbouring countries, it may even develop new synergies in energy politics because a possible Cyprus-Turkey gas pipeline connection is expected to have a direct positive impact on the financial viability of Southern Cyprus' offshore projects.

- *Egypt Pipeline Project*: This proposed pipeline was called the Arab Gas Pipeline (AGP). The aim of the project was to connect Egypt's gas fields. Currently, the existing pipeline reaches Syria but due to turmoil in both Egypt and Syria, very limited development has been observed in this project. The projected route was connecting Aleppo (Syria) and Kilis (Turkey), but based on the proximity of the pipeline to Çukurova Region, it would not be surprising to observe positive impacts on Çukurova Region's energy economics.

A2.1.4 Oil transport and storage

As with natural gas, Turkey is also a major transit point for oil (Figure A 2-13) as it links the oil-rich east to high consuming regions in Europe. Pipelines carrying Caspian oil and Iraqi oil cross Turkey and connect to Ceyhan oil terminal in Çukurova Region[209].

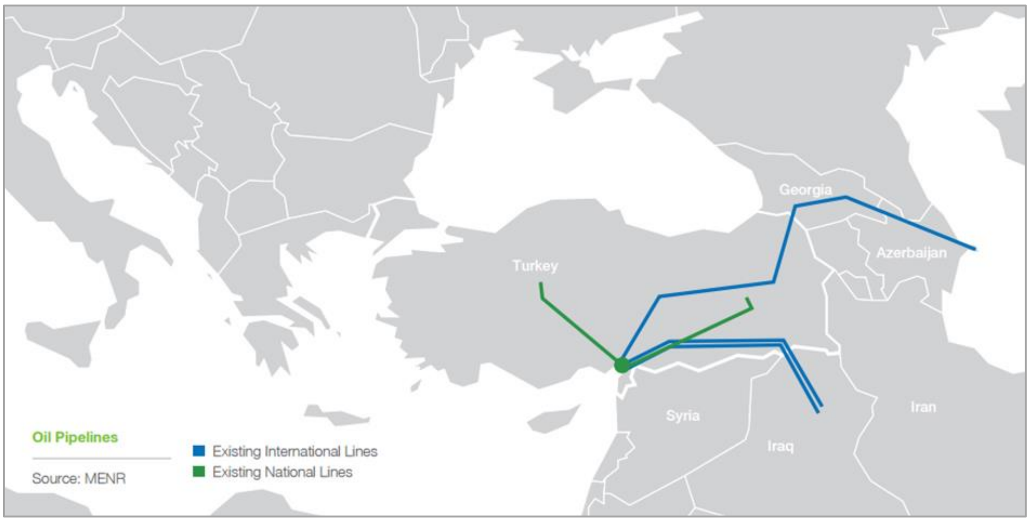


Figure A 2-13: Major oil pipelines in Turkey. (EIA, 2015[210])

From the perspective of Çukurova Region, oil and gas sources located around Turkey, should be seen as highly relevant for regional energy economics. It is not surprising that Ceyhan is considered as a tailor-made candidate for oil trade/transit thanks to its proximity to Middle Eastern and Caspian sources and its experience in terminal operations. Turkey has 12 major oil terminals. The most important of these is Ceyhan, which has seven crude storage tanks with a total capacity of 1 million barrels and a 2,000 m long jetty, where two 300,000 tonne tankers can dock simultaneously. Ceyhan is the destination for two major oil pipelines from Azerbaijan and Kirkuk.

Regarding refinery capacities, although Çukurova Region currently does not have any active refinery sites, plans for new investments are under consideration around Ceyhan-Yumurtalık by various corporate utilities.

With the aim of creating an energy hub in the southern part of Turkey, Ceyhan was specified as a "Ceyhan Energy Specialized Industry Zone" in 2007 with Council of Minister's Decree No: 2007/12632. The importance of the project is also mentioned in the 2015-2019 Strategic Plan of the Ministry of Energy and Natural Resources, which underlines the government's plans to develop a detailed road map on the Ceyhan Integrated Energy Hub Project. Figure A 2-14 shows that Ceyhan is the focal point of imported oil, and even Kırıkkale Refinery in Central Anatolia is directly connected to Ceyhan Region for oil procurement.
The following existing oil pipelines are targeting to reach domestic and international markets via Çukurova Region:

- *Baku-Tiblisi-Ceyhan (BTC) Oil Pipeline:* BTC pipeline has been transporting crude oil from Azeri-Chirag-Guneshli oil field in the Caspian Sea to the Mediterranean Sea since 2005. The pipeline connects Baku and Ceyhan through its 1,769 km length. Pipeline capacity is 1 million barrels per day (bpd), and, as of early 2016, the pipeline has been estimated to have transported ca. 2.5 billion barrels of crude oil loaded on 3,278 tankers and sent to world markets. Besides the oil sourced from Azerbaijan, Ceyhan port benefited from the increased trade. Moreover, this pipeline paved the way for diverting tanker traffic in the Black Sea (and correspondingly at the Bosphorus) to an alternative route in the south of Turkey.

- ***Kirkuk-Ceyhan Oil Pipeline*:** Being the Iraq's largest oil export pipeline, this route transports petroleum produced in the Kirkuk region of Iraq to Yumurtalık, Adana. The pipeline currently exports 100,000 bpd. That figure is expected to rise to 150,000 bpd following a recent oil agreement reached between Baghdad and Erbil.

A further project, the Samsun-Ceyhan crude oil pipeline project, which aims to transport crude oil from Kazakhstan to the Mediterranean over the Black Sea (without crossing the Bosphorus and Dardanelles) has yet not been realized. Nevertheless, the existence of such a project underlines even further the importance of Ceyhan terminal for export opportunities to global markets.

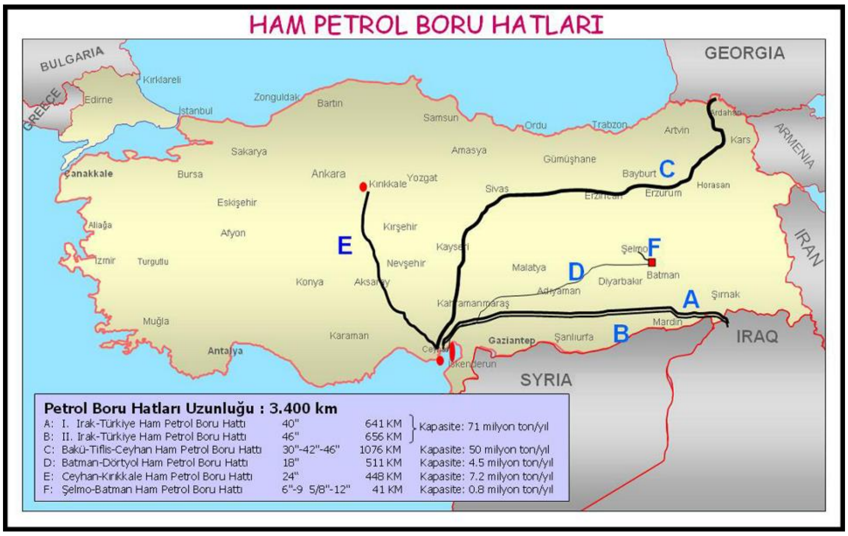


Figure A 2-14: Oil pipelines with connections to Ceyhan. (BOTAŞ,2015[211])

A2.2 The transport and logistics sector in Çukurova

A2.2.1 Regional characteristics relevant to the transport and logistics sector

Reports on international trade performance indicate that Çukurova is slightly losing its importance in Turkey's international trade. Despite its strategic location, the region saw negative growth of 5% in both export and import operations from 2014 to 2015 (Table A 2-8), which has a negative impact on the transportation and logistics sector.

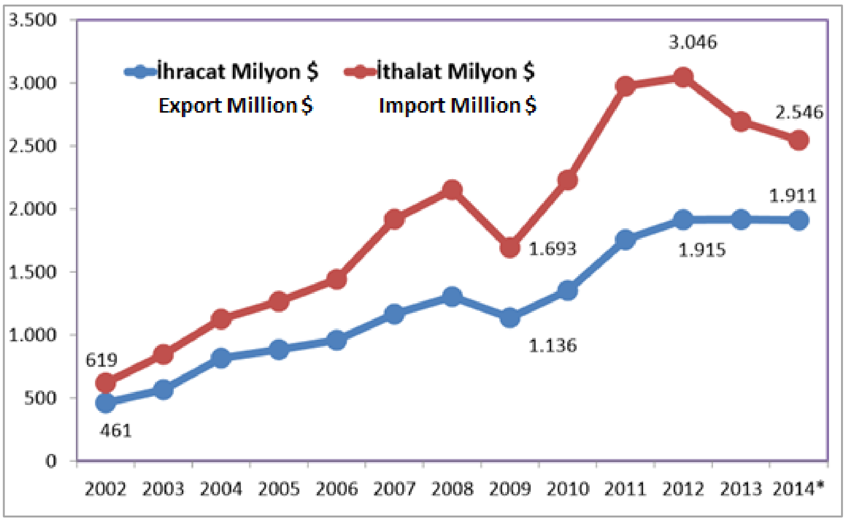


Figure A 2-15: International trade statistics for Adana. (Source: Report authors, based on Turkish Exporters Assembly data[212])

Table A 2-8: Import-export statistics for Çukurova Region (Source: Turkish Exporters Assembly[213])

Imports & exports	*2012*	*2013*	*2014*	*2015*
Adana - import	$3,046m	$2,694m	$2,547m	$2,048m
Mersin - import	$1,129m	$1,227m	$1,419m	$1,190m
Turkey - import	$236,545m	$251,661m	$242,183m	$207,234m
Region as % of Turkey - import	**1.76%**	**1.56%**	**1.64%**	**1.56%**
Adana - export	$1,915m	$1,889m	$1,909m	$1,679m
Mersin - export	$1,313m	$1,514m	$1,792m	$1,435m
Turkey - export	$152,462m	$151,626m	$151,153m	$133,665m
Region as % of Turkey - export	**2.12%**	**2.24%**	**2.45%**	**2.33%**

Destinations for exports

Although there are 147 different countries to which Çukurova exports its products, some 80% of the export revenues of the region in 2015 were obtained from Iraq, Russia, Germany, Syria, Spain, USA, Italy, Ukraine, United Arab Emirates, Netherlands, France, Cyprus, Egypt and China. The top 30 countries for exports are shown in Figure A 2-16.

Destinations including Iraq, Syria and UAE are accessible by road, rail and air transportation, whereas other destinations are accessible via maritime or air transportation.

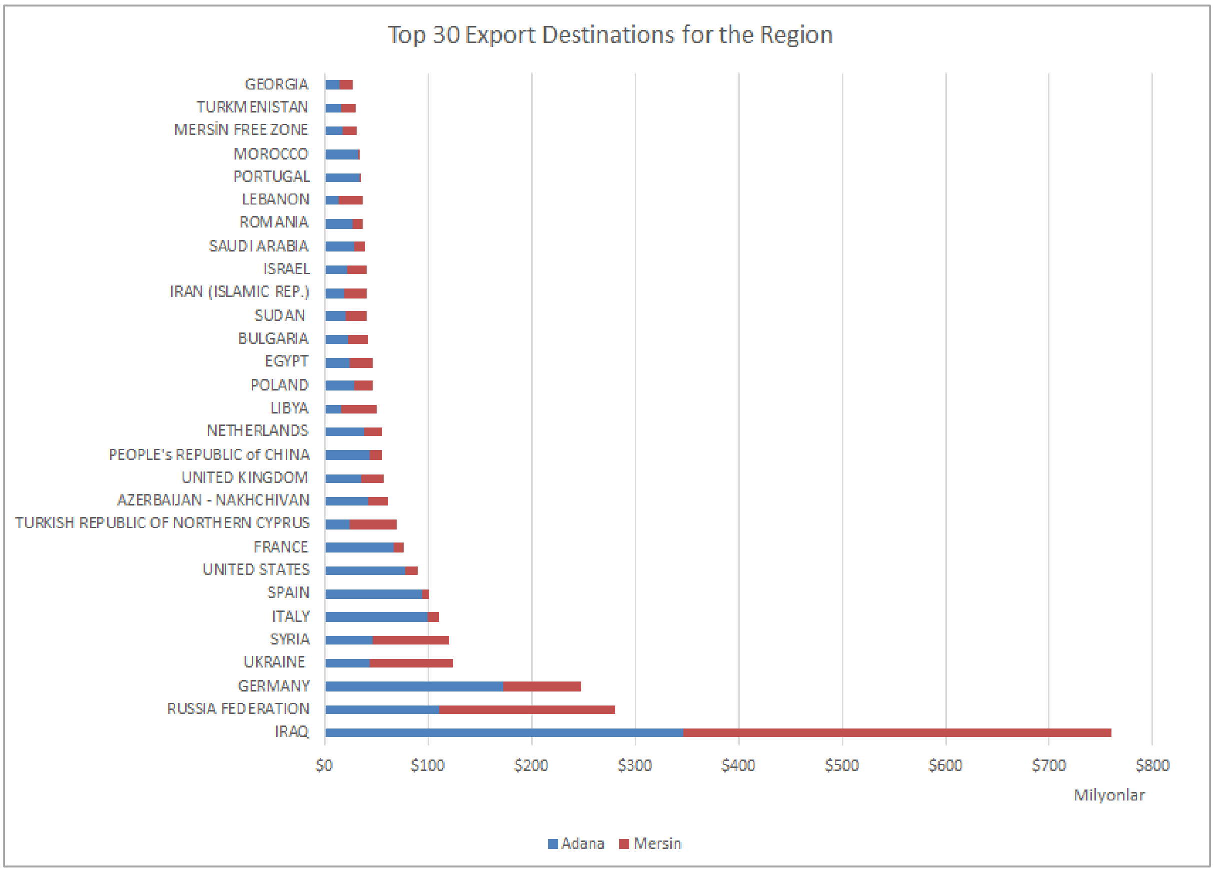


Figure A 2-16: Top 30 destinations and associated export volumes for Adana and Mersin in 2013. (Source: Report authors, based on Turkish Exporters Assembly data[214])

Main product categories exported from Çukurova Region

Figure A 2-17 and Figure A 2-18 present the main product categories exported from the region. Some 45% of regional exports, or outbound product flow, is comprised of agricultural products, followed by textile products (15%) and chemical products (11%).

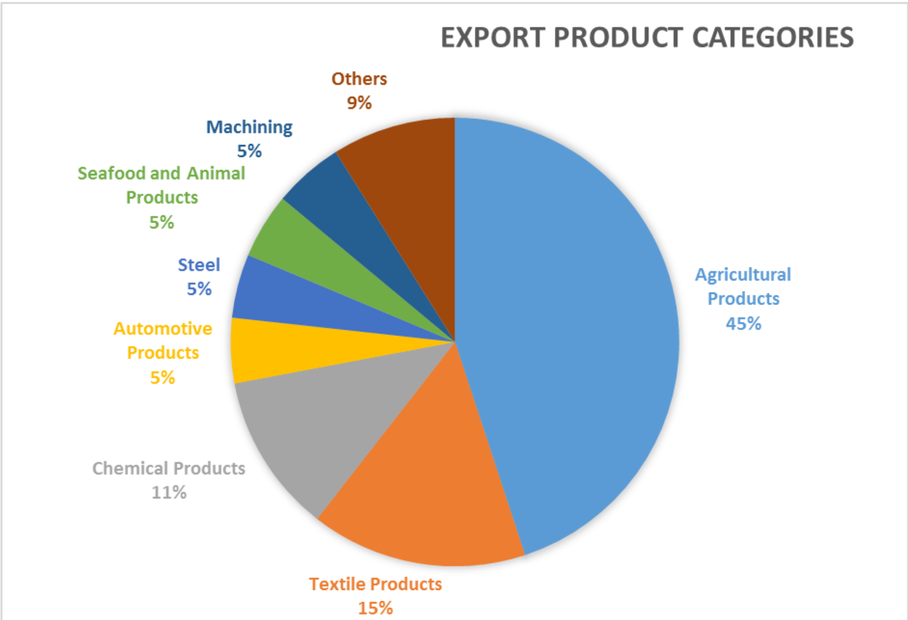


Figure A 2-17: Main product categories exported from Çukurova Region (%). (Source: Report authors, based on Turkish Exporters Assembly data[215])

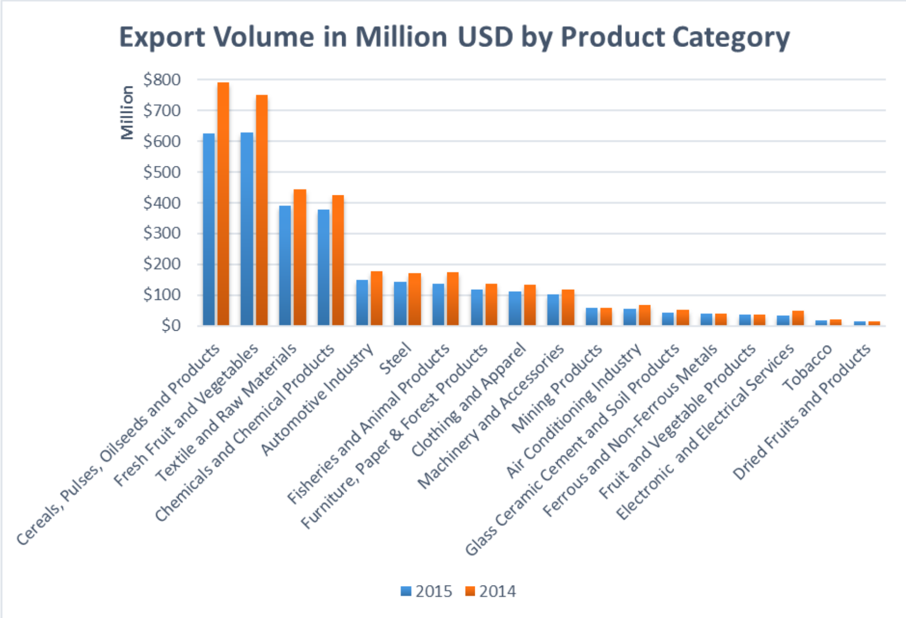


Figure A 2-18: Main product categories exported from Çukurova Region (million USD). (Source: Report authors, based on Turkish Exporters Assembly data[216])

Productivity in the agriculture sector

As of 2014, the transport and logistics sector produced 12.6% of the gross domestic product of Turkey. The transport and logistics sector is expecting the highest share of both public and private investments nationwide, accounting for 37% of total public investment, and 18% of private investment. However, the share of investments in the logistics sector for Adana and Mersin (87,398,000 TL) in the total public investment for the sector (15,597,750,000 TL) was only 0.6% in 2014[217]. Relatively inadequate investments, slow development and out-migration in the region gradually led to decreased productivity in both the agricultural and manufacturing sectors. Being the driving sector of the region, the agriculture sector has a considerable impact on the performance of the transport and logistics sector in the region. According to the Economic Report for 2014 prepared by the Union of Chambers and Commodity Exchanges of Turkey (TOBB), agricultural production of cotton decreased by 3.3% from 2012 to 2013. Despite the negative trend in cotton, 45% of corn, 50% of soy bean, 34% of peanuts, 65% of grapefruit and 29% of orange production in Turkey takes place in Adana. Mersin produces 23% of all citrus fruits in Turkey, 9.8% of all the country's fruits and 6.2% of its vegetables[218]. Since the agricultural output of the region generally serves domestic demand, road is the preferred transportation mode for agricultural products. Also, Iraq is the highest volume export destination, and road transportation to Iraq is preferred due to close proximity, safety and flexibility. This also explains why rail transportation is not preferred in the region.

Crisis in Syria

According to interviews with Adana Sanayi Odası (Adana Chamber of Industry) and Adana Hacı Sabancı OSB (Organized Industrial Zone), external factors such as the crisis in Syria have made Çukurova region relatively more attractive. Gaziantep has traditionally been a centre of attraction for investors, but the Syrian crisis has made some investors perceive Gaziantep as a risky location. Some investors are therefore relocating to Adana.

A2.2.2 Road networks

Çukurova Region is connected to Turkey's southeast and eastern regions via the bi-directional D-400 motorway and E-90 highway, which extends to Syria and Iraq through Habur (Figure A 2-19 and Figure A 2-20). Through the Taurus Mountains, the highway reaches out to Central Anatolia, and it extends to Mersin in the western direction. In addition to the highway, there is a bi-directional motorway between Adana and Mersin. There is a tunnel and a road construction connecting Mersin and Antalya along the Mediterranean coast. Another important project to improve the accessibility of Mersin Port and its hinterland from other regions is the road construction that extends to the north (Konya and Karaman) out of Silifke. The D-400 motorway, which runs in an east-west direction, passes through the city centers of both Mersin and Adana, adversely affecting the traffic on Mersin-Erdemli motorway especially during summer. To relieve urban traffic in Adana and to ease the traffic around the port, the southern Adana beltline (highway) project has been initiated. However, there is no known project to relieve the traffic problem around Mersin Port.

Figure A 2-19: Existing road network in Çukurova Region. (Source: KGM[219]).

Figure A 2-20: Existing road network in the Çukurova Region showing interconnections across Turkey. (Source: KGM [220])

As shown in Figure A 2-21, Çukurova Region is an integral part of Routes 3 and 4 of the Euro-Asian Transport Linkages Project[221]. Considering the major export products of the region (which are perishable) and their destinations (Iraq, Syria, Iran and other Middle East countries), the highways and their freight transportation are extremely important in terms of efficient transport, shorter lead times and competitiveness of the region. In addition to access to the Middle East, Çukurova Region needs improved access and highway connectivity to countries including Russia, Georgia and Ukraine. Figure A 2-21 indicates only two corridors from the region to the Black Sea region, which are far from the intermodal terminals providing maritime transportation to Russia and former-Soviet Union countries.

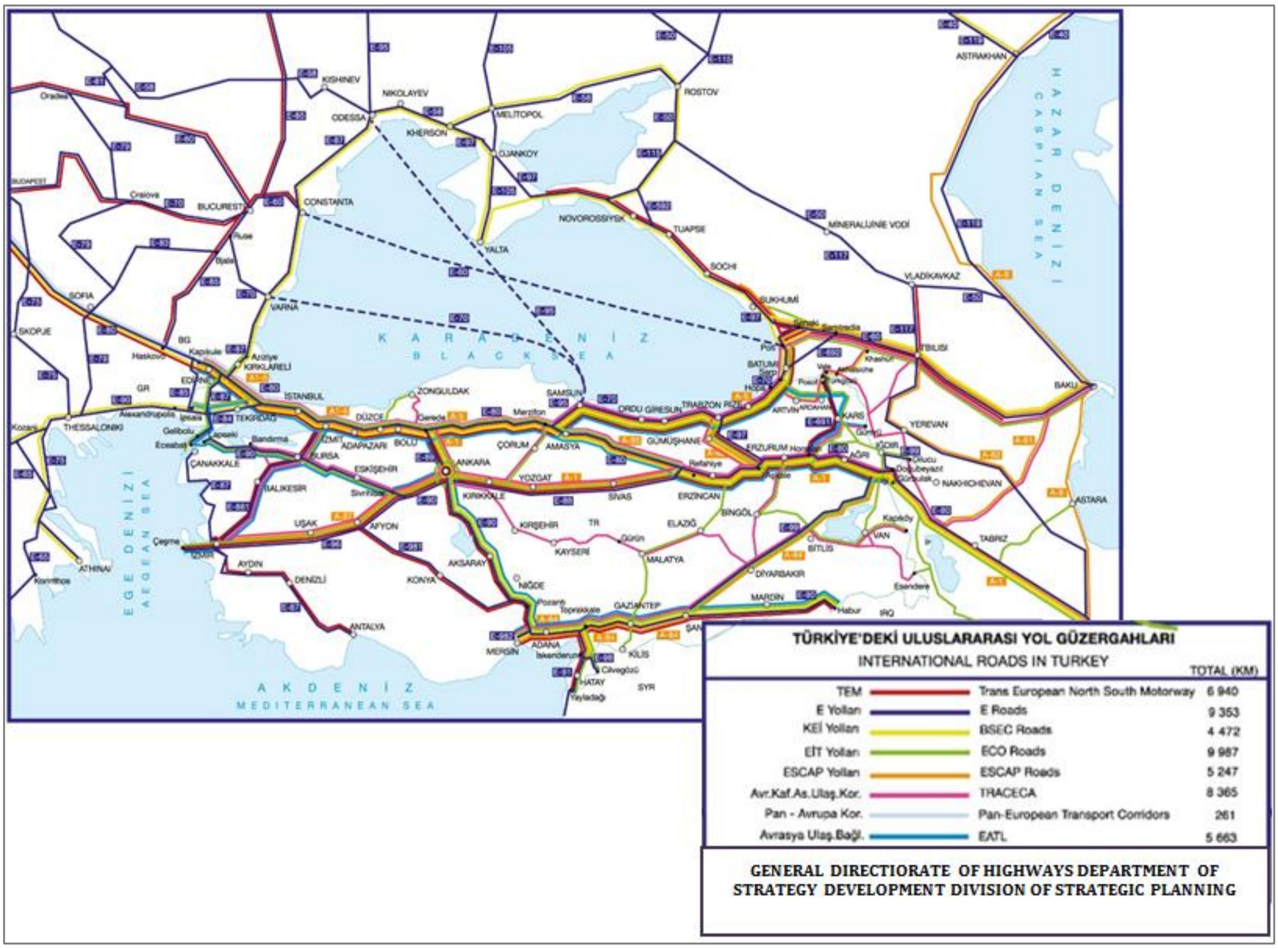


Figure A 2-21: International road network of Turkey. (Source: KGM[222])

Table A 2-9 presents the type and length of state and provincial road infrastructure in Adana and Mersin. It is noteworthy that approximately 14% of the total road length is city asphalt concrete, while 79% is surface treated road. This indicates lower freight transport capacity and negative impact on the logistics performance of the region.

Table A 2-9: Type and length (km) of state and provincial roads as of 2014. (Source: KGM[223])

	City Asphalt Concrete	Surface Treated	Stone Tiled	Stabilized	Earth Road	Impassable	Total (km)
Adana	146	667	1	10	99	29	**952**
Mersin	151	1047	2	0	0	17	**1217**

The overall road and rail network of Çukurova Region relative to the total network of Turkey is summarized in Table A 2-10. Some 3.56% of Turkey's road network by length is located in the region.

As can be seen from the table, over the period 2009 to 2013, there was almost no improvement in the length of road transportation infrastructure of the region, which leads to longer transport times, higher transport costs, higher production costs and consequently decrease in value added production of the region. As the major sector contributing to the economy is agriculture, which takes place in rural areas, it is contradictory to observe that only around 3% of the nation's village/rural roads are found in the region.

Table A 2-10: Length of road networks in Turkey and in Çukurova region. (Source: Report authors; data from General Directorate of Highways, Turkish State Railways and General Directorate of Local Administrations).

	Province and State Road	Highway	Village (Rural) Road	Railway
TR Türkiye				
2009	62 219	2 036	298 405	9 080
2010	62 785	2 080	302 398	9 594
2011	62 930	2 119	305 227	9 642
2012	63 255	2 127	320 366	9 642
2013	63 496	2 127	323 043	9 718
TR62 Adana, Mersin				
2009	2 143	304	9 412	289
2010	2 141	311	9 493	289
2011	2 137	311	9 633	289
2012	2 172	309	9 642	289
2013	2 169	309	9 697	289
TR622 Mersin				
2009	1 188	157	4 937	106
2010	1 185	157	4 999	106
2011	1 185	157	5 121	106
2012	1 220	157	5 122	106
2013	1 217	157	5 177	106

Source: General Directorate of Highways, Turkish State Railways and General Directorate of Local Administrations

Figure A 2-22 presents the freight transportation and freight traffic volume on major road networks in Turkey. After the Marmara and Aegean regions, Çukurova Region can be clearly seen to be an important logistics hub in southern Turkey, with approximately 12,000 heavy freight vehicles in 2009 and 19,611 freight vehicles in 2015. Figure A 2-22 and Figure A 2-23 also indicate the main freight corridors and major destinations (Iraq, Syria, Israel, Northern Cyprus Turkish Republic, etc.) for the region. It is also possible to observe the bottlenecks in the north-south corridors of the region.

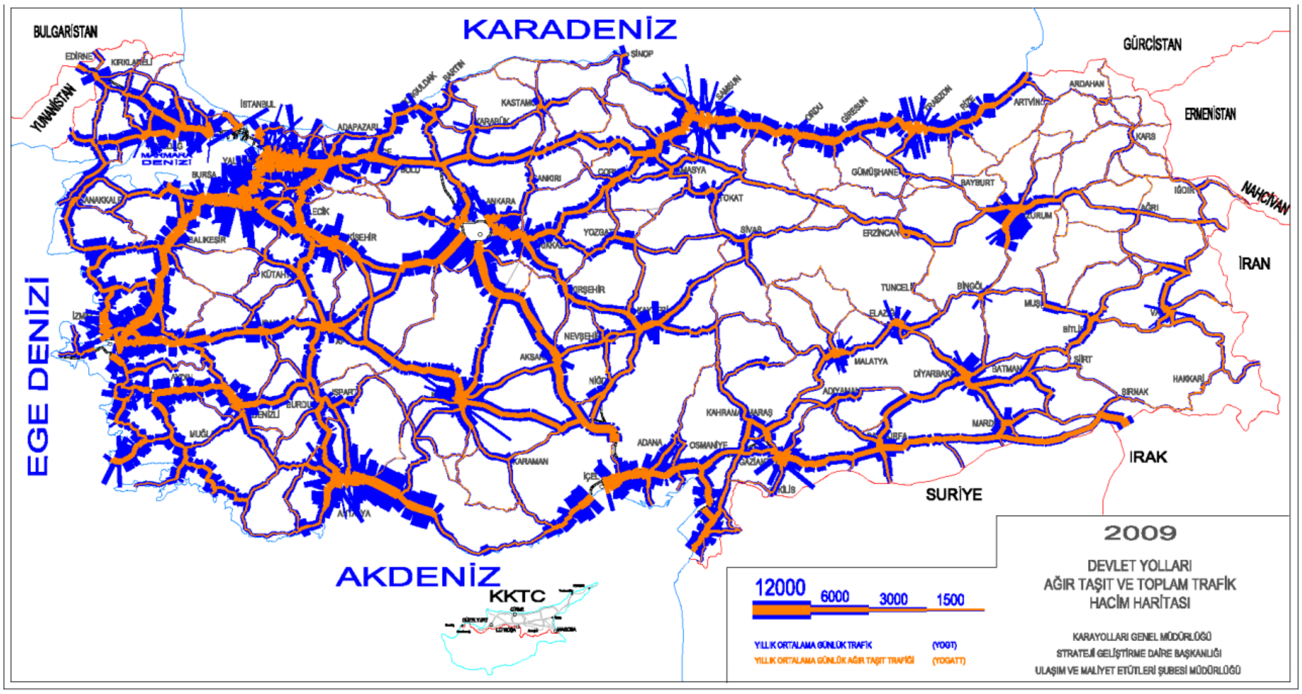


Figure A 2-22: Freight Transportation and Traffic Volume Map for Turkey (2009). (Source: KGM, 2011[224])

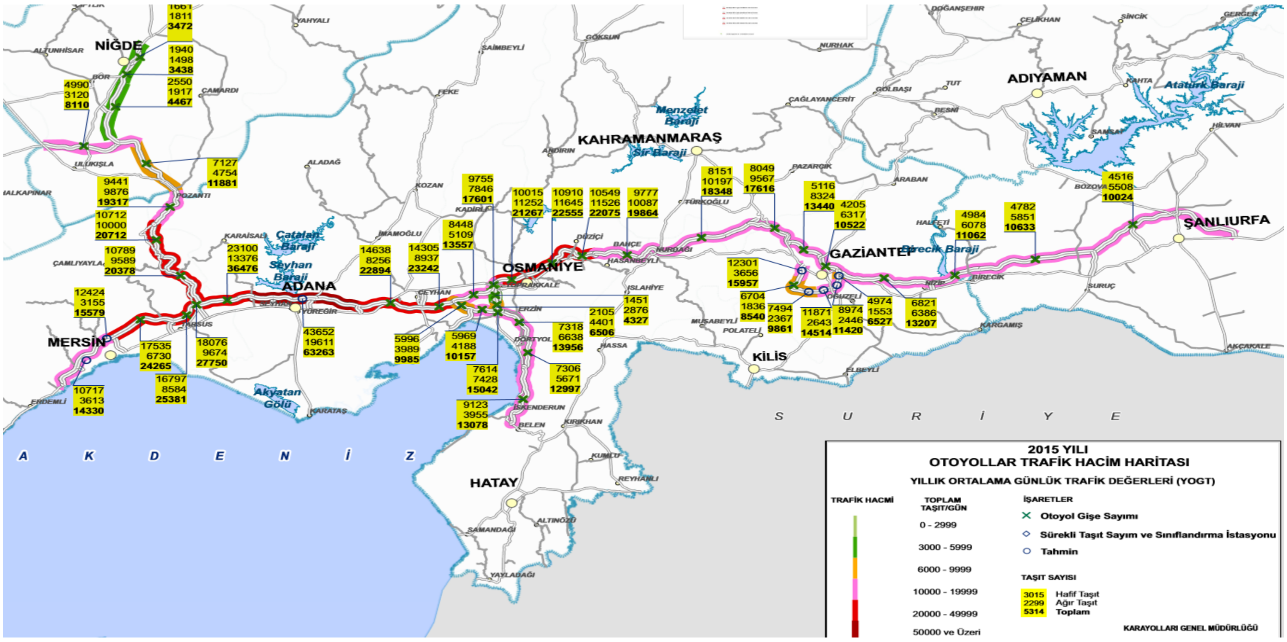


Figure A 2-23: Freight Transportation and Traffic Volume Map for Çukurova Region. (Source: KGM, 2015[225]).

Based on 2011 KGM Statistics, the total freight ton-km of the region was reported to be 9,520,000 ton-km, with Adana reporting 4,464,000 ton-km and Mersin, 5,056,000 tons-km. With these freight statistics, Çukurova Region includes 4.9% of the overall freight traffic in Turkey. More recent nationwide figures are reported in Table A 2-11, from where it can be seen that passenger transportation by air is steadily increasing while road transportation is being replaced by air. Regarding freight transportation, while road is still the most preferred mode with approximately 88% weight, maritime transportation shows a slightly increasing trend while railway remains almost constant. Similar trends are reflected in the Çukurova Region.

Table A 2-11: Freight (ton-km) and Passenger (passenger-km) transportation in Turkey (2012-2014) (Source: TUIK, 2016)[226]

Passenger Transportation										
Transportation		Million Passenger			Change %		Share %		
Ulaşım Yolları		2012	2013	2014[(1)]	2013	2014	2012	2013	2014
Yurt içi	(Domestic)								
Kara yolu [(2)]	(Highway)	258.874	268.179	284.256	3,6	6,0	91,9	91,1	90,6
Demir yolu	(Railway)	2.949	2.976	3.075	0,9	3,3	1,0	1,0	1,0
Hava yolu [(3)]	(Airway)	19.731	23.357	26.416	18,4	13,1	7,0	7,9	8,4
Toplam	(Total)	281.554	294.512	313.747	4,6	6,5	100,0	100,0	100,0
Yurt dışı	(International)								
Hava yolu [(3)]	(Airway)	64.945	79.696	93.005	22,7	16,7	100,0	100,0	100,0
Toplam	(Total)	64.945	79.696	93.005	22,7	16,7	100,0	100,0	100,0

Freightage										
Transportation		Million Passenger			Change %		Share %		
		2012	2013	2014[(1)]	2013	2014	2012	2013	2014
Yurt içi	(Domestic)								
Kara yolu [(2)]	(Highway)	216.123	224.048	237.831	3,7	6,2	88,4	88,1	88,2
Demir yolu	(Railway)	10.473	10.241	11.079	-2,2	8,2	4,3	4,0	4,1
Deniz yolu [(4)]	(Seaway)	15.753	17.332	18.247	10,0	5,3	6,4	6,8	6,8
Boru hattı	(Pipeline)								
Only Crude - Petroleum		2.173	2.800	2.622	28,9	-6,4	0,9	1,1	1,0
Toplam	(Total)	244.522	254.421	269.779	4,0	6,0	100,0	100,0	100,0
Yurt dışı	(International)								
Demir yolu	(Railway)	750	509	470	-32,1	-7,7	0,1	0,0	0,0
Deniz yolu [(6)]	(Seaway)	1.030.000	1.050.000	1.060.000	1,9	1,0	95,5	95,9	96,3
Boru hattı	(Pipeline)								
(Crude-Petroleum-transit)		48.216	44.417	39.956	-7,9	-10,0	4,5	4,1	3,6
Toplam	(Total)	1.078.966	1.094.926	1.100.426	1,5	0,5	100,0	100,0	100,0
Natural Gas (million m3)		45.922	45.269	45.900	-1,4	1,4	-	-	-

Source: KB.
(1): Estimated realization
(2): Transportation activities in the road network under the responsibility of the highways headquarters
(3): Transportation only by Turkish Airlines
(4): Recorded transportation activities by maritime transport and communications ministries

A2.2.3 Railway networks

The railway network in Çukurova Region is categorized as "Region 6", indicated by the yellow lines in Figure A 2-24. There are 15 logistics hubs, 9 terminals, 33 stations and 37 stops in Region 6. The Adana–Mersin Railway Line (constructed in 1882) connects Mersin to Adana at the east, with seven stops in Mersin Province, most of which are used by commuter trains. Mersin Railway Station is the southernmost train terminal of Turkey and is connected to the Port of Mersin. The other major stations are Tarsus Railway Station in Tarsus and Yenice Railway Station in Yenice.

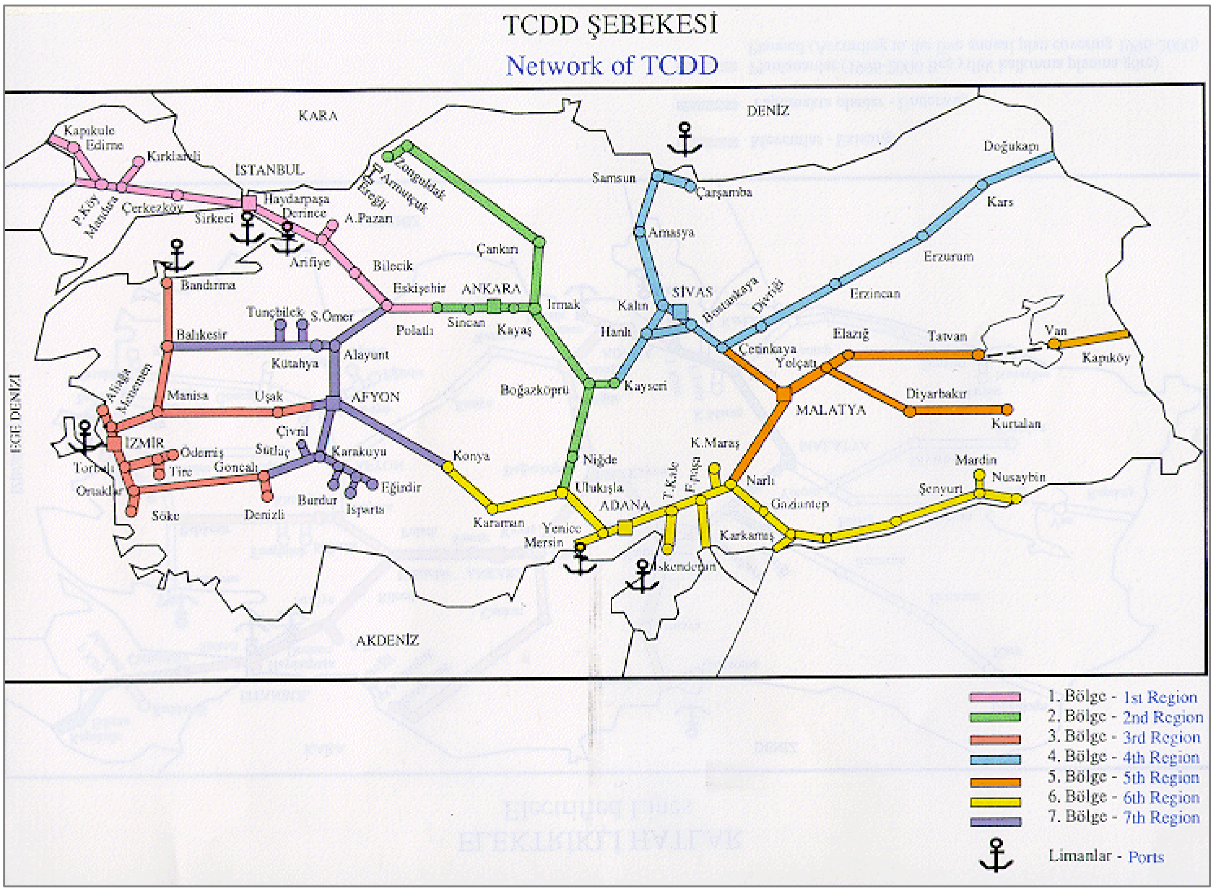


Figure A 2-24: Railway network in Turkey (TCDD 2001) [227]

According to the State Railway Statistics (Table A 2-12), there was a 21.4% decrease in rail freight carried in 2015 compared to 2011. While 23.2% of total rail freight was passing through Region 6 in 2011, this ratio decreased to 19.2% as of 2015. There could be several possible causes for this decrease. First, the general outlook of Turkey's economy which has seen decreasing import/export may cause recession in the region's economy and lead to decreased logistics activity in all transportation modes. The second possible reason is the industrialization of the Çukurova, meaning production of more valuable items which might be more suitable for road or air transportation instead of rail transportation. The third reason could be related to the heavy emphasis on the agricultural products, which are perishable and thus not able to last for long trips by train. Yet another reason is the unavailability of reliable rail freight networks to major export destinations such as Iraq, Russia, Syria, etc.

Table A 2-12: Passenger and Freight Gross tonne-kilometers[xxviii]. (Source: Adapted from TCDD[228]).

	2011	2012	2013	2014	2015
6. BÖLGE - 6th Region					
YOLCU - Passenger	572.020	662.833	643.310	668.150	537.540
YÜK - Freight	4.399.914	4.096.087	3.359.991	3.998.386	3.457.560
İŞ TRENİ - Service Train	58	469	1	8.000	2.972
TOPLAM - Total	4.971.992	4.759.389	4.003.302	4.674.536	3.998.072

Both Adana and Mersin have rail connections with all other regions except the Aegean region (Region 3). With three strategic connections to northeastern, eastern, and southeastern Anatolia, the Çukurova Region is moving beyond national borders; reaching out to Syria, Iraq, Iran, Georgia and Central Asia.

[xxviii] 'Gross tonne-kilometer' is the unit of measure representing the movement over a distance of one kilometre of one tonne of rail vehicle including the weight of tractive vehicle.

As an important part of the Silk Road TRACECA project, the railway construction work continues. The railway line passing through Nigde, Amasya and reaching Samsun connects Çukurova Region to the port of Samsun and to Russia. With the opening of Kavkaz Train Ferry Line on February 19, 2013, intermodal freight loaded at Kavkaz Port is transported to Asia and the Middle East. Similar intermodal practices are planned between the ports of Samsun and Georgian and Bulgarian ports. Thus, the Port of Mersin will be accessible from the Port of Varna, increasing the potential for intermodal freight transportation.

Table A 2-13 provides detailed information on line sections and codes of railroads passing through the 6th Region which includes Adana and Mersin (Lines 72, 73, 74, 75 and 76). In addition, the total length of lines, mainline passenger and total passenger numbers, and freight statistics per line are shown. It can be seen that Ulukışla-Yenice and Yenice-Mersin lines are particularly important in terms of total number of passengers, freight and service trains operated.

Table A 2-13: Train-kilometers by Line Sections (2015). (Source: TCDD,2016)[229]

HAT KESİMLERİ VE KODLAR Line Sections and Their Codes	Hat Uzunluğu Length of Line (Km)	Banliyö Suburban	Anahat Yolcu Mainline Passenger	Toplam Yolcu Total of Passenger	Yük Freight	İş Treni Service Train	Toplam Total
6.BÖLGE - 6th Region							
72 - Horozluhan - Ulukışla	247,8	-	113.212	113.212	480.268	4.778	598.258
73 - Ulukışla - Yenice	109,0	-	240.432	240.432	875.577	12.478	1.128.487
74 - Yenice - Mersin	43,2	-	975.834	975.834	218.866	2.122	1.196.822
75 - Yenice - Adana	24,0	-	450.487	450.487	130.419	28.304	609.210
76 - Adana - Toprakkale	78,3	-	188.511	188.511	369.010	5.475	562.996
77 - Toprakkale - İskenderun	59,6	-	43.104	43.104	511.031	7.795	561.930
78 - Toprakkale - Fevzipaşa	63,1	-	92.825	92.825	534.317	1.772	628.914
79 - Fevzipaşa - Narlı	69,4	-	50.611	50.611	585.945	3.259	639.815
80 - Köprüağzı - K.Maraş	29,1	-	-	-	4.429	636	5.065
81 - Fevzipaşa - Tahtaköprü	39,0	-	14.306	14.306	817	54	15.177
82 - Narlı - Gaziantep	84,2	-	-	-	139.273	1.895	141.168
83 - Gaziantep - Karkamış	91,0	-	-	-	2.772	106	[illegible]
84 - Karkamış - Hudut	325,6	-	-	-	-	392	[illegible]
TOPLAM -Total	**1.263,3**	**-**	**2.169.322**	**2.169.322**	**3.852.724**	**69.066**	**6.091.112**
GENEL TOPLAM Grand Total	**8.729,60**	**3.348.427**	**19.152.122**	**22.500.549**	**18.549.770**	**822.254**	**41.872.573**

A2.2.4 Airports

The only airport currently serving Çukurova Region is Adana Airport or Adana Şakirpaşa Airport (IATA: ADA, ICAO: LTAF), an international airport located in Adana. The location of the airport is shown in Figure A 2-25 and general and technical information on the airport is provided in Table A 2-14. As of June 2016, there were 436 weekly departures to 23 routes from the airport, connecting the region to eight destinations in Turkey, 11 in Germany, 3 in the Middle East and one in Northern Cyprus. Adana Airport is the sixth busiest airport by passenger traffic in Turkey, with 5.4 million passengers in 2015. The airport is ranked 77th in the busiest airports in Europe[230].

Şakirpaşa railway station is 1.9 km walking distance to the airport terminals, and is located one block north of the D400 state road. There are frequent train services to Mersin Central, Tarsus and Adana Central stations, and fewer daily services to eastern stations of Adana; Yüreğir, İncirlik and Ceyhan. Also from the station, there are once-daily trips to Osmaniye, İskenderun, İslahiye, Karaman and Niğde.

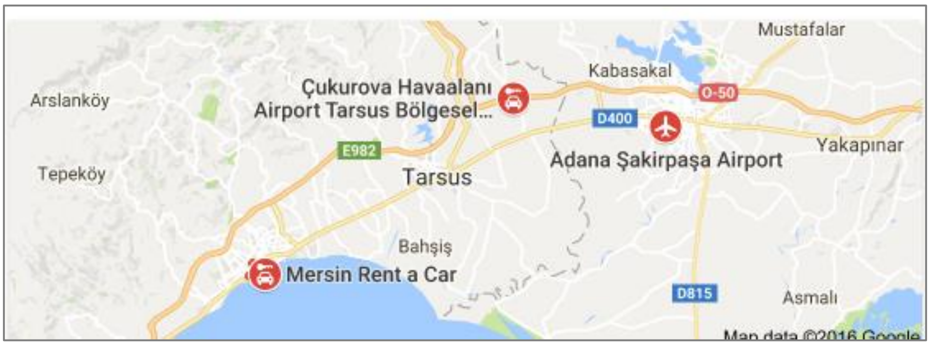


Figure A 2-25: Location of Adana Şakirpaşa Airport. (Source: Google Maps).

Table A 2-14: General and Technical Information for Adana Şakirpaşa Airport. (Source: DHMI[231])

City	Adana
Starting Date of Operation	1937
Aerodrome Status	Civil
ICAO Code	LTAF
IATA	ADA
Traffic Type	Domestic / International
Terminal Building Total Area	10.749 m^2
Geographical Coordinates	36°58`56"N, 35°16`49"E

Technical Information & Facilities

Benefit	DHMI
Distance to City	3,5 kilometers
Transportation	Bus, Shuttle, Taxi
Height (AMSL)	65 FT (19.74M)
Illumination Category	CAT I
Firefighting Category	CAT IX
VIP	Available
Cafe Restaurant	Available
Bank Services	Available
Health Services	Available
PTT (Post Office)	Available
Parking	660 Vehicle

RUNWAYS

Direction	Length(m)	Resistance	Surface
05/23	2750x45	115 PCN	Composite

TAXI ROUTES

Length(m)	Covering	Resistance
3250x23	Asphalt	PCN 100

APRONS

Size	Covering	Resistance	Airplane Capacity
269x100	Concrete	PCN 100	13+1 (Nato Apron)
104x98	Concrete	PCN 100	

It is striking to note that for Şakirpaşa Airport, international passenger and cargo traffic have been significantly greater than domestic traffic between 2002-2012 (Figure A 2-26). According to latest figures, international passenger traffic increased 15% in 2015 compared 2014, whereas domestic passenger travel increased by 13% over the same period. When air freight statistics in 2015 are examined, a 14% increase in international domestic freight traffic and only a 6% increase in domestic freight traffic is observed, which is contrary to the trend observed in many other airports in Turkey including Izmir. A similar trend (i.e. more international traffic than domestic) has been observed only in Istanbul Ataturk and Adana Şakirpaşa Airports. When we look at the freight statistics in Izmir and other regions, we can conclude that Çukurova airports have the potential to be the second-largest international hub airport in Turkey. This is one of the parameters that shows the increasing regional and international significance of the region from an economic perspective.

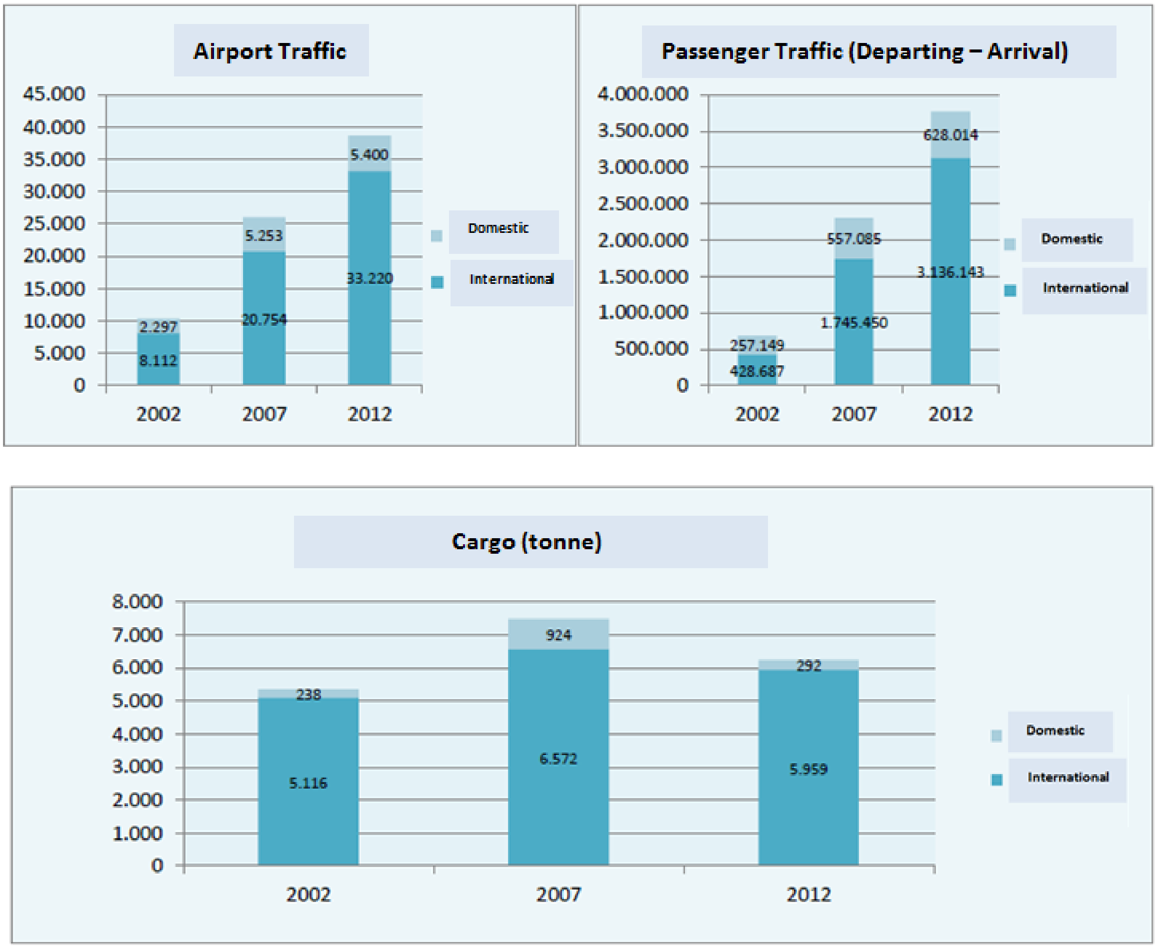


Figure A 2-26: Adana Şakirpaşa Airport Freight Transport by Aircraft and Airline Passenger Traffic. (Source: DHMI[232])

Table A 2-15: National Air Transportation Statistics for Turkey (2012-2014). (Source: DHMI,2016[233])

Elements	Passenger Transportation (2)			Change %		Cargo (3)			Change %	
	2012	2013	2014 (1)	2013	2014	2012	2013	2014 (1)	2013	2014
General Directorate Of State Airports Authority (DHMI)										
Domestic	55,000,664	64,040,856	70,220,557	16.4	9.6	559,570	649,937	690,997	16.1	6.3
International	60,507,044	66,384,365	71,357,455	9.7	7.5	1,510,081	1,709,406	1,879,958	13.2	10.0
Total Turkey (General Directorate Of State Airports Authority)	115,507,708	130,425,221	141,578,012	12.9	8.6	2,069,651	2,359,343	2,570,955	14.0	9.0
Overall										
Domestic	64,721,316	76,148,526	85,416,166	17.7	12.4	633,074	744,027	810,858	17.5	8.8
International	65,630,304	73,281,895	80,304,068	11.7	9.7	1,616,059	1,851,289	2,082,142	14.6	11.1
Total (overall)	130,351,620	149,430,421	165,720,234	14.6	11.1	2,249,133	2,595,316	2,893,000	15.4	10.4
(1): Transient, (2): Excluding direct transit of Turkey, (3): Sum of air cargo, mail transported and luggage										

A2.2.5 Seaports

Considering global trade patterns moving towards the east, from the EU/USA into the Near East and China, Çukurova Region is perceived as a natural gateway for trade, owing the fact that it includes the closest sea gateways to the energy-rich landlocked Near East and Central Asia.

In terms of the maritime network, the Port of Mersin is the largest piece of infrastructure facilitating seaborne containerized import/export operations, not only for the Çukurova Region but also the adjacent landlocked inner Anatolia and nationwide. It is the third largest container port in Turkey after Marport (1.9 mio TEU capacity) and recently-introduced Asyaport (2.5 mio TEU capacity), both of which are located in Marmara Region.

The hinterland of Mersin Port is important, extending beyond Çukurova Region, due mainly to the port's direct railway connection into landlocked fertile lands in inner and southeastern Turkey (Figure A 2-27). For instance, there was approximately 30 mio tons of cargo activity seen in Mersin's hinterland in 2013. The principal provinces which are served by Mersin's hinterland are as follows: Mersin, Adana, Kayseri, Konya, Gaziantep, Ankara, Sivas, Kahramanmaraş, Malatya, Elazığ, Diyarbakır.[234]

The general layout of the Port of Mersin is presented in Figure A 2-28. It is currently operated on a concession basis by international joint venture PSA / Akfen called "Mersin International Port (MIP)". MIP is able to handle various types of commodities including containers, (1.8 mio TEU/ year capacity[235]) and bulk cargo into trucks via RO-RO, thanks to its well-established railway, road and short-sea feeder system connections.

Furthermore, in terms of fulfilling the ambitions of "Target 2023", the Government of Turkey was planning to establish infrastructure for a completely new container project adjacent to the MIP by reclaiming land. The capacity of this new port project was intended to reach almost 11.4 mio TEU capacity by 2033[236]. However, the parameters show that there has been no actual work done so far to materialize this project, as its feasibility has not been evaluated and shared with the private sector, (which was going to operate it on a concession basis) and the local industrial stakeholders (who would be the main customer of this new project). Therefore, MIP can currently be considered as the main facilitator of containerized cargo transactions.

In the Province of Mersin, there are also other smaller scale cargo-specific sea infrastructures such as Yesilovacik Port serving an integrated cement plant, Tasucu Port handling mainly transportation between the island of Cyprus and the mainland, Atas Jetty serving the state refinery next to MIP, in addition to Mersin Free Zone (MESBAŞ) jetty and SEKA facility (Figure A 2-28).

Figure A 2-27: The hinterland of the Port of Mersin. (Source: Mersin International Port[237]).

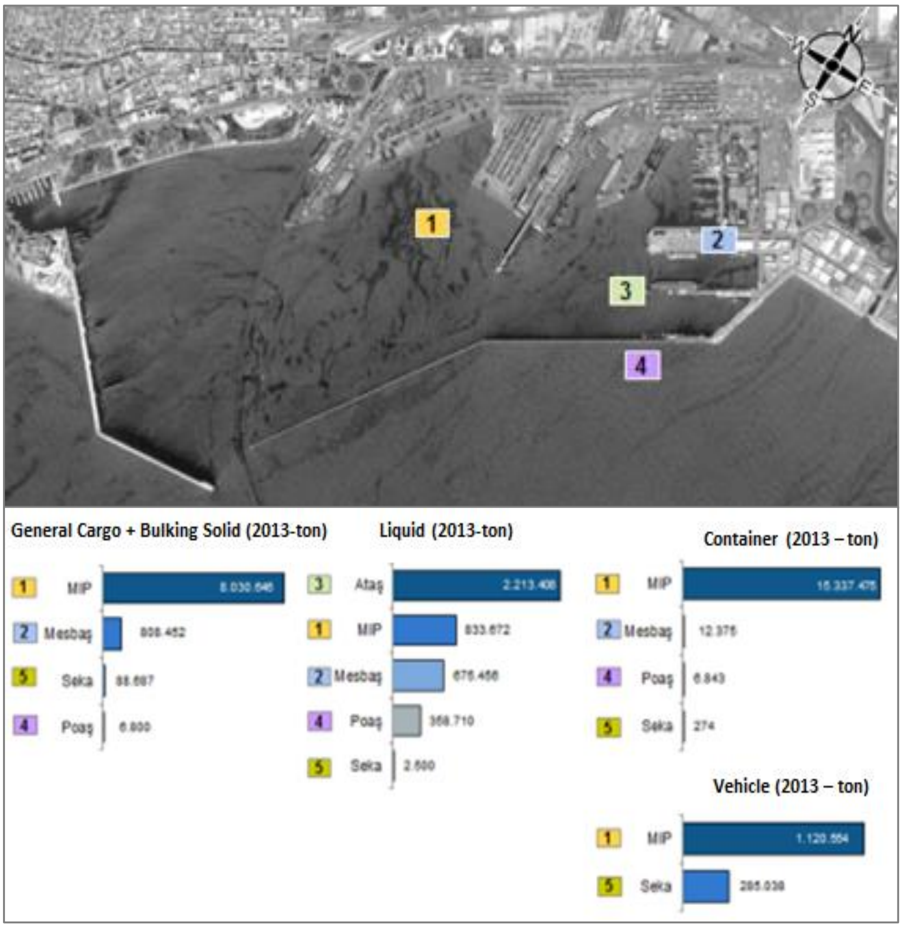


Figure A 2-28: The general scheme of the Port of Mersin (MIP) and its adjacent jetties. (Source: Mersin International Port, 2015[238])

As can be clearly seen from Figure A 2-29, the hinterland (based on road network features) of Mersin Port is the second largest in Turkey, with İskenderun Port having the largest.

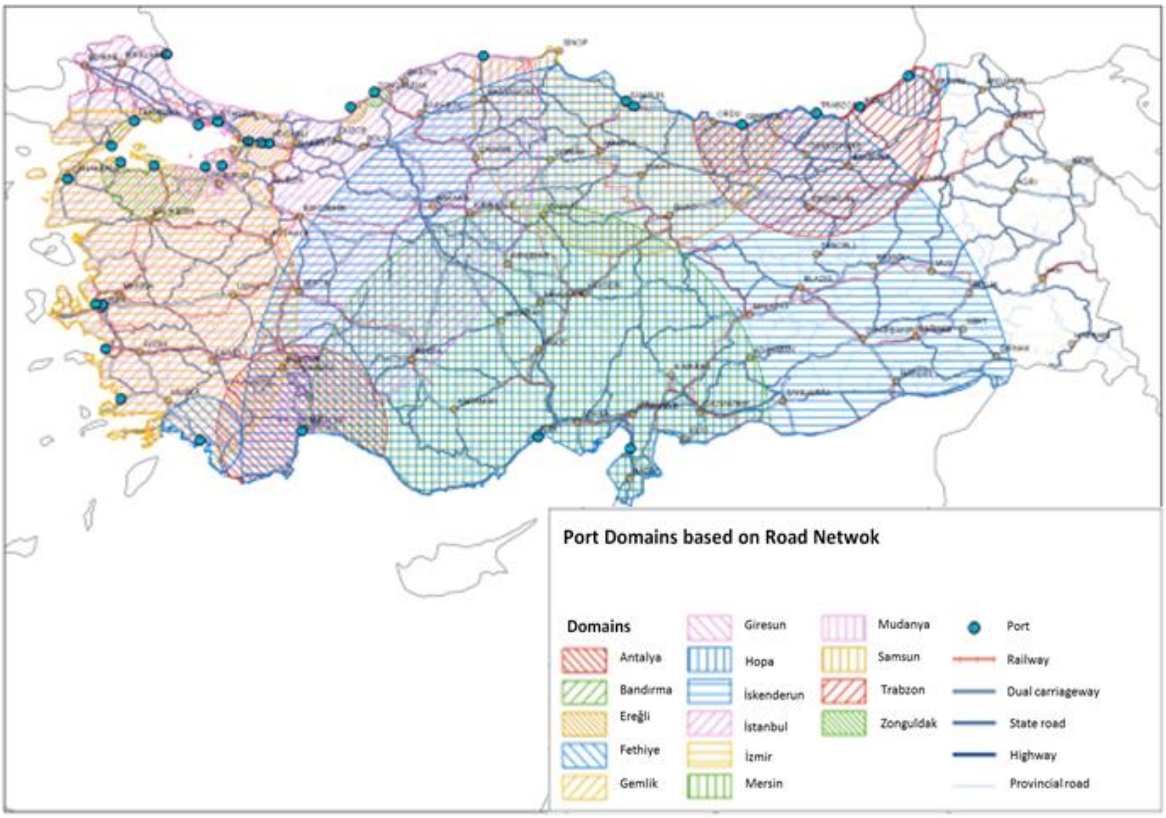


Figure A 2-29: Hinterlands of Turkish Ports. (Source: OECD,2013[239])

The vicinity of Ceyhan can also be considered as a coastal region of Adana province. As noted in Section A2.1 this area is specialized and is planned as the gateway for energy hubs from the Middle East to global markets, as well as industrial production plants such as integrated cement plants (i.e. Sonmez Cement Toros jetty, CIMKO Cement SANKO Port) and energy production zones such as thermal power plants. Both cement plants and thermal power plants (ISKEN jetty - Sugözü Power Plant) have extensive port facilities serving their raw material and product import/export operations. ISKEN-Sugözü thermal plant is served by the world's largest floatable trans-shipment vessel, which is privately chartered and operated by a global shipping company on a concession basis.

The Province of Adana on the other hand has more industrial and custom-made sea infrastructure. Adana does not have a container terminal comparable to Mersin. In summary, the main seaports are located in the "Gulf of Iskenderun" where Botaş, Yumurtalık, Ceyhan, Toros Gubre and "Adana Free Zone" facilities are located (Figure A 2-30).

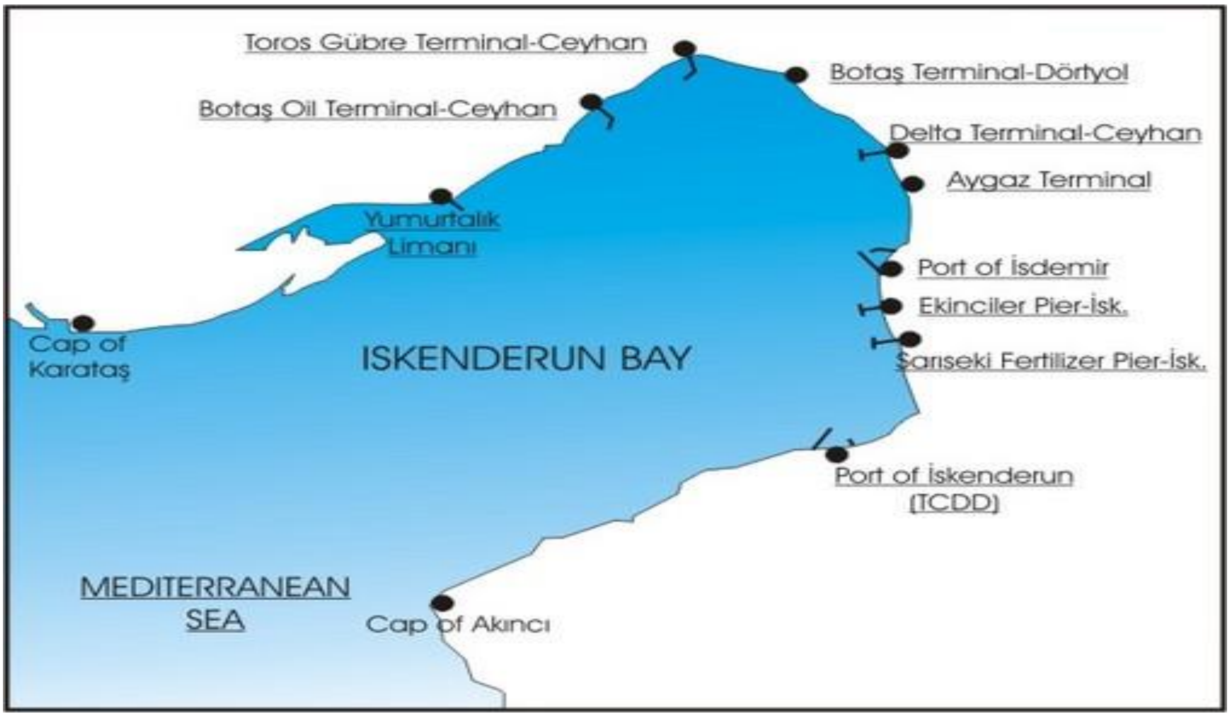


Figure A 2-30: Overview of sea infrastructure in Iskenderun (most of the northwest part of the bay lies within Çukurova region). (Source: Euromar Agency Services[240]).

A2.2.6 Logistics hubs

Çukurova Region is currently promoting a single logistics center, "Yenice Logistics Center" which is considered to be the distribution center serving the railway connections coming from inland Anatolia, in coordination with MIP and the new container port project in Mersin. The project is still under development and it is planned to have a capacity of 896,000 tons/year to be operational within an area of 416,000 m². The main cargoes to be handled will be containers as in a dry-port system, agricultural equipment, cotton, cement, chemicals, military goods and pipeline equipment. In coordination with the new container port project in Mersin, shuttle train shipments are planned to provide a smooth intermodal system.

A2.2.7 Private sector stakeholders

The main stakeholders of the logistics industry in the region are export and import firms, industrial zones, and public institutions[241]. Table A 2-16 and
Table A 2-17 provide general information on export and import firms operating in the logistics sector and organized industrial zones, respectively.

Table A 2-16: Information on export and import firms operating in the logistics industry in the region (2012). (Source: Bilim Sanayi ve Teknoloji Bakanlığı, 2013[242])

Indicator	Mersin	Adana
Number of Export Firms	935	923
Export Volume (USD)	1,915,935	1,311,918
Number of Import Firms	689	1054
Import Volume (USD)	1,129,215	3,046,332

Table A 2-17: Information on organized industrial zones (OIZ) located in Mersin and Adana (2013). (Source: Bilim Sanayi ve Teknoloji Bakanlığı, 2013[243])

Industrial zones	Size (hectares)	Employment (# personnel)	Industries served
Mersin Tarsus OIZ (1997)	602	5,520	Iron & steel, plastics, food
Silifke OIZ (under construction)	92	540	Marble and food
Adana Hacı Sabanci OIZ (2001)	1,510	27,000	Textiles, iron & steel and plastics
Adana Kozan OIZ (2007)	164	80	Food and clay

A3 Risk assessment methodology - further information

A3.1 Step 1 – Select critical infrastructure

The first step is to select the CI in Çukurova for the assessment. This is initially based on a 'long list' of potential candidates, in which the following criteria are considered in identifying CI:

1. The **impact on essential services due to damage or disruption** to the infrastructure that leads to reduced asset performance.
2. The **duration of the disruption**, the length in time of unavailability of the critical infrastructure.
3. High-level estimates of the **economic impact** arising from loss of the essential service
4. The **geographical extent of the impact** i.e. whether it is felt regionally, nationally or transnationally
5. **'Cascading effects'** where disruption to the infrastructure can lead to a chain of events elsewhere.

This long-list then is shortened based on the following criteria:

1. Availability of data from public sources sufficient to build a (high level) operational model in RiskAPP
2. Availability of data from public sources to define vulnerability and exposure of the CI
3. Only existing infrastructure will be assessed, not planned new developments
4. Ensuring coverage of different types of infrastructure.

Based on the criteria defined in Step 1 of the methodology, the following CI were selected for assessment:

1. Energy sector:
    a. Sanibey Yedigoze Hydropower Plant (HPP)
    b. İsken Sugözü Thermal Power Plant (TPP)
    c. Baku-Tbilisi-Ceyhan (BTC) Oil Pipeline
    d. Yumurtalik-Kırıkkale Oil Pipeline

2. Transport / logistics sector:
    a. Mersin International Port
    b. Seyhan Viaduct across Seyhan River on the E-90 European Highway.

A3.2 Step 2- Develop hazard scenarios

Hazard is defined by the IPCC as "*the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources*." **In this risk assessment, the level of hazard is given by the current and future frequency and magnitude of adverse climate and geophysical events.**

The second step requires the development of a set of hazard scenarios to be used in the simulation of the effects on CIs. Appendix 1 "*Climate and Geophysical Hazard Assessment*" details the robust evidence base used for developing the plausible scenarios for climate-related hazards across Çukurova:

1. Storms and hail,
2. Flood,
3. Extreme temperatures,
4. Sea level rise and coastal flooding,

5. Landslides (precipitation induced).

For the above climate-related hazards, the observed/current level of hazard as well as potential future changes due to climate change by the 2030s (the period 2020 – 2050) and 2050s (the period 2040 – 2070) are considered. In addition, information on the following geophysical hazards is also shown in Annex A3.7:

1. Earthquake,
2. Landslide (earthquake induced).

In some instances, robust quantitative frequency/ magnitude information is not available e.g. for future time periods. In such circumstances, the portfolio of evidence is used to make an expert judgement of a reasonable level of hazard for the risk assessment. A summary of the current and future levels of hazards in Çukurova can be seen in Table A 3-1. For the future time periods, an upwards arrow indicates a likely increase in the hazard level (a double arrow indicates a strong increase). A dash or question mark indicates 'no change' or 'uncertain change' respectively.

Table A 3-1: Summary of the current and future levels of hazard in Çukurova. (Source: Report authors).

Hazard		Summary of hazard level in Çukurova			
		Current		Future: 2030s	Future: 2050s
Geophysical hazards	Earthquake	Medium	In both Mersin and Adana there is a 10% chance of a potentially-damaging earthquake in the next 50 years.	-	-
	Landslide (earthquake induced)	Low	The landslide inventory report compiled by the General Directorate of Mineral Research and Exploration (MTA) states no records of earthquake triggered landslides (neither from historical or contemporary events) in Mersin and Adana provinces.	-	-
Climate hazards	Storm (extra tropical)	Medium	Probable maximum intensity peak wind speeds are in the range of 81-120km/h for 1 in 100-year return period events.	↑	↑
	Tornado	Low	Observed tornadoes in the region range up to F2 on the Fujita scale[xxix].	?	?
	Hail	Low	Statistics for the whole of Turkey: • 42 severe hail cases, or 0.54 cases per 10,000 km² per year • 29 severe hail days, or 0.37 days per 10,000 km² per year.	?	?
	Flood (fluvial or pluvial)	Medium	Medium: 20% chance that potentially damaging and life-threatening floods will occur in the coming 10 years in Çukurova. 2-3 notable flood events over 1985-2011 in Çukurova.	↑	↑
	Heat waves	Medium	The low-lying coastal plain of the Çukurova region is amongst the higher heatwave hazard zones in Turkey. The intensity, length and number of heatwaves have increased since the 1960s across the country, including the Çukurova region	↑	↑↑
	Flood (coastal)	High	Satellite data has been used to determine the 100-year wave height to be 6.1m (± 0.03m)	↑	↑
	Landslides	Low	Level of threat from landslides triggered by precipitation is relatively high in some localised	?	?

[xxix] See Annex A3.7 for a description of the Fujita scale

(precipitation induced)		regions of Çukurova, for example the mountainous border between Adana and Mersin provinces

A3.3 Step 3 – Screen for susceptibility to hazards

Step 3 requires expert judgement of how susceptible each of the CIs are to each hazard identified in Step 2. This prevents unnecessary hazard scenarios being used in the RiskAPP process. Susceptibility is based on the following criteria:

1. **The sensitivity of the CI** to a hazard e.g. a buried pipeline will not be sensitive to wind storms,
2. **The location** of the asset in relation to the hazard e.g. a thermal power plant located far inland will not be susceptible to coastal flooding.

Table A 3-2 summarises the outcome of this processing Çukurova. Hazards coloured in orange are taken forward for the risk assessment. Where appropriate a short rationale and reference is given to explain the decision.

Table A 3-2 Susceptibility matrix for selected critical infrastructure in Çukurova to natural hazards. (Orange shading indicates the asset is susceptible to a particular hazard; green shading indicates it is not susceptible.). (Source: Report authors).

Hazard	Energy				Transport & logistics	
	Sanibey Yedigoze Hydropower Plant	**İsken Sugözü Thermal Power Plant**	**BTC Oil Pipeline**	**Yumurtalik-Kırıkkale Oil Pipeline**	**Mersin International Port**	**E-90 European Highway (Seyhan Viaduct across Seyhan River)**
Earthquake	Yes	Yes	Relevant but no significant effect on pipeline[xxx]	Yes	Yes	Yes
Landslide (earthquake-induced)	No significant effect on this plant	Yes	No - buried pipeline	Yes	No - this location is not affected by this hazard	Yes
Storm (extra tropical)	Yes	Yes[244]	No - buried pipeline	Yes - pump stations and tanks are exposed to hazard	Yes	Yes
Tornado	Yes[245]	Yes[246]	No - buried pipeline	Yes - pump stations and tanks are exposed to hazard	Yes	Yes
Hail	No significant effect on hydropower plant	No – the power plant location does not experience extreme hail conditions	No - buried pipeline	Yes - pump stations and tanks are exposed to hazard	Yes	Yes
Flood (fluvial or pluvial)	Yes	Yes[247]	No - buried pipeline	Yes	Yes	Yes
Heat wave	Yes	Yes	No - buried pipeline	Yes - pump stations and tanks are exposed to hazard	Yes	No significant effect
Flood (coastal)	Not located at the coast. Elevation above 200m	Yes	No - buried pipeline	Yes	Yes	No - far away from coast

[xxx] See Annex A3.8.4

Hazard	Energy				Transport & logistics	
	Sanibey Yedigoze Hydropower Plant	İsken Sugözü Thermal Power Plant	BTC Oil Pipeline	Yumurtalik-Kırıkkale Oil Pipeline	Mersin International Port	E-90 European Highway (Seyhan Viaduct across Seyhan River)
Landslide (precipitation-induced)	No significant effect on this plant	Yes	No - buried pipeline	Yes	No - this location is not affected by this hazard	Yes

A formal 'menu' of quantitative hazard scenarios is developed based on international best practice and convention on return periods for each hazard type. The scenarios combine a balance of less frequent, very extreme events and more common, potentially less damaging ones. Each hazard is (usually) represented by between 2-4 hazard scenarios of varying magnitude and frequency. If an asset is deemed susceptible (as per Table A 3-2) each relevant hazard scenarios is applied. For example, if a power station is susceptible to flood risk, scenario #4, #5 and #6 should be applied at that location in order to fully account for the risk (Table A 3-3).

Table A 3-3 'Menu' of hazard scenarios to be applied to CI assets when susceptible. (Source: Report authors).

Scenario number	Hazard	Return period	Time period	Scenario description	Source of scenario
#1	Earthquake	72 years	Current	Likely with small intensity	Akkar et al. 2017[248]
#2	Earthquake	475 years	Current	Fairly common with mid intensity	Akkar et al. 2017[249]
#3	Earthquake	2500 years	Current	Rare with very high intensity	Akkar et al. 2017[250]
#4	Flood	20 years	Current	Likely with small intensity	UNEP[251]
#5	Flood	100 years	Current		UNEP[252]
#6	Flood	500 years	Current	Rare with very high intensity	UNEP[253]
#7	Storm	100 years	Current		MunichRe's Nathan[254]
#8	Storm	100 years	2030/ 2050	'zone 2' used as basis for 'new' magnitude of hazard	MunichRe's Nathan[255]
#9	Tornadoes	unknown	Current	F1	Kahraman, A., & Markowski, P. (2013).[256]
#10	Tornadoes	unknown	Current	F2	Kahraman, A., & Markowski, P. (2013).[257]
#11	Hail	Not relevant	Current		Kahraman et al. 2011 and 2016[258],[259]
#12	Heatwaves	5 years	Current		WHO 2010[260]
#13	Heatwaves	5 years	2030	30% increase (RCP 8.5 ensemble median of 90th percentile of temperature) medium to high	WHO 2010[261] & IPCC SREX[262]
#14	Heatwaves	5 years	2050	45 % increase (RCP 8.5 ensemble median of 90th percentile of temperature) medium - v high	WHO 2010[263] & IPCC SREX[264]
#15	Coastal flood	100 year	Current	<= 6.1 m coastal elevation	Simav et al. (2013 & 2014)[265],[266]
#16	Coastal flood	100 year	2030	<= 6.2 m coastal elevation	Simav et al. (2013 & 2014)[267],[268]
#17	Coastal flood	100 year	2050 (less extreme scenario)	<= 6.3 m coastal elevation	Simav et al. (2013 & 2014)[269],[270] and IPCC 5AR[271]

#18	Coastal flood	100 year	2050 (extreme scenario)	<= 10 m coastal elevation	Simav et al. (2013 & 2014)[272],[273] and Jevrejeva, S et al. (2014)[274]
#19	Landslides (precipitation induced)	n/a	Current	Probability of occurrence of landslides induced by precipitation.	UNEP[275]
#20	Landslides (earthquake induced)	n/a	Current	Probability of occurrence of landslides induced by earthquake.	UNEP[276]

A3.4 Step 4 - Identify vulnerabilities

Vulnerability is defined by the IPCC as the "*The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt*." **In this risk assessment, vulnerability is given by the relationship between hazard events and the damage (or decrease in efficiency) this will cause the infrastructure, expressed in percentage or category of damage.**

Step 4 relies on CI experts researching the relationship between the potential levels of a hazard and the damage they may cause. Ideally, this should be done by referring to established research such as 'fragility curves' (Figure A 3-1).

Fragility curves are generally derived from datasets of historical surveys on damages caused to CIs and their components by past events. Fragility curves can also be computed using computer simulations methods such as the finite element method. If these methods are not viable, expert judgement is used to assess the possible response of each asset to each hazard.

As a CI is usually made up of sub-components or 'elements' it is required to make an assessment of vulnerability for each one. For example, in a hydropower plant, there are 3 main elements that are potentially vulnerable:

1. the dam,
2. the turbine with attached generator, and
3. the substation that elevates the voltage.

The design of the individual elements is a key determinant of vulnerability. Taking the substation element as an example, firstly the typology of the substation should be identified. For instance, if it is designed to withstand seismic activity, it is likely to be 'anchored' to the ground. Whether it is anchored or not will influence the choice of fragility curve (or other information) to determine its vulnerability. The vulnerability of the CI as a whole is represented by the integration of the vulnerability of each element in RiskAPP. Within the scope of the CIRA, only some components are accounted for in the risk assessment approach. In future, a deeper analysis on each major component and its relationship with others could be conducted in order to gain a deeper knowledge of risks and interactions of threats.

By way of example, Figure A 3-1 shows a fragility curve for a medium/large power plant with anchored components. The black line represents a medium intensity earthquake of 0.40 [g] (i.e. 40% of vertical acceleration applied to the side of the power plant because of earthquake). According to the fragility curve, the most probable damage is 'moderate'. This is a damage state that implies some diffuse damage to pumps, some cosmetic repairs to internal finishing, and that leads to reduced power production. Fragility data used in this assessment are provided in Annex A3.8. Where quantitative fragility curves were not available, CI experts were asked to provide their opinion on the percentage of damage or in levels of damage.

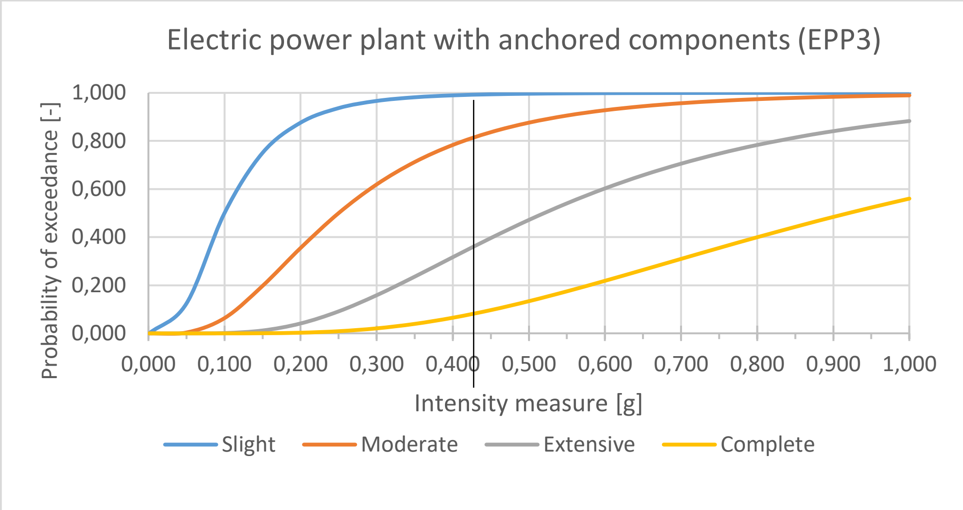


Figure A 3-1 Example of fragility curves for a medium/large power plant with anchored component for earthquake hazards. (Source: Cavalieri et al, 2014[277])

A3.5 Step 5 – Collect exposure data

Exposure is defined by the IPCC as "*The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.*" **In this risk assessment, exposure is given by the economic impact and geographical extent of the cascading consequences if it's damaged.**

The **fifth step** refers to the collection or development of the following information for each CI:

1. The location of the asset,
2. The impact on the economy if the service provided by the CI is disrupted,
3. The geographical extent of the impact i.e. whether it is felt regionally, nationally or transnationally,
4. 'Cascading effects' where disruption to the infrastructure can lead to a chain of events affecting other sectors of the economy.

Firstly, information on the location of CI assets is stored in a Geographical Information System (GIS) which allows RiskAPP to 'overlay' the localised hazard data. Figure A 3-2 shows an example of how a CI's location is represented in RiskAPP. Secondly, the impact on the economy is based on the relationship between the CI's essential service and its contribution to GDP. Table A 3-4 shows the relationships between loss of service (downtime) from energy assets in Çukurova and estimated GDP loss and Table A 3-5 shows the equivalent relationships for disruption to transport/logistics assets. Thirdly, the geographical extent of the impact and cascading effects are assessed qualitatively, by sector experts.

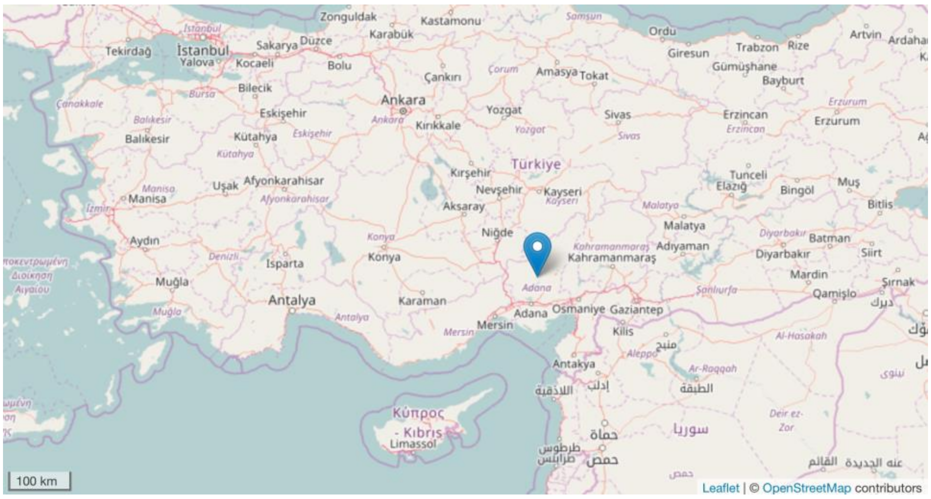


Figure A 3-2 Map from RiskAPP© representing the location aspect of exposure. (Source: Report authors).

Table A 3-4 Impact on Turkey's GDP of loss of service for one day from selected energy assets in Çukurova Region. (Source: Report authors).

Energy Asset	Capacity (GWh [power plant] and barrels per day [pipeline])	Estimated GDP loss per day of downtime (million USD)*
Sanibey Yedigoze Hydropower Plant	672	6.1
İsken Sugözü Thermal Power Plant	9,183	84
Yumurtalik-Kırıkkale Oil Pipeline	141,000	11.6**

* GDP estimated as a proportion of 2015 total GDP for Turkey. Source: http://data.worldbank.org/country/turkey
** The figure for the oil pipeline includes: (1) loss of revenue for the refinery owners associated with disruption of oil supplies via the pipeline, assuming that disruption leads to lost refinery production (2) Loss of tax revenue to the government due to loss of sales of refined products. This figure therefore does not represent a full picture of GDP loss; rather it provides a partial view of the economic impact of pipeline disruption.

Table A 3-5 Impact on Turkey's GDP of loss of service for one day from selected transport/logistic assets in Çukurova Region. (Source: Report authors).

Transport Asset	Capacity	Estimated GDP loss per day of downtime (million USD)*
Mersin International Port	1.8 million TEUs/year	21
Seyhan Viaduct on E-90	36,232 vehicles/day	5.1

* GDP estimated as a proportion of 2015 total GDP for Turkey. Source: http://data.worldbank.org/country/turkey

A3.6 Step 6 and 7 – Implement the model in RiskAPP and assess the risks

Risk is defined by the IPCC as the probability of occurrence of hazardous events or trends (associated with its magnitude) multiplied by the impacts (e.g. on the economy) if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. **In this risk assessment, Risk = Hazard x Vulnerability x Exposure.**

In the **sixth** step, the risk assessment is performed using the RiskAPP algorithm. Information on hazards, vulnerability and exposure are combined to provide a measure of risk (the downtime in days and the economic impact, expressed as loss of GDP). In **step 7**, the results from the algorithm are analysed critically and presented.

Table A 3-3 presents the return periods for each scenario. The exceedance probability is calculated as the inverse of the return period. The associated damage and downtime for each scenario and each type of CI was identified through a literature review (see Annex A3.8) and, where no literature was available, from the judgement of the expert team.

As noted above, RiskAPP provides a quantitative assessment of downtime and economic consequence. However, the geographical extent of the impact and the 'cascading effects' are necessarily based on more qualitative interpretation by experts. For each CI, the final step in the risk assessment addresses the following questions:

1. What is the potential level of damage to the CI, including:
    a. Damage to the integrity of the asset (on a scale from 0-100%, where 100% implies that the cost of repairs equals the value of the asset, not necessarily 'total destruction'),
    b. Decrease in asset performance?
2. How long will disruption last? *The duration of disruption is expressed in days of downtime.*
3. What are the high level economic impacts? *The economic impact is computed as total loss connected to the event. The economic risk is calculated as the total loss for the event multiplied by the probability of occurrence of the event.*[xxxi]
4. What is the geographical extent of the impact? *Is the impact local, regional, national or trans-national?*
5. What are the cascading impacts? *Which consequences will the disruption of the asset produce to other infrastructures or services?*

By way of example, consider a house worth USD 100,000 which sits on an active fault. The fault is expected to trigger an earthquake that shakes the house with a PGA of 0.5 [g] (50% of the weight of the house applied laterally) with an annual probability of 5%. The house has a seismic design, so the expected damage with 0.5 [g] earthquake is 30%. The following simplified formula leads to a risk of USD 1,500 per year:

$$Risk = Hazard \times Vulnerabilty \times Exposure = 0.05 \; \times \; 0.3 \; \times 100'000\$ = 1'500\;\$ \qquad (1)$$

Since many earthquakes, stronger or weaker, i.e. rarer or more frequent, might happen, the overall risk is the sum of all these possible events. **In the Çukurova risk assessment, the economic risk is expressed in terms of economic (GDP) loss (not the financial loss to the company or organisation operating the asset).**

A3.7 Hazard data assessment for use in risk assessment

A3.7.1 Introduction

The purpose of this hazard assessment is to provide a robust evidence base for developing plausible hazard scenarios for the Çukurova Region Critical Infrastructure Risk Assessment (CIRA). This section summarises the current understanding of the frequency and magnitude of the following climate-related hazards across Çukurova:

1. Storms and hail

xxxi Other factors of uncertainty are not accounted in the present study.

2. Flood
3. Extreme temperatures
4. Sea level rise and coastal flooding
5. Landslides (precipitation induced)

For the above climate-related hazards, this section outlines the current (observed) level of hazard as well as potential future changes due to climate change by the 2030s (the period 2020 – 2050) and 2050s (the period 2040 – 2070). In addition, the following geophysical hazards are explored:

1. Earthquake
2. Landslide (earthquake induced)

The frequency of a natural hazard event is the number of times it occurs within a specified time interval. The magnitude of a natural hazard event is related to the energy released by the event.[278] In some instances, robust quantitative frequency/ magnitude information is not available e.g. for future time periods. In such circumstances, the portfolio of evidence is used to make an expert judgement of a reasonable level of hazard for the risk assessment. (A summary of the current and future levels of hazards in Çukurova can be seen in Table A 3-1).

A3.7.2 Global sources of hazard and disaster data for Turkey

There are several global sources of natural hazard information for Çukurova. For example, a new web-based tool developed by Global Facility for Disaster Reduction and Recovery (GFDRR), ThinkHazard![279] allows users to assess the level of natural hazard within a user-defined area, including river flood, earthquake, drought, cyclone, coastal flood, tsunami, volcano, and landslide. The hazard level is calculated according to the frequency at which the hazard is expected to occur with a damaging level of intensity i.e. is considered to be able to cause damage to a development project.

The Centre for Research on the Epidemiology of Disasters (CRED) Emergency Events Database, EM-DAT, contains data on the occurrence and effects of over 22,000 large impact disasters from 1900 to present day. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies. Table A 3-6 presents the country profile for Turkey showing relevant disaster types, number of events, deaths, total population affected and losses due to damage. The top ranked event by number, deaths, population affected and losses is earthquakes. Flooding is the next most commonly observed hazard, and extreme temperature and storms show a relatively low level of (reported) occurrence.

Table A 3-6: Country level disaster profile on EM-DAT for Turkey (1900 - 19/07/2016). (Source: EM-DAT[280]).

Disaster type	Disaster subtype	Events count	Total deaths	Total affected	Total damage ('000 US$)
Earthquake	Ground movement	77	89236	6924329	24685400
Extreme temperature	Cold wave	3	69	0	0
Extreme temperature	Heat wave	2	14	300	1000
Extreme temperature	Severe winter conditions	2	17	8150	0
Flood	--	15	946	372620	65000
Flood	Flash flood	11	252	1341382	1892000
Flood	Riverine flood	19	210	71021	238500
Landslide	Landslide	10	293	13481	26000

Disaster type	Disaster subtype	Events count	Total deaths	Total affected	Total damage ('000 US$)
Storm	Convective storm	5	49	13636	2200
For an event to be recorded, it must fulfil at least one the following criteria: Ten (10) or more people reported killed; Hundred (100) or more people reported affected; Declaration of a state of emergency; Call for international assistance. Source: EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium)					

PreventionWeb.net is a participatory web platform with the primary purpose of facilitating an understanding of disaster risk reduction (DRR) and the work undertaken by disaster risk experts. The country level disaster & risk profile for Turkey[281], which provides a percentage breakdown of "nationally reported" economic losses, indicates that earthquakes and floods contributed to ~94% and 3.5% of disaster related losses respectively over the period 1990 to 2014 (see Figure A 3-3). "Internationally reported" losses for Turkey on PreventionWeb.net for the same period and derived from EM-DAT data show earthquakes and floods contributing to ~92% and ~8% of disaster related "economic issues". (It is likely that some nationally reported losses may not be reported to international organisations, or do not meet the minimum criteria for inclusion in the EM-DAT database).

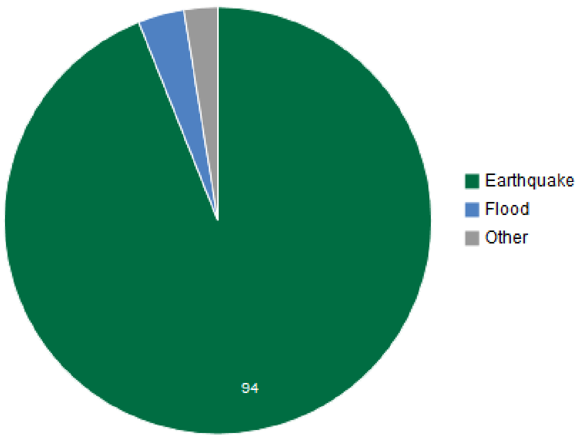


Figure A 3-3 Percentage of nationally reported economic losses for Turkey by hazard type 1990 – 2014. (Source: PreventionWeb[282].)

Munich Re's NATHAN Risk Suite provides global hazard data that has been recorded at Munich Re over the last forty years.[283] It allows insurance sector users to assess the risks of natural hazards around the world, from location-specific individual risks through to entire risk portfolios. NATHAN Light is an openly available demo version of the full tool, providing access to a restricted set of hazards.

Finally, the UNEP PREVIEW Global Risk Data Platform is a portal for spatial data on global risk from natural hazards. Users can visualise, download or extract data on past hazardous events, human and economic hazard exposure and risk from natural hazards. It covers tropical cyclones and related storm surges, drought, earthquakes, biomass fires, floods, landslides, tsunamis and volcanic eruptions.[284]

A3.7.3 Regional sources of hazard and disaster data for Çukurova

Turkey's Disaster and Emergency Management Directorate (AFAD) provide open access to their web-based Turkish Disaster Database (TABB)[285]. It should be noted that TABB is currently in the process of being updated and therefore considered incomplete. The records suggest landslides to be the most frequent type of event for Adana and Mersin, followed by flood. The highest number of casualties are associated with storm and flood events. However, the current (incomplete) records do not yet show the numbers of casualties attributed to earthquakes and should be treated with caution (see Figure A 3-40). Out of the events recorded and returned by TABB, storms currently show up as the highest contributor to injured people. In terms of numbers of damaged buildings, earthquakes by far outweigh all other disaster types as the contributing hazard (see Figure A 3-40).

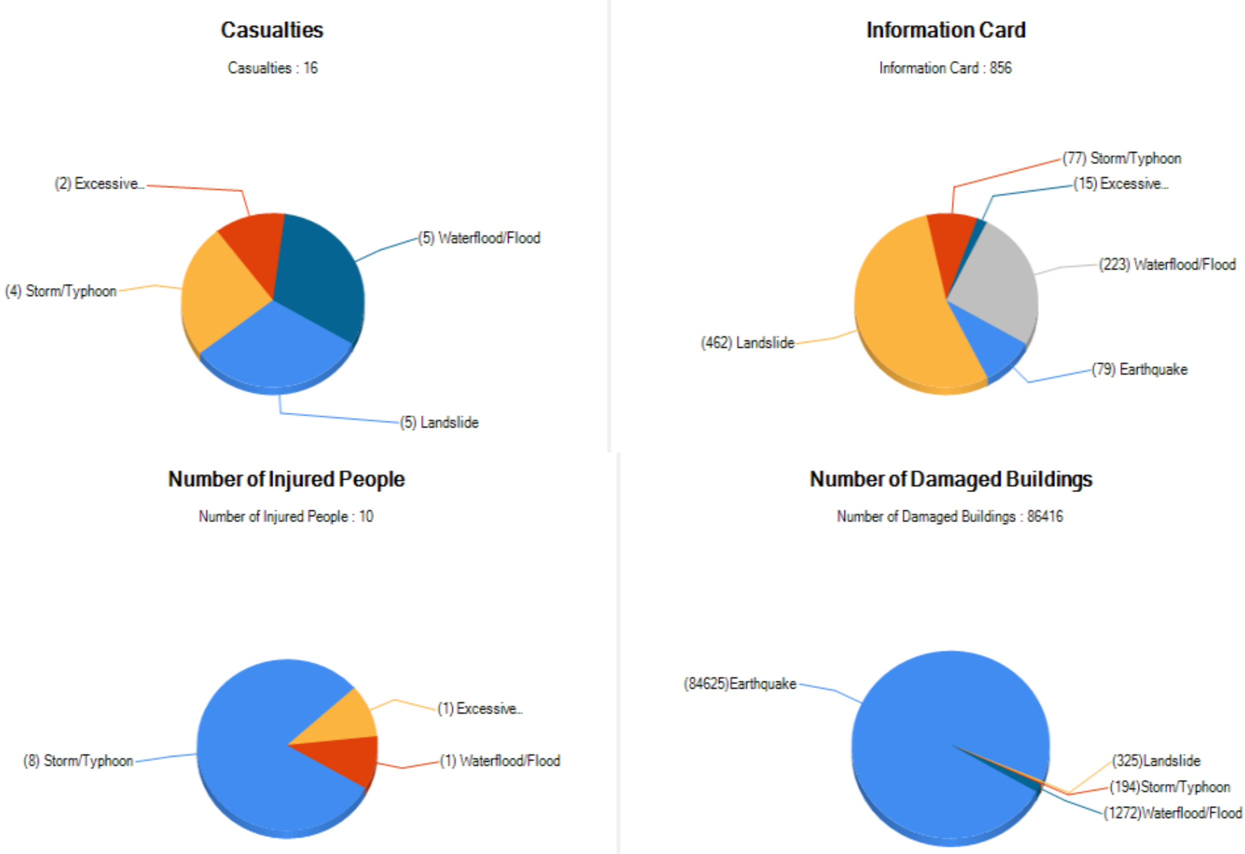


Figure A 3-4 TABB report: Casualties, Information Card, Number of Injured People and Number of Damaged Buildings by event type, Adana and Mersin. (Source: AFAD[xxxii]).

A3.7.4 Climate hazards

Storms, tornadoes and hail - current level of hazard

Figure A 3-5 presents hazard data for extra tropical storms, which suggests that the Çukurova region is categorised as Zone 1, with probable maximum intensity peak wind speeds in the range of 81-120km/h for 1 in 100-year return period events.

Analysis of UNEP's GAR (Global Assessment Report on Disaster Risk Reduction) platform[286] confirms that the Çukurova region has not been affected by tropical cyclones (which normally form at lower latitudes, commonly between ~5° and ~30° latitude).

[xxxii] For the purposes of the analysis, it is assumed that the term "Information Card" refers to number of recorded events.

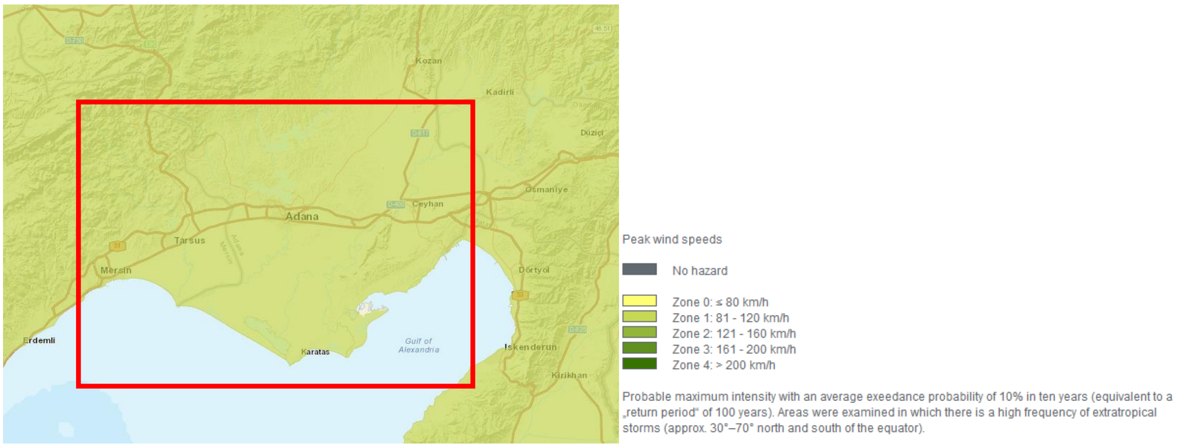


Figure A 3-5 Probable maximum intensity peak wind speeds for 1 in 100-year return period storm events. (Çukurova region shown by red box). (Source: MunichRe[287])

National data for convective storm frequency has been presented in Turkey's Sixth National Communication[288], based on monthly average number of thunderous days recorded at 277 stations over the period 1960-2013 (see Figure A 3-6). Thunderstorms are usually seen in May and June ('May' & 'Haz' in Figure A 3-6) in the country in general, especially in inner and northeast parts. The Çukurova region (and Mediterranean and Aegean coats in general) can experience thunderstorms all year around.

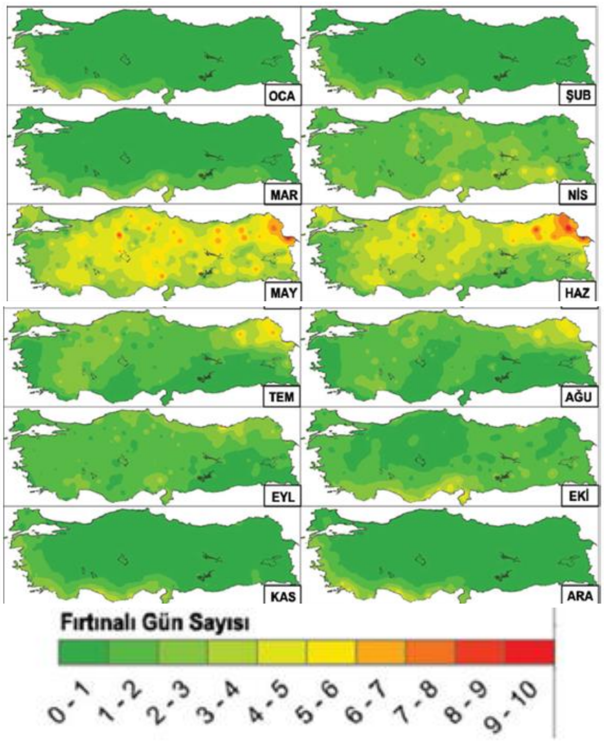


Figure A 3-6 Monthly average number of thunderstorm days, 1960 to 2013. (Source: Ministry of Environment and Urbanization, 2016[289]).

The intensity of the tornadoes observed in Turkey range on the Fujita scale from:

- F0: wind speeds of 84-116 km/h and which causes minor damage, to
- F3: wind speeds of 182-253 km/h and which can cause large scale damage (see Table A 3 7).

Table A 3-7 Characteristics of tornadoes of different intensity on the Fujita Scale. (Source: Report authors).

Scale	Speed		Relative frequency	Average Damage Path Width	Potential damage	Example photo
	mph	km/h				
F0	40–72	64-116	38.9%	10–50 metres (33–164 ft)	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.	 Source: NOAA-NWS Birmingham[290]
F1	73–112	117–180	35.6%	30–150 metres (98–492 ft)	Moderate damage. The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.	 Source: NOAA-NWS Birmingham[291]
F2	113–157	181–253	19.4%	110–250 metres (360–820 ft)	Significant damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; highrise windows broken and blown in; light-object missiles generated.	 Source:NOAA-NWS Birmingham[292]

F3	158–206	254–332	4.9%	200–500 metres (660–1,640 ft)	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.	 Source: NOAA-NWS Birmingham[293]
F4	207–260	333–418	1.1%	400–900 metres (1,300–3,000 ft)	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.	 Source: NOAA-NWS Birmingham[294]

Tornadoes had been considered rare and exceptional events in Turkey until recently, with awareness levels being raised due to significant events in 2004 and 2012. When recent data, considered in the Sixth National Communication to be "more representative", is taken into consideration, 45 tornado events were observed on average in a year in Turkey. The tornadoes seen in Mediterranean and Aegean shores especially in winter months are relatively frequent. From the records, observed tornadoes in the study area range up to F2 on the Fujita scale (see Figure A 3-7), which categorises events as having wind speeds of 181-253 km/h with the potential to cause considerable damage.

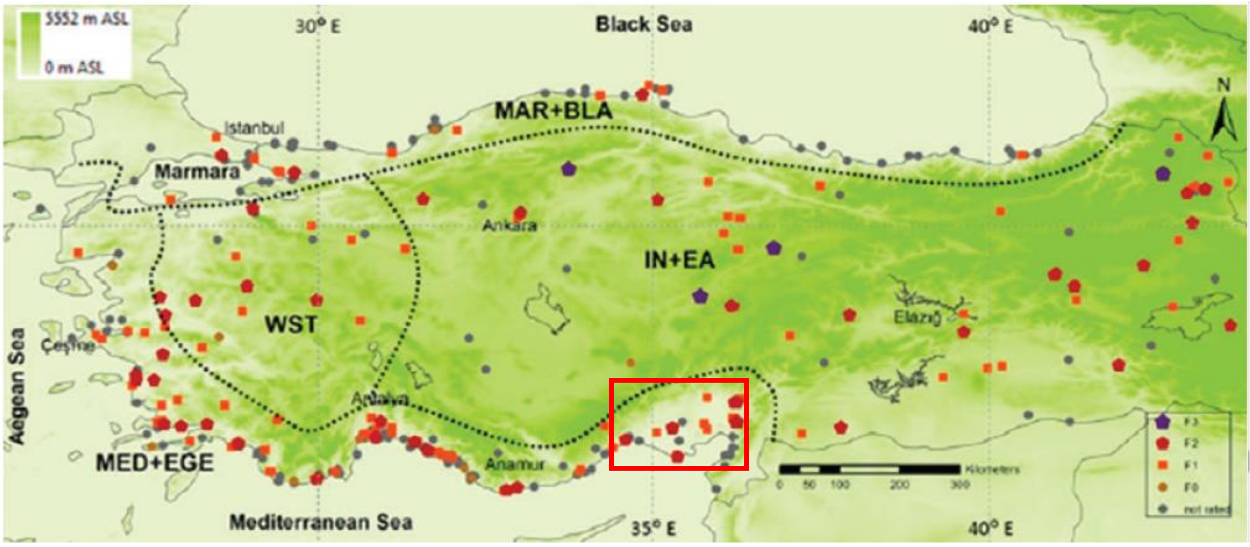


Figure A 3-7 Geographical distribution of tornadoes in Turkey. (Çukurova region shown by red box). (Source: Ministry of Environment and Urbanization, 2016[295]). [xxiii]

A 2011 study on severe hail events (>=2 cm diameter) in Turkey[296] used data and information extracted from newspaper records, meteorological observations and government agencies compiling over 600 records for between 1950 and 2010. The number of known severe hail days derived from the analysed records was 129. The geographical distribution is homogeneous, but the Mediterranean coast, Marmara region, northeast part of the country as well as central Anatolia have a higher density of recorded events (see Figure A 3-8).

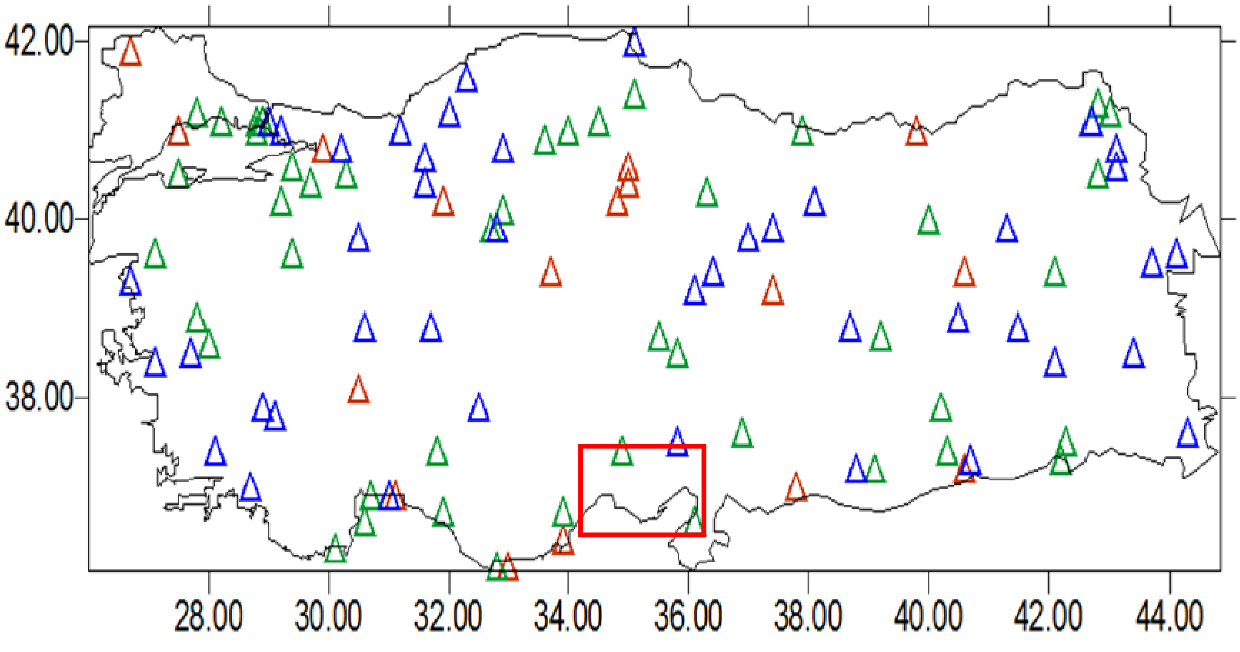


Figure A 3-8 Geographical Distribution of severe hail (>= 2cm diameter). Blue triangles represent large hail 2-3 cm diameter; Green represent hail 3-4 cm diameter , Red triangles show very large hail occurrences >4 cm diameter. (Çukurova region shown by red box). (Source: Kahraman et al, 2011[297]).

A subsequent, more detailed study[298] reported 1489 severe hail cases on 1107 severe hail days (days with at least one severe hail case, in this case defined as hail >= 1.5cm) covering 1925–2014. The annual

[xxiii] The time period for this data set is not stated in the Sixth National Communication of Turkey.

average across the most recent 5 years in the dataset (2009–13) is considered by the study authors to more representative of the true frequency of hail events due to greater availability of internet reports, giving the following results:

- 42 severe hail cases, or 0.54 cases per 10,000 km^2 per year
- 29 severe hail days, or 0.37 days per 10,000 km^2 per year.

Storms, tornadoes and hail - future changes

The evidence for future changes in storm frequency and magnitude in Çukurova is mixed and relatively weak. For example, the European chapter of IPCC's AR5 WGII report includes Turkey within its sub-regional class of 'Southern Europe'. The report applies medium confidence to projections of small increases in extreme wind speed connected to changes in storm tracks for Central and Northern Europe. However, changes in other parts of Europe (including Turkey) and other seasons are considered less clear. A potential small decreasing trend in Southern Europe for wind extremes is also projected, albeit cited as being of low confidence.[299] More recent research which simulated a meteorological field over the Mediterranean discusses how the topography, and in particular the mountain ranges, affect European and African wind patterns. Due to this complexity, it is cited that present-day forecasting and future scenario projections are subject to higher uncertainties than for the case of more regular and larger topographies[300].

The IPCC's SREX report on extreme events states that IPCC's Fourth Assessment Report (AR4) noted a likely net increase in the frequency/intensity of Northern Hemisphere extreme extratropical cyclones and a poleward shift in the tracks since the 1950s[301].

In the UK Met Office Hadley Centre's country report for Turkey[302], it was also suggested that the Eastern Mediterranean region, including Turkey, could experience a decrease in storm track activity during this century, which may therefore also result in decreased precipitation (note, projected changes in precipitation events which may lead to changes in flood risk is discussed separately in the Sections that follow). This outcome is based on two research studies cited in the Met Office report which modelled future changes under the SRES A2 emissions scenario, with one of the studies using a suite of 18 GCMs in the analysis.

Turkey receives much of its precipitation through storms which originate in the northern Atlantic. A potential for a northward shift of storm tracks has been attributed to the Azores High potentially moving slightly to the north in a future climate compared to its present location in the Atlantic Ocean. A northward shift in the location of the Azores High may therefore push storm tracks northward, resulting in fewer numbers of intense storms reaching southern parts of Turkey (see Figure A 3-9). Conversely, a northward movement of storm tracks may result in an increase in intense storms in northern Turkey[303].

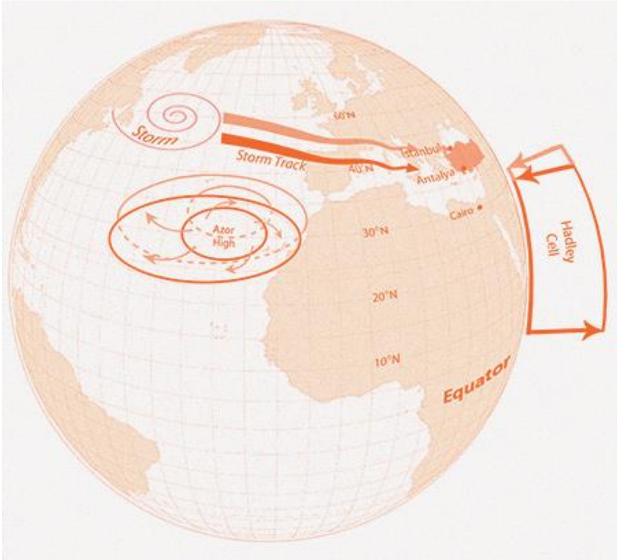


Figure A 3-9 The influence of the northern Atlantic's Azores High on storm tracks. (Source: Şen, [304]).[xxxiv]

With regards to future changes in hail occurrence, the IPCC reports a "lack of information about past and future changes in hail occurrence in Europe"[305]. However, it may be inferred that a future northward shift in storm tracks together with an associated reduced potential for precipitation in southern Turkey would result in a reduced potential for hailstorms in the Çukurova region.

Flood - current level of hazard

The hydrology of the Çukurova region is a complex interaction of major river basins and groundwater dominated, low-lying coastal plains.[306] The Seyhan, Ceyhan and Tarsus (Berdan) are the three major rivers in the region. The Seyhan has its source in the Taurus Mountains and after the confluence of the Zamantı and Göksu rivers, drains the Çukurova Plain and discharges into the Mediterranean Sea. The Catalan (operational since 1997) and Seyhan (operational since 1956) dams together provide protection for the city of Adana against a 500-year flood event (see Figure A 3-10).[307] Flood risk management plans are being developed country-wide in recognition of the threat floods have and will continue to pose Turkey. For example, in Çukurova, the Ceyhan Basin Flood Management Plan is due to be completed in 2018. [308]

The UNEP GAR (Global Assessment Report on Disaster Risk Reduction) uses a probabilistic approach for modelling riverine flood major river basins globally (1km x 1km resolution). The GAR flood hazard data available for the region does not take into consideration the mitigating impact of the various flood defence measures e.g. dams. However, such hazard maps are a useful indication of the magnitude of impact if defences fail, are overtopped or are absent.[309]

[xxxiv] The Hadley Cell a large-scale atmospheric convection cell in which air rises at the equator and sinks at medium latitudes, typically about 30° north or south.

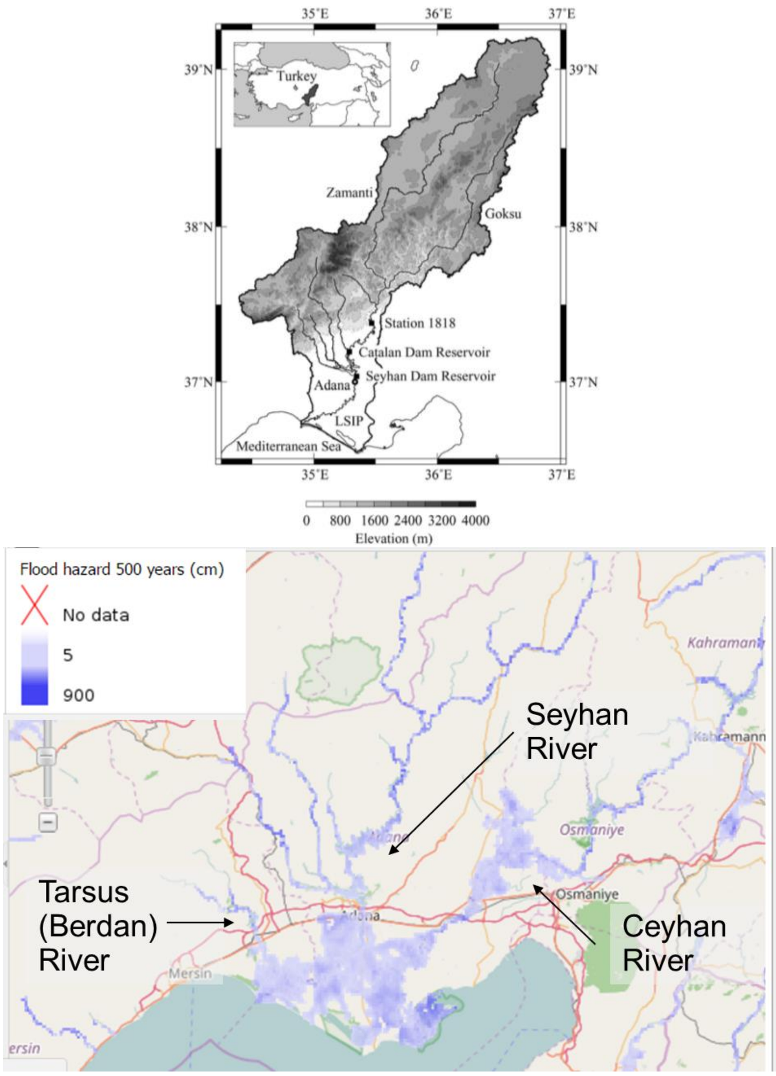


Figure A 3-10 LEFT: The Seyhan basin and location of Catalan and Seyhan dams upon which the city of Adana relies for flood defence. RIGHT: Depth in cm for return frequencies of a 500-year flood along the Tarsus, Seyhan and Ceyhan basins. (Source: UNEP[310]).

The GFDRR ThinkHazard! data portal presents regional summaries of flood hazard data based on a global hydrological model - Global Flood Risk with IMAGE Scenarios (GLOFRIS) and indicates a low-medium level of hazard across Mersin (also referred to as Icel) and Adana provinces (Figure A 3-11). This is interpreted by ThinkHazard! as being more than 20% chance that potentially damaging and life-threatening floods will occur in the coming 10 years.[311]

This level of hazard in the region is supported by event observations data from the Dartmouth Flood Observatory (DFO). The DFO is a global database of the count of the number (and geographical extent) of floods recorded from 1985-2011. The Çukurova region lies in a 'low-medium' flood hazard zone, which implies 2-3 notable flood events over that time period.[312]

It should be noted that global scale flood hazard assessments focus on flooding from rivers whereas local, heavy rainfall can also cause 'pluvial' flash flooding. The level of hazard associated with this type of flooding (and other, more complex mechanisms such as groundwater flooding) are uncertain in Çukurova. Indeed, across Turkey, heavy precipitation events have already increased. For example, between 1971-2004 the maximum 1-day precipitation increased at most locations in the country, with an estimated average increase of 27 mm in 100 years. Mediterranean coasts showed the greatest trends.[313]

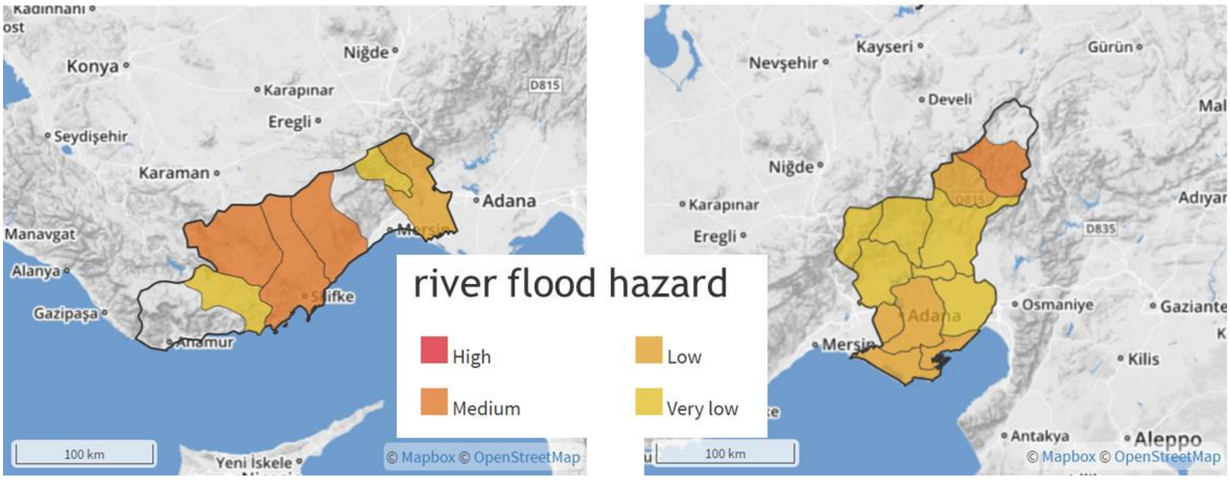


Figure A 3-11 River flood hazard level in Mersin (also referred to as Icel) and Adana provinces. (Source: GFDRR[314]).

Flood - future changes

Çukurova is expected to receive, on average, gradually less rainfall over the 2030s and 2050s (relative to the recent past).[315] This is reflected in the IPCC CMIP5 (Coupled Model Intercomparison Project 5) projections for the region in Figure A 3-12, which show that by the period 2041-2070 the mean annual rainfall is likely to have decreased in the region by between 10 and 20 %.

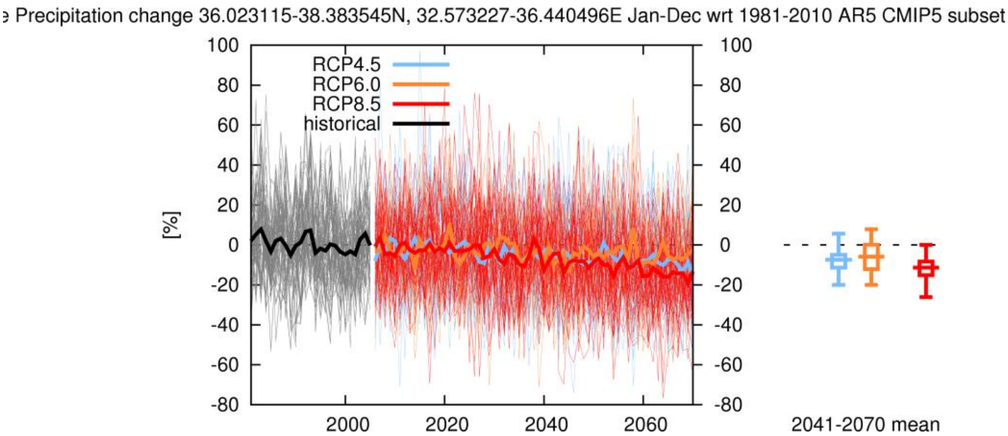


Figure A 3-12 The projected change in average annual rainfall in Çukurova covering the baseline period 1981-2010, 2030s (2021 – 2050) and 2050s (2041 – 2070). CMIP5 model ensemble, RCP 4.5, 6.0 and 8.5. (Source: KNMI[316]).

A regional study has suggested that because of the gradual reduction in rainfall, by the end of the century (2070-2099), critical flood events will occur much less frequently under the changing climate in the Seyhan basin.[317] The World Bank Climate Change Knowledge portal also provides projections (based on older CMIP3 GCM data) for individual basins in Çukurova.[318] Figure A 3-13 shows the projected changes in a variety of hydrological parameters in the Ceyhan basin. The highlighted parameter '*90%*' shows the change in the 90th percentile flow in the basin, an indicator of the level of flood hazard. The trend is for a reduction in the 90th percentile flow of around 20%.

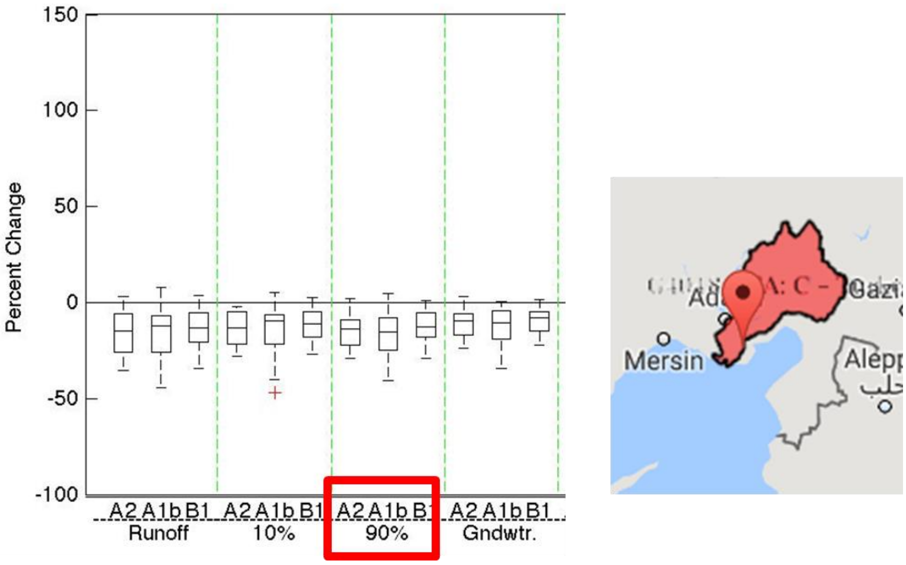


Figure A 3-13 The projected change in a variety of hydrological parameters in the Ceyhan basin. The highlighted parameter '90%' shows the change in the 90th percentile flow in the basin – an indicator of the level of flood hazard. Projections are based on CMIP3 models across 3 SRES emission scenarios for the 2030s (2030 – 2039). (Source: World Bank[319]).

Although, on average, rainfall and river flows may be decreasing, there is evidence that extreme rainfall events will increase in Çukurova. This could raise the level of hazard for flash, pluvial flooding. There is an established physical relationship between the temperature of the atmosphere and its ability to hold moisture. This is known as the *Clausius-Clapeyron relation* which suggests an increase in the moisture-holding capacity of the atmosphere of approximately 7% per °C temperature rise.[320]

Globally, climate model projections reveal an increase in the probability of occurrence of extreme rainfall events.[321] In the region where Turkey lies, a very rainy day which is currently expected every 20 years could occur every 15 years by the 2050s (see Figure A 3-14).

Specific hydrological studies would be required to project the frequency/ magnitude of flooding in Çukurova with greater precision. However, it's likely that uncertainty about the level of future flood risk will remain. Figure A 3-15 shows the projected change in the magnitude of annual maximum one day and 5-day consecutive rainfall event in the region. There is no discernible trend in either metric with many models showing an increase and others a decrease.

Extreme temperature - current level of hazard

The Çukurova region is characterised by very warm summers and cool winters. Mersin for example fluctuates between a monthly average high of 25 -30°C in the summer and around 10°C in the winter (see Figure A 3-16, top). Analysis of weather records at nearby Iskenderun[xxxv] shows the 5yr return period for maximum daily temperature during August (usually the hottest month) is around 36°C. During the same period a maximum of 34°C is an annual event (see Figure A 3-16, bottom).

[xxxv] NOTE: Iskenderun was selected as the nearest meteorological station with sufficiently long record of daily data (36.5847° N, 36.1756° E)

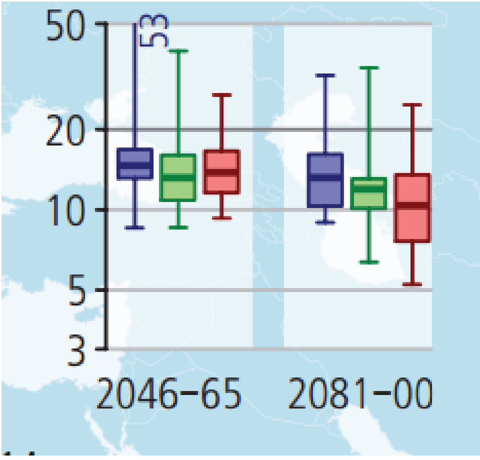


Figure A 3-14 Projected return periods for a daily precipitation event that was exceeded in the late 20th century on average once during a 20-year period (1981–2000) in the 'West Asia' IPCC region. A decrease in return period implies more frequent extreme precipitation events (i.e., less time between events on average). The coloured bars are different emission scenarios i.e. B1 (low - purple), A1B (medium - green) and A2 (high - red). The box plots represent the spread of results across different climate models. (Source: IPCC, 2012[322])

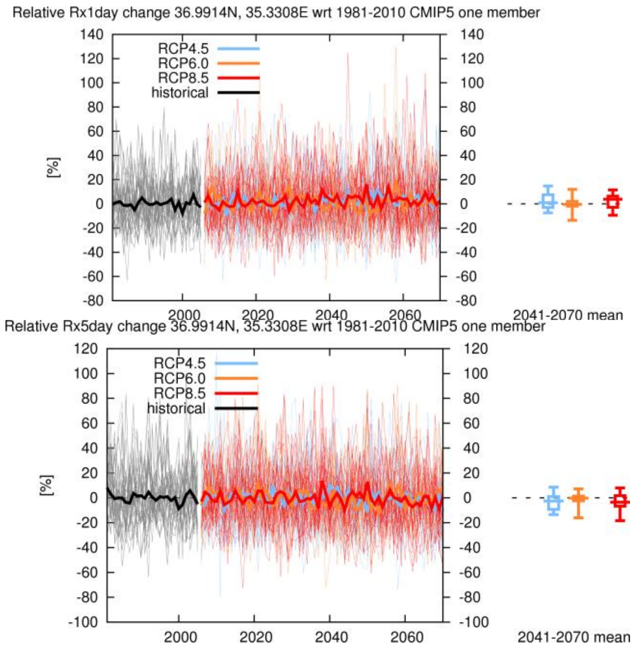


Figure A 3-15 Projected change in the magnitude of annual maximum one day (LEFT) and 5-day consecutive rainfall event (RIGHT) in Çukurova (point location at Adana) covering the baseline period 1981-2010, 2030s (2021 – 2050) and 2050s (2041 – 2070). CMIP5 model ensemble, RCP 4.5, 6.0 and 8.5. (Source: KNMI[323]).

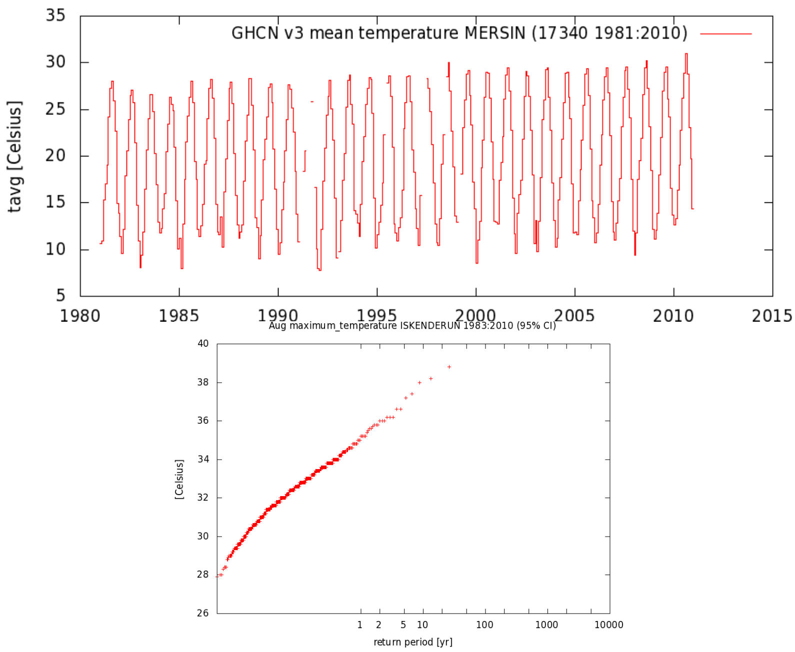


Figure A 3-16 TOP: Monthly average temperature at Mersin from 1981-2010. BOTTOM: return period for maximum temperature during August between 1981-2010. (Source: Global Historical Climatology Network, GHCN-M v3 via KNMI[324])

Heatwaves are characterised by *persistently* extremely high temperatures over several days or weeks and have had notable consequences in Turkey, particularly in 1987, 1994, 2000, 2001, 2004, 2005 and 2007.[325] The low-lying coastal plain of the Çukurova region is amongst the higher heatwave hazard zones in Turkey (see Figure A 3-17).

Figure A 3-17 Turkey: Heat Wave Hazard Distribution Map (Five-year return period). (Source: WHO, 2010[326])

There has been evidence that the intensity, length and number of heatwaves have increased since the 1960s across the country, including the Çukurova region (see Figure A 3-18).[327] Across the whole country, between 1971-2004, the maximum temperature increased, by an estimated average of 5°C in 100 years.[328]

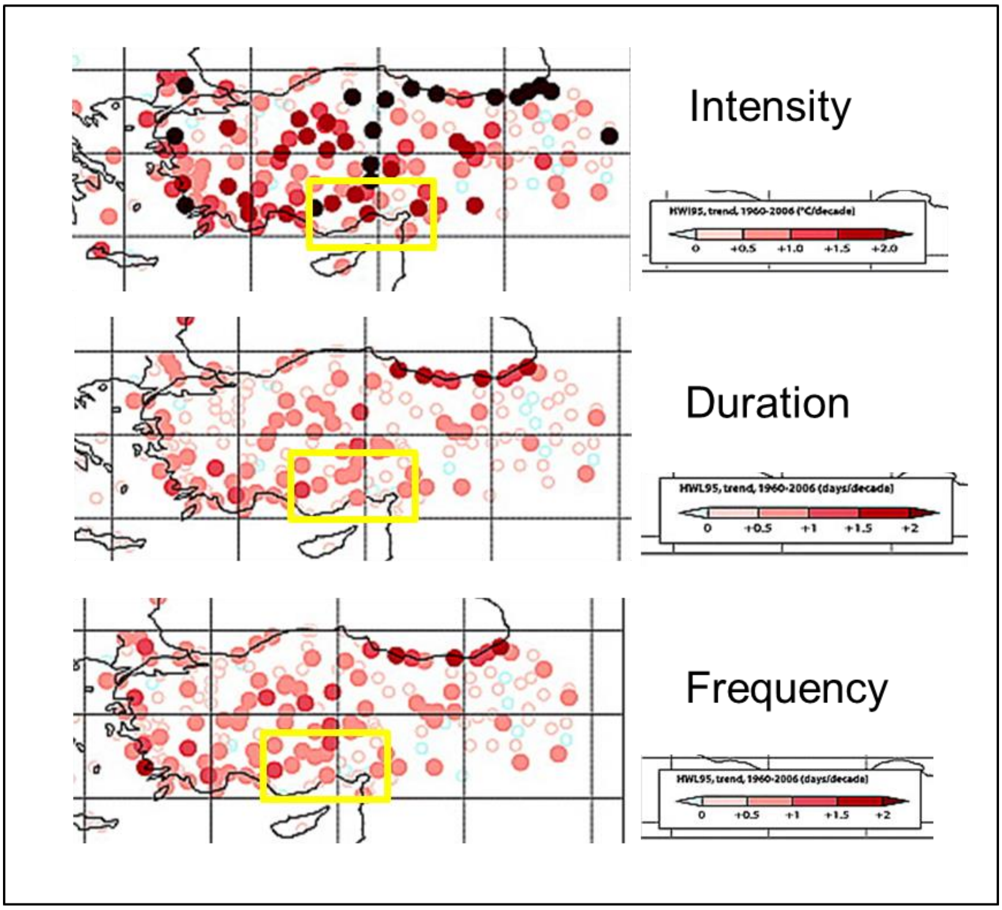


Figure A 3-18 Heat wave intensity (HWI95), heat wave duration (HWL95) and heat wave number (HWN95) across Turkey between 1960 - 2006. Darker red and black spots represent a stronger trend. The Çukurova Region is highlighted by a yellow box. (Source: Kuglitsch et al, 2010329).

Extreme temperature - future changes

Globally, climate model projections reveal an increase in the probability of occurrence of extreme and very extreme temperatures and associated heat waves in the coming years.[330,331] In the region where Turkey lies, even based on the most conservative emissions scenario, a hot day which is currently expected every 20 years would occur every 2 years by the 2050s (see Figure A 3-19).

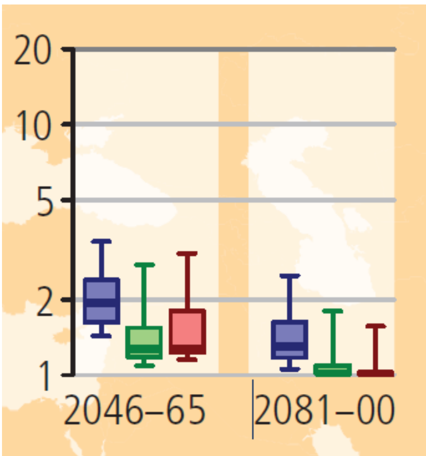


Figure A 3-19 The projected change in the ’20 year’ extremely warm day by the 2050s and end of the century in the ‘West Asia’ IPCC region. The coloured bars are different emission scenarios i.e. B1 (low - purple), A1B (medium - green) and A2 (high - red). The box plots represent the spread of results across different climate models. (Source: IPCC, 2012[332]).

Specific climatological studies would be required to project the frequency/ magnitude of heatwaves in Çukurova with greater precision. However, there are climate indices of extreme temperatures which are available from climate models for the Çukurova region. For example, Figure A 3-20 shows the projected change in the proportion of days where the temperature is greater than the 90th percentile (computed for a past, baseline period). The results show starkly how extreme temperatures are likely to increase dramatically in the region. This will exacerbate the current trend of more intense, frequent and lengthy heatwaves.

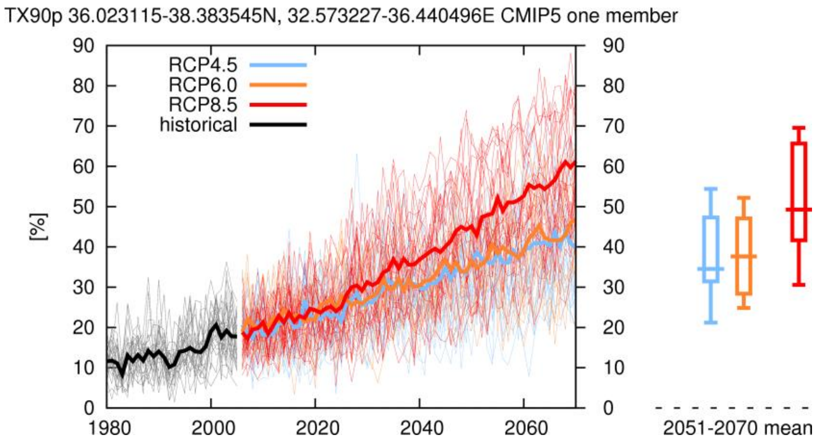


Figure A 3-20 The projected proportion of 'days over the 90th percentile high temperature' in Çukurova covering the baseline period 1981-2010, 2030s (2021 – 2050) and 2050s (2041 – 2070). CMIP5 model ensemble, RCP 4.5, 6.0 and 8.5. (Source: KNMI[333])

Coastal flooding & sea level rise - current level of hazard

The coastline of the Çukurova is characterised by an extensive, low-lying deltaic zone. The current level of hazard relating to coastal inundation is driven primarily by the probability and magnitude of 'Extreme Wave Height' driven by storms in the Mediterranean. Satellite data has been used to determine the 100-year wave height to be 6.1m (± 0.03m).[334, 335] Figure A 3-21 shows the extent of potential inundation caused by a wave height of 6.1m, which accounts for around 5% of the entire region.

Coastal flooding & sea level rise - future changes

Adana City is considered the city most vulnerable to the impacts of Sea Level Rise (SLR) in Tukey[336], which can exacerbate existing issues of coastal flooding, storm damage, erosion, and salinisation[337]. The rate of recent SLR along the coastline of Çukurova has been estimated at 3.4 ± 0.1 mm/year based on 12 years of satellite altimetry covering the period of 1993–2004. Extrapolating this rate out to 2050 gives a total additional rise of around 17-18 cm, which is broadly in line with global projections (Figure A 3-22). Sea level globally is likely to rise by between 0.26 m and 0.98 m by the end of the century (relative to 1986 – 2005) according to the latest IPCC projection.[338] This is accounted for by thermal expansion of the ocean and increased loss of mass from glaciers and ice sheets. However, some experts suggest that it is possible these projections underestimate ice sheet melting, with some recent upper estimates of between 1.8 and 9 m by the end of the century.[339,340]

Global assessments do not account for local processes such as relative vertical movement of land. Along the Mediterranean coast, subsidence, as in many other coastal areas, becomes important particularly in deltaic or river mouth areas.[341] Changes in storm surges and wave storminess as well as localised responses to wind direction, oceanic currents and wave propagation will also have an impact on the frequency and magnitude of coastal inundation.[342] Generally, there is low confidence in wave model projections because of uncertainties regarding future wind states, particularly storm geography.[343]

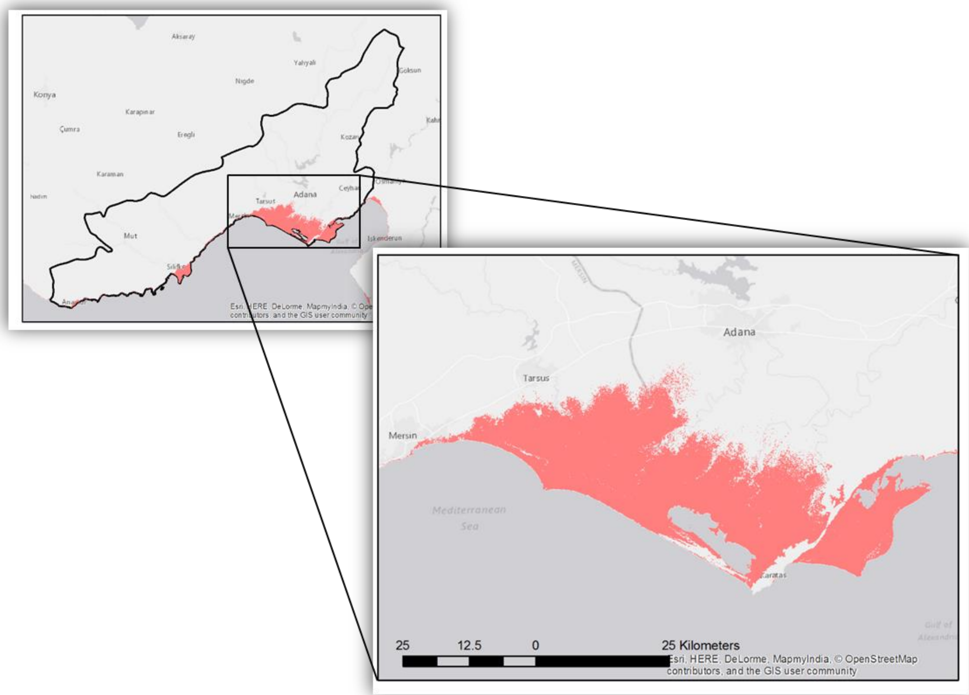


Figure A 3-21 Areas of Çukurova below (or equal to) 6.1m elevation. Elevation data: SRTM 90m. (Source: USGS Earth Explorer[344])

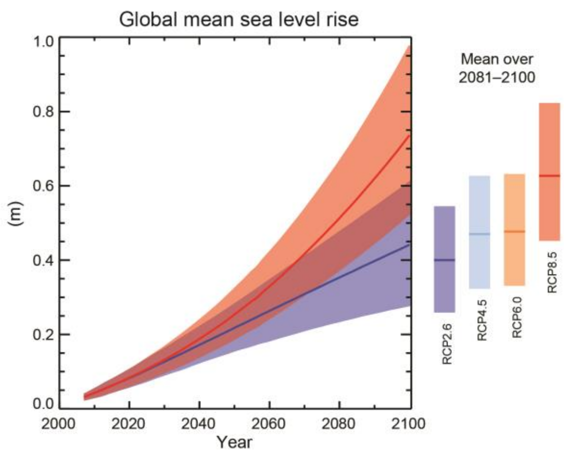


Figure A 3-22 Projections of global mean sea level rise over the 21st century relative to 1986–2005. (Source: IPCC, 2013[345]).

Landslides (precipitation induced) - current level of hazard

The level of threat from landslides triggered by precipitation is relatively high in some localised regions of Çukurova, for example the mountainous border between Adana and Mersin provinces (i.e. Taurus mountains). The level of hazard in Figure A 3-23B is defined by six parameters: slope factor, lithological (or geological) conditions, soil moisture condition, vegetation cover, precipitation and seismic condition.[346] A comparable assessment of earthquake induced landslide hazard in the region suggests that precipitation is the primary driver (Figure A 3-23C).

Although there have been documented incidences of landslides occurring[347], the GFDRR ThinkHazard! database suggest that the hazard level, in both Mersin and Adana provinces overall, is relatively low.[348]

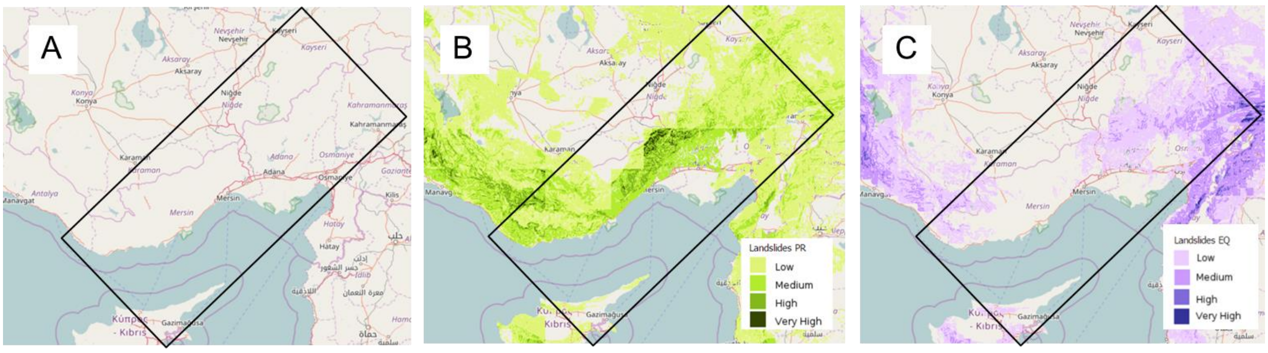


Figure A 3-23 A: Çukurova Region B: Current precipitation induced landslide risk C: Current Earthquake induced landslide risk. (Source: UNEP[349])

Landslides (precipitation induced) - future changes

There are several global trends identified by the IPCC which could have implications for the region. For example, there is currently 'low confidence' in global trends in large landslides in some regions i.e. there is no evidence to suggest the frequency and/or magnitude of such has changed due to climate change. However, there is high confidence that changes in heavy precipitation will affect landslides in some regions (see earlier sections on future changes in flood hazards). The assessment is further complicated because the level of hazard is strongly influenced by human activities such as poor land use practices, deforestation, and overgrazing.[350] Understanding how climate change will affect the level of landslide hazard across Çukurova requires an in-depth study beyond the scope of this report.

A3.7.5 Geophysical hazards

Earthquake

For the CIRA, earthquake hazard in Adana and Mersin is assessed using the results of a recent probabilistic seismic hazard study which updated the seismic hazard maps for Turkey[351].

Peak Ground Acceleration (PGA) and Peak Ground Velocity (PGV) distributions for different annual exceedance probabilities from this study can be used to assess the risk of damage to critical infrastructure in Çukurova.

This is because the earthquake risk for critical infrastructure is based on the known relationship between PGA, PGV and likely damage with reference to the Modified Mercalli Intensity (MMI) scale.

Figure A 3-24 and Figure A 3-25 show the PGA and PGV distributions at different annual exceedance probabilities respectively. The distributions are given for generic rock conditions but they will be modified for regional soil conditions in the risk assessment stage to represent more realistic ground-motion amplitudes. The chosen annual exceedance probabilities represent different target earthquake levels in the new seismic design code[352] of Turkey that came into effect in 2017 through legislation.

The 43-year and 72-year return period earthquake levels (having exceedance probabilities of 69% and 50% in 50 years, respectively) each represent "very frequent" and "frequent" ground motions. Building and non-building systems are expected to be operational under these earthquake levels if they are not categorised as critical facilities, and the standards can be implemented to existing structures where necessary. The 475-year and 2475-year return period earthquake levels (having exceedance probabilities of 10% and 2% in 50 years, respectively) represent "rare" and "very rare" ground motions respectively. Building and non-building systems are expected to suffer either moderate (475-year return period) or severe damage (2475-year return period) without causing injury to people under such ground motions. However, for critical infrastructures, the 475-year and 2475-year return period earthquake levels can be considered as thresholds for continuous functionality and safety evaluation that would lead to imposing further limitations on structural/non-structural damage. Although there are no specific seismic design codes for critical infrastructures, international documentation and standards can be used, for example, ASCE 7-10: Minimum Design Loads for Buildings and Other Structures[353], NEHRP Recommended Seismic Provisions for New Building Structures[354], and Seismic Design of Industrial Facilities[355].

The plots in Figure A 3-24 and Figure A 3-25 indicate that the level of seismic hazard increases gradually towards the Adana province as it is closer to the fault segments on the East Anatolian Fault zone (see Figure A 3-25). The Mersin province is influenced by deep inslab and shallow interface subduction earthquakes. For this reason, the earthquake induced seismic hazard is relatively larger along the shoreline and decreases in the interior parts of the province.

Figure A 3-26 shows the MMI distribution in Mersin and Adana to relate the ground-motion amplitudes (e.g., PGA and PGV) at different annual exceedance probabilities to potential structural damage. Figure A 3-27 presents the relationships between PGA, PGV, MMI and the potential for structural damage. Although the presented MMI *vs.* damage relationships are for buildings in general, they are useful indicators for potential damage levels for critical infrastructures in Mersin and Adana. For the purposes of the risk assessment, the MMI distributions presented in Figure A 3-26 will be modified for regional soil conditions and they will be used together with critical infrastructure fragilities specific to the type of infrastructure in order to assess a rational distribution of earthquake induced risk in the region.

The earthquake induced structural damage is relatively lower in Mersin because the seismic hazard in this province is considered moderate with respect to Adana. The potential damage to buildings is negligible in both provinces for ground-motion amplitudes of 43-year and 72-year return periods. The buildings in Mersin province merely suffer light damage for a 2475-year earthquake level whereas one would expect moderate to heavy damage for buildings located in the Adana province at the same earthquake level. Most of the buildings in the Adana province are susceptible to light damage at 475-year ground-motion amplitudes. The differences in MMI distribution between Adana and Mersin, presented in Figure A 3-26, are expected since the seismic activity is higher in Adana due to closer proximity to the fault segments on the East Anatolian Fault Zone. As discussed previously, the active fault segments have a lower effect in Mersin and the source of seismic hazard is mainly deep inslab and shallow interface subduction earthquakes.

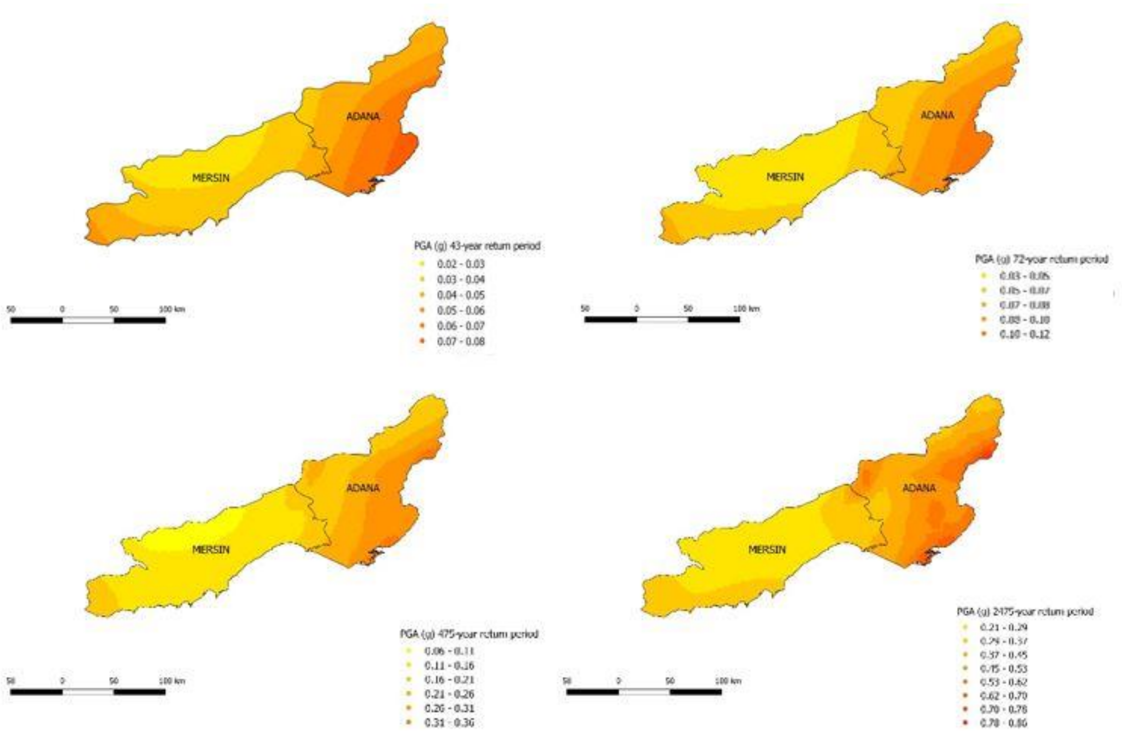


Figure A 3-24 PGA distribution in Mersin and Adana provinces for (a) 43-year (69% exceedance probability in 50 years representing "very frequent" ground motions), (b) 72-year (50% exceedance probability in 50 years representing "frequent" ground motions), (c) 475-year (10% exceedance probability in 50 years representing "rare" ground motions) and (d) 2475-year (2% exceedance probability in 50 years representing "very rare" ground motions) return periods. (Source: Akkar et al, 2017356).

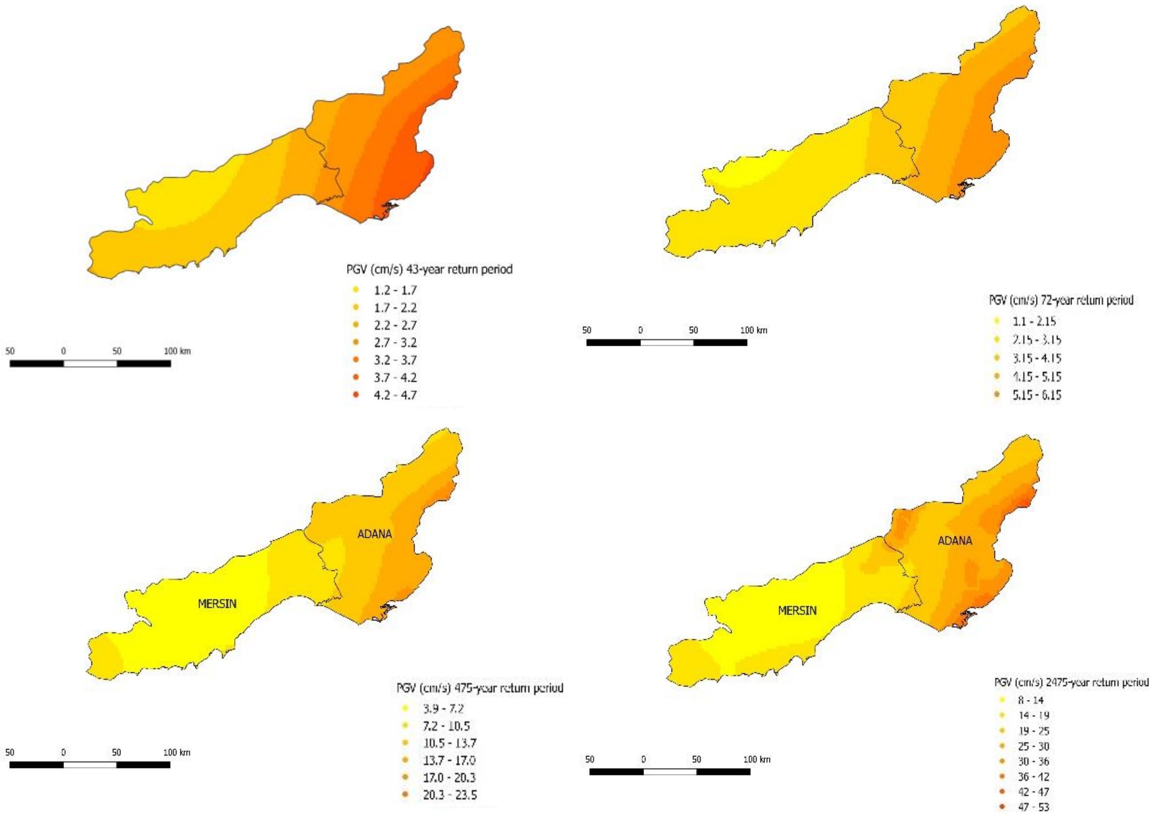


Figure A 3-25: PGV distribution in Mersin and Adana provinces for (a) 43-year (69% exceedance probability in 50 years representing "very frequent" ground motions), (b) 72-year (50% exceedance probability in 50 years representing

“frequent” ground motions), (c) 475-year (10% exceedance probability in 50 years representing “rare” ground motions) and (d) 2475-year (2% exceedance probability in 50 years representing “very rare” ground motions) return periods. (Source: Akkar et al, 2017[357]).

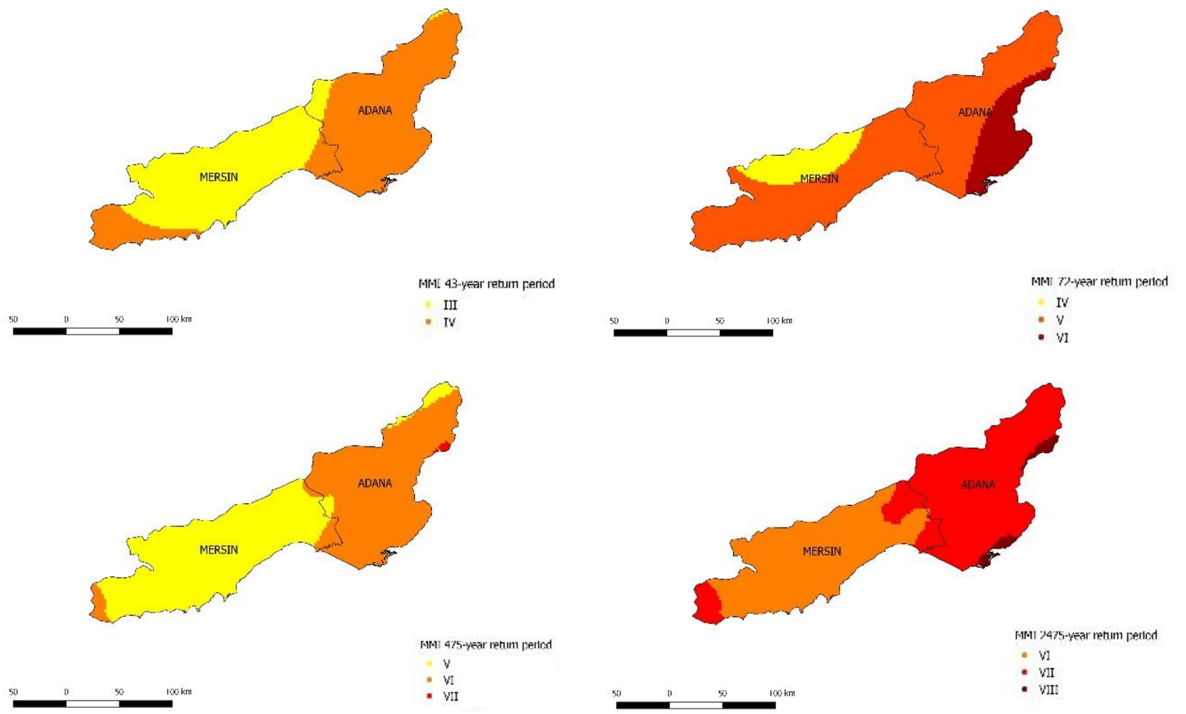


Figure A 3-26: MMI distribution in Mersin and Adana provinces when buildings are subjected to ground motions of (a) 43-year (69% exceedance probability in 50 years representing “very frequent” ground motions), (b) 72-year (50% exceedance probability in 50 years representing “frequent” ground motions), (c) 475-year (10% exceedance probability in 50 years representing “rare” ground motions) and (d) 2475-year (2% exceedance probability in 50 years representing “very rare” ground motions) return periods. (Source: Akkar et al, 2017[358]).

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	very light	light	moderate	moderate to heavy	heavy	very heavy
PGA (% g)	*<0.17*	*0.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PGV (cm/s)	<0.1	01.-1.1	1.1-3.4	3.34-8.1	8.1-16	*16-31*	*31-60*	*60-118*	*>116*
MMI	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure A 3-27: MMI scales, corresponding PGA and PGV levels and their relationship with structural damage. (Source: Ward et al, 1999[359]).

Landslide

Recent studies indicate that the horizontal PGA thresholds for earthquake triggered landslides start from 0.3g[360] although the geologic and topographic conditions also play a significant role in determining the level of hazard.

Figure A 3-29 shows the mapped landslide locations in Mersin and Adana provinces, compiled by the General Directorate of Mineral Research and Exploration[361] (MTA). Figure A 3-28 shows two different examples of regional topographic maps to help illustrate the relation between slope and the locations of landslides. It can be seen that the landslide locations are spatially distributed along the relatively precipitous Taurus Mountains in Mersin whilst they are sparse in Adana where slopes are generally less steep.

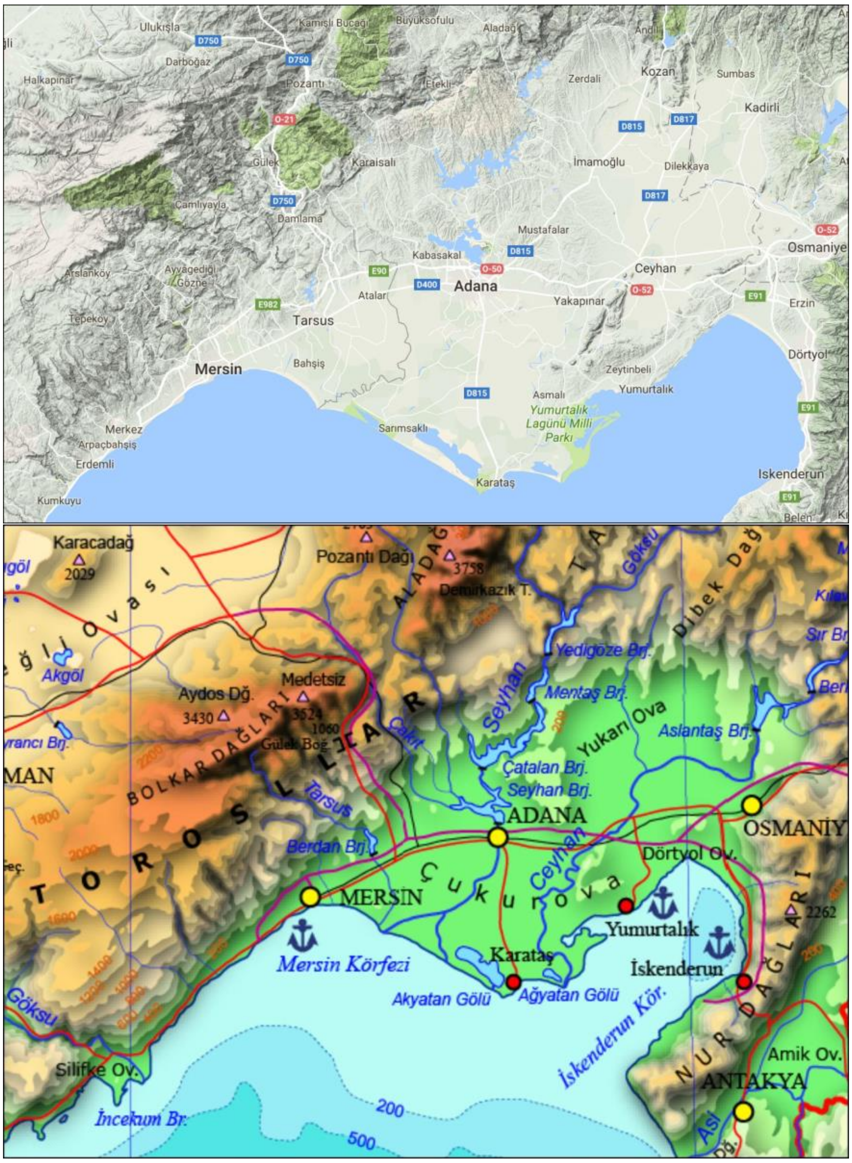


Figure A 3-28 Maps showing the topographic slopes in the Adana and Mersin provinces. (Source: Google; MTA[362]).

When the PGA distribution at different return periods (Figure A 3-24) and the landslide distribution map (Figure A 3-29) is compared, +0.3g PGA levels are observed towards eastern regions of Adana province for 475-year and 2475-year earthquake levels. Despite the relatively high PGA levels, these regions appear to have a lower landslide hazard as suggested from the mapped locations of landslides in Figure A 3-29, which is probably due to the lower topography.

The landslide inventory report compiled by the MTA states no records of earthquake triggered landslides (neither from historical or contemporary events) in Mersin and Adana provinces. The recorded events are therefore likely to cover landslides triggered by non-seismic factors such as heavy precipitation, loss of vegetation, soil erosion etc.

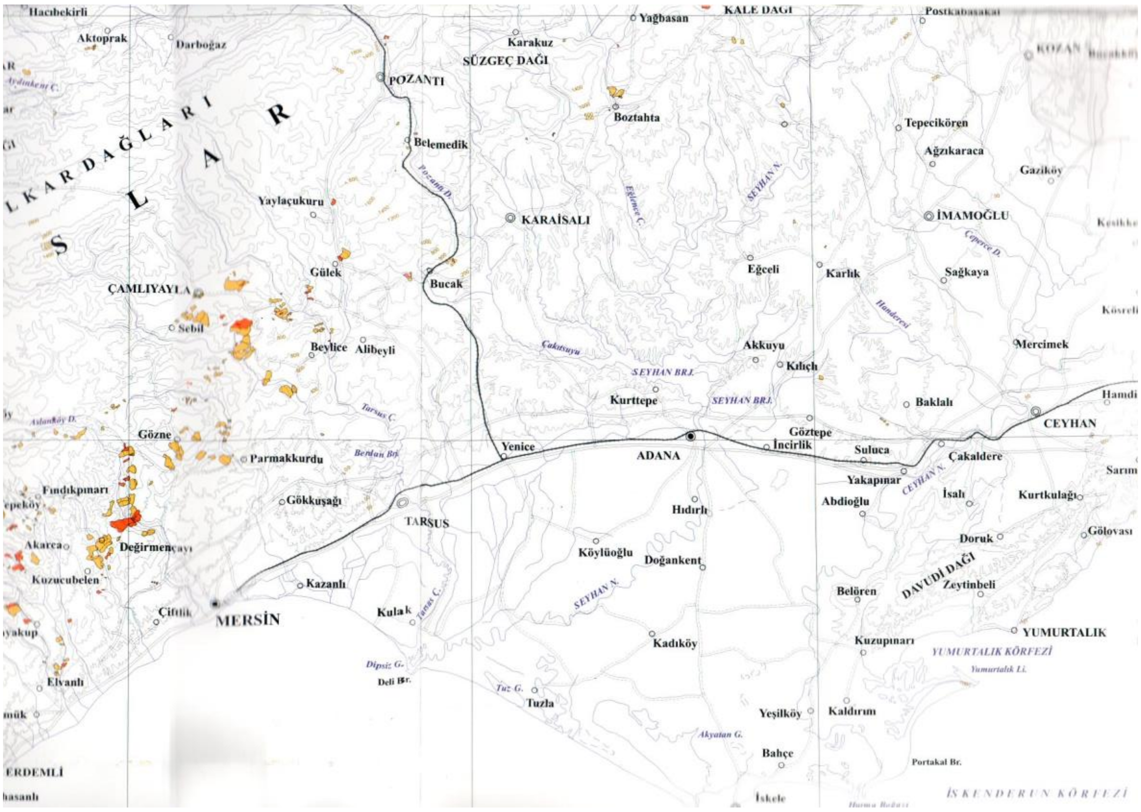


Figure A 3-29 Spatial distribution of landslide locations in Mersin and Adana. Red and yellow colour codes refer to deep and shallow landslide locations, respectively. (Source: MTA[363]).

A3.8 Vulnerability information (earthquake fragility curves)

A3.8.1 Electric power networks (power plants and substations)

The following fragilities define the earthquake-induced risk for electric power plants (EPPs) and substations[364]. The EPPs are classified as *small* (less than 200 MW) and *medium/large* (more than 200 MW) capacity whereas the substations are divided into *low voltage* (34.5–150 kV), *medium voltage* (150–350 kV) and *high voltage* (350 kV and above) facilities. The fragilities represent the exceedance probability of four different damage states (slight/minor, moderate, extensive and complete) for anchored and unanchored components. The descriptions of damage states are also given as tables for EPPs (Table A 3-12) and substations (Table A 3-19). The fragilities use PGA as the ground-motion intensity and are log-normal cumulative distributions with logarithmic mean (λ) and standard deviation (β).

Table A 3-8 Fragility function parameters for small power generation plants with anchored components. (Source: Cavalieri, 2014)[365]

Damage state	Median (g)	λ	β
Slight/minor	0.10	−2.30	0.55
Moderate	0.21	−1.56	0.55
Extensive	0.48	−0.73	0.50
Complete	0.78	−0.25	0.50

Table A 3-9 Fragility function parameters for small power generation plants with unanchored components. (Source: Cavalieri, 2014)[366]

Damage state	Median (g)	λ	β
Slight/minor	0.10	−2.30	0.50
Moderate	0.17	−1.77	0.50
Extensive	0.42	−0.87	0.50
Complete	0.58	−0.54	0.55

Table A 3-10 Fragility function parameters for medium/large power generation plants with anchored components. (Source: Cavalieri, 2014)[367]

Damage state	Median (g)	λ	β
Slight/minor	0.10	−2.30	0.60
Moderate	0.25	−1.39	0.60
Extensive	0.52	−0.65	0.55
Complete	0.92	−0.08	0.55

Table A 3-11 Fragility function parameters for medium/large power generation plants with unanchored components. (Source: Cavalieri, 2014)[368]

Damage state	Median (g)	λ	β
Slight/minor	0.10	−2.30	0.60
Moderate	0.22	−1.51	0.55
Extensive	0.49	−0.71	0.50
Complete	0.79	−0.24	0.50

Table A 3-12 Description of damage states for power generation plants and the power availability after each damage state. (Source: Cavalieri, 2014)[369]

Damage state	description	Serviceability	Power availability
Complete	Extensive damage to large horizontal vessels beyond repair, extensive damage to large motor operated valves, or the building being in complete damage state	Not repairable	No power available
Extensive	Considerable damage to motor driven pumps, or considerable damage to large vertical pumps, or the building being in extensive damage state	Operational after repairs	
Moderate	Chattering of instrument panels and racks, considerable damage to boilers and pressure vessels, or the building being in moderate damage state	Operational without repair	Reduced power flow
Slight/ minor	Turbine tripping, or light damage to diesel generator, or the building being in minor damage state		
None	None		Nominal power flow

Table A 3-13 Fragility function parameters for low voltage substations with anchored components. (Source: Cavalieri, 2014)[370]

Damage state	Median (g)	λ	β
Slight/minor	0.13	−2.04	0.65
Moderate	0.26	−1.35	0.50
Extensive	0.34	−1.08	0.40
Complete	0.74	−0.30	0.40

Table A 3-14 Fragility function parameters for low voltage substations with unanchored components. (Source: Cavalieri, 2014)[371]

Damage state	Median (g)	λ	β
Slight/minor	0.15	−1.90	0.70
Moderate	0.29	−1.24	0.55
Extensive	0.45	−0.80	0.45
Complete	0.90	−0.10	0.45

Table A 3-15 Fragility function parameters for medium voltage substations with anchored components. (Source: Cavalieri, 2014)[372]

Damage state	Median (g)	λ	β
Slight/minor	0.15	−1.9	0.6
Moderate	0.25	−1.39	0.5
Extensive	0.35	−1.05	0.4
Complete	0.7	−0.36	0.4

Table A 3-16 Fragility function parameters for medium voltage substations with unanchored components. (Source: Cavalieri, 2014)[373]

Damage state	Median (g)	λ	β
Slight/minor	0.1	−2.30	0.6
Moderate	0.2	−1.61	0.5
Extensive	0.3	−1.20	0.4
Complete	0.5	−0.69	0.4

Table A 3-17 Fragility function parameters for high voltage substations with anchored components. (Source: Cavalieri, 2014)[374]

Damage state	Median (g)	λ	β
Slight/minor	0.11	−2.21	0.50
Moderate	0.15	−1.90	0.45
Extensive	0.20	−1.61	0.35
Complete	0.47	−0.76	0.40

Table A 3-18 Fragility function parameters for high voltage substations with unanchored components. (Source: Cavalieri, 2014)[375]

Damage state	Median (g)	λ	β
Slight/minor	0.09	−2.41	0.50
Moderate	0.13	−2.04	0.40
Extensive	0.17	−1.77	0.35
Complete	0.38	−0.97	0.35

Table A 3-19 Damage state definitions and their serviceability after each damage state. (Source: Cavalieri, 2014)[376]

Damage state description		Serviceability	Power availability
Complete	Failure of all disconnect switches, all circuit breakers, all transformers, or all current transformers, or the building being in complete damage state	Not repairable	No power available
Extensive	Failure of 70 % of disconnect switches (e.g., misalignment), 70 % of circuit breakers, 70 % of current transformers (e.g., oil leaking from transformers, porcelain cracked), or failure of 70 % of transformers (e.g., leakage of transformer radiators), or the building being in extensive damage state	Operational after repairs	
Moderate	Failure of 40 % of disconnect switches (e.g., misalignment), or 40 % of circuit breakers (e.g., circuit breaker phase sliding off its pad, circuit breaker tipping over, or interrupter-head falling to the ground), or failure of 40 % of current transformers (e.g., oil leaking from transformers, porcelain cracked), or the building being in moderate damage state	Operational without repair	Reduced power flow
Slight/ minor	Failure of 5 % of the disconnect switches (i.e., misalignment), or failure of 5 % of the circuit breakers (i.e., circuit breaker phase sliding off its pad, circuit breaker tipping over, or interrupter-head falling to the ground), or the building being in minor damage state		
None	None		Nominal power flow

A3.8.2 Ports

The analytical fragilities provided for ordinary gravity quay walls/retaining structures at harbors that are commonly used in Europe are proposed by Kakderi and Pitilakis[377]. The fragilities exclusively consider ground shaking (functions of PGA) and disregard ground failure due to permanent fault displacement. The latter earthquake induced hazard is not likely for the Mersin as it is located far from the existing active faults in the region. The fragilities assume log-normal distribution and Table A 3-20 shows the parameters for their computation. Table A 3-21 describes the damage states represented by these fragility curves.

The fragility curves and the description of damage states for cargo handling and storage components at harbors are given in Table A 3-22 and

Table A 3-23, respectively. This information is provided by HAZUS[378], which is the only available source of fragilities for such structural components. The fragilities are described by PGA and permanent ground (fault) displacement (PGD). The latter intensity measure is of no use for the Mersin port since the active fault sources are far from the port location.

For the vulnerability assessment of liquid fuel facilities at the harbors, the fragility curves in Table A 3-24[379] can be used. These curves are applicable to fuel facilities with unanchored equipment and housed in low-rise reinforced concrete buildings that is assumed to be valid for the building typology at the Mersin port. The description of damage states for fuel facilities is provided in Table A 3-25.

Table A 3-20 Parameters of fragility curves for waterfront structures subject to ground shaking. The wall height is designated by H and Vs is the shear wave velocity for site classification: Vs = 500 m/s - NEHRP C and Vs = 250 m/s - NEHRP D. The fragilities should be used with PGA values representing outcrop (generic rock - Vs30 = 760 m/s) conditions. (Source: Kakderi and Pitilakis, 2010[380]).

	Median PGA (g) (rock outcrop conditions)			
	Minor damages	Moderate damages	Extensive damages	β (log-standard deviation)
$H \leq 10$ m, $V_s = 250$ m/s	0.11	0.37	0.81	0.54
$H \leq 10$ m, $V_s = 500$ m/s	0.07	0.34	–	0.58
$H > 10$ m, $V_s = 250$ m/s	0.14	0.44	0.96	0.49
$H > 10$ m, $V_s = 500$ m/s	0.10	0.40	–	0.57

Table A 3-21 Damage states of waterfront structures at harbors (Source: Kakderi and Pitilakis, 2010[381]).

Damage state	Normalized residual hor. displ. (u_x/H)
Minor	Less than 1.5 %
Moderate	1.5–5 %
Extensive	5–10 %
Complete	Larger than 10 %

Table A 3-22 Parameters of fragility curves for cargo handling and storage components subjected to ground shaking and ground failure. (Source: National Institute of Building Sciences, 2004[382])

		Peak ground acceleration (PGA)		Permanent ground deformation (PGD)	
Description	Damage state	Median (g)	β (log-standard deviation)	Median (m)	β (log-standard deviation)
Stationary equipment	Minor	0.30	0.60	0.08	0.60
	Moderate	0.50	0.60	0.15	0.70
	Extensive/ complete	1.00	0.70	0.30	0.70
Unanchored or rail mounted equipment	Minor	0.15	0.60	0.05	0.60
	Moderate	0.35	0.60	0.10	0.60
	Extensive/ complete	0.80	0.70	0.25	0.70

Table A 3-23 Description of damage states for cargo handling and storage components subjected to ground shaking and ground failure. (Source: National Institute of Building Sciences, 2004[383])

Damage state	Description: Stationary equipment	Description: Unanchored or rail mounted equipment	Serviceability	
Minor	Slight damage to structural members with no loss of function	Minor derailment or misalignment without any major structural damage to the rail mount. Minor repair and adjustments may be required before the crane becomes operable	Reduced use	Operational without repair
Moderate	Derailment due to differential displacement of parallel track. Rail repair and some repair to structural members is required		Not usable	Operational after repairs
Extensive/ complete	Considerable damage to equipment. Toppled or totally derailed cranes are likely to occur. Replacement of structural members is required			Not repairable

Table A 3-24 Parameters of fragility curves for fuel facilities subject to ground shaking (Source: SRM-LIFE, 2007[384])

Description	Damage state	Peak ground acceleration (PGA): Median (g)	Peak ground acceleration (PGA): β (log-standard deviation)
Unanchored equipment with backup power – building with low level seismic design	Minor	0.12	0.50
	Moderate	0.23	0.50
	Extensive	0.43	0.60
	Complete	0.62	0.60
Unanchored equipment without backup power– building with low level seismic design	Minor	0.10	0.50
	Moderate	0.19	0.45
	Extensive	0.43	0.60
	Complete	0.62	0.60
Unanchored equipment with backup power– building with medium level seismic design	Minor	0.13	0.50
	Moderate	0.26	0.50
	Extensive	0.56	0.60
	Complete	0.80	0.60
Unanchored equipment without backup power– building with medium level seismic design	Minor	0.11	0.50
	Moderate	0.20	0.45
	Extensive	0.56	0.60
	Complete	0.80	0.60
Unanchored equipment with backup power– building with high level seismic design	Minor	0.14	0.50
	Moderate	0.27	0.50
	Extensive	0.61	0.60
	Complete	0.90	0.60
Unanchored equipment without backup power– building with high level seismic design	Minor	0.12	0.50
	Moderate	0.21	0.45
	Extensive	0.61	0.60
	Complete	0.90	0.60

Table A 3-25 Damage states for fuel facilities subject to ground shaking. (Source: SRM-LIFE, 2007[385])

Damage state	Description		Serviceability	
	Anchored equipment	Unanchored equipment		
Minor	Slight damage to pump building, minor damage to anchor of tanks, or loss of off-site power (check electric power systems for more on this) for a very short period and minor damage to backup power (i.e. to diesel generators, if available)	Elephant foot buckling of tanks with no leakage or loss of contents, slight damage to pump building, or loss of commercial power for a very short period and minor damage to backup power (i.e. to diesel generators, if available)	Reduced use	Operational without repair
Moderate	Elephant foot buckling of tanks with no leakage or loss of contents, considerable damage to equipment, moderate damage to pump building, or loss of commercial power for few days and malfunction of backup power (i.e., diesel generators, if available)	Elephant foot buckling of tanks with partial loss of contents, moderate damage to pump building, loss of commercial power for few days and malfunction of backup power (i.e., diesel generators, if available)	Not usable	Operational after repairs
Extensive	Elephant foot buckling of tanks with loss of contents, extensive damage to pumps (cracked/sheared shafts), or extensive damage to pump building	Weld failure at base of tank with loss of contents, extensive damage to pump building, or extensive damage to pumps (cracked/sheared shafts)		Not repairable
Complete	Weld failure at base of tank with loss of contents, or extensive to complete damage to pump building	Tearing of tank wall or implosion of tank (with total loss of content), or extensive/complete damage to pump building		

A3.8.3 Bridges

Earthquake effects on roadway elements can be grouped into two categories, (1) ground shaking and (2) ground failure such as liquefaction, fault displacement, and slope instability. Different damage criteria have been proposed for the fragility analysis of roadway elements. The number of damage states is variable and is related with the functionality, traffic state, and/or the repair duration. In

Table A 3-26 and Table A 3-27 the damage states for each component are defined and are correlated to the serviceability of the network.

Table A 3-26 Damage states for roadway components

	Description	Serviceability
Tunnels		
DS1	Minor cracking and spalling and other minor distress to tunnel liners	Open to traffic, closed or partially closed during inspection, cleaning and possible repair works
DS2	Ranges from major cracking and spalling to rock falls	Closed during repair works for 2–3 days
DS3	Collapse of liner or surrounding soils to the extent that the tunnel is blocked either immediately or within a few days after the main shock	Closed for a long period of time
Metro/urban tunnels in soil		
DS1	Minor cracking and spalling and other minor distress to tunnel lining	Open to traffic, closed or partially closed during inspection and possible repair works
DS2	Major cracking and spalling of tunnel lining	Closed during repair works for 2–3 days
DS3	Extensive damage of liner or surrounding soils to the extent that the tunnel is blocked either immediately or within a few days after the main shock	Closed for a long period of time
Embankments (road/track on)		
DS1	Surface slide of embankment at the top of slope; minor cracks on road surface; minor track displacement	Open, reduced speed
DS2	Deep slide or slump of embankment; medium cracks on road surface and/or settlement; medium track displacement	Partially open during repairs (roadway). Closed during repairs (railway)
DS3	Extensive slump and slide of embankment; extensive cracks on road surface and/or settlement; extensive tracks displacement	Partially open during repair or closed during reconstruction works (roadway). Closed (railway)
Cuts (road/track in)		
DS1	Surface slide; minor cracks on road surface; minor displacement of the tracks	Open, reduced speed
DS2	Deep slide or slump; medium cracks on road surface and/or settlement; medium displacement of the tracks	Partially open during repairs (roadway). Closed during repairs (railway)
DS3	Extensive slump and slide; extensive cracks on road surface and/or settlement; extensive displacement of the tracks	Partially open or closed during repairs/ reconstruction (roadway). Closed (railway)

Table A 3-27 Damage states for roadway components (continued)

	Description	Serviceability
Bridge abutments		
DS1	Minor settlement of approach fill (roadway: 2–8 m; railway: 1–5 cm)	Open. Reduced speeds or partially closed during repair
DS2	Moderate settlement of approach fill (roadway: 8–22 cm; railway: 5–10 cm)	Closed or partially closed during repair works (roadway). Closed (railway)
DS3	Extensive settlement of approach fill (roadway: >22 cm; railway: >10 cm)	Closed during repair/reconstruction works
Slopes (road/track on or running along)		
DS1	Surface slide at top of slope; minor cracks on road surface; minor track displacement	Open, reduced speed
DS2	Deep slide or slump; medium cracks on road surface and/or settlement; medium displacement of the track	Partially open or closed during repairs (roadway). Closed during repairs (railway)
DS3	Extensive slump and slide; extensive cracks on road surface; extensive displacement of the track	Closed during repairs/reconstruction
Road pavements		
DS1	Slight cracking/offset of pavement surface	Open. Reduced speeds or partially closed during repair works
DS2	Localized moderate cracking/offset of pavement	Closed during repairs (few days)
DS3	Major cracking/offset of pavement and subsurface soil	Closed during repairs (few days to weeks)
Tracks		
DS1	Minor (localized) derailment due to slight differential settlement of embankment or ground offset	Operational after inspection or short repairs
DS2	Considerable derailment due to differential settlement or ground offset	Closed to traffic. Local repairs or replacement of tracks is required
DS3	Major differential settlement of the ground resulting in potential derailment over extended length	Closed to traffic. Replacement of track's segments is required. Duration of closure depends on length of damaged lines

The existing fragility functions for roadways are based on empirical, analytical or expert judgment methods. Most of them follow a lognormal distribution. The most common intensity measures are PGA when ground shaking is the cause of damage, or PGD in case of ground failure. The available fragility curves for ground failure are limited. The vulnerability of roadway components due to liquefaction, landslide and rock-falls require detailed site class information. Similarly, damage due to fault rupture require precise mapping of faults along the motorway. To the experts' best knowledge, the critical motorways and highways in the Mersin and Adana provinces do not cross any active fault. To this end vulnerability of roadways due to ground deformation is not covered here. The following is the suggested fragility functions for the most important roadway components due to ground shaking.

Tunnel: The analytical fragilities of ALA[386] can be used for the vulnerability of tunnels. The intensity measure is PGA and

Table A 3-28 presents the fragility parameters (logarithmic mean, μ, and standard deviation, β) for different soil conditions and tunnel types.

Abutments: Table A 3-29 shows the PGA-based fragilities for abutments[387]. The fragilities are log-normal cumulative distribution functions. In Table A 3-29, h designates the height of the abutment and letters C and D are site classes having average shear-wave velocities ranging between 180 m/s ≤ Vs30 < 360 and Vs30 < 180 m/s, respectively.

Table A 3-28 PGA-based fragility functions of tunnels. See Table A3-26 for damage states. (Source: American Lifelines Alliance, 2001[388]).

Typology	Damage state	μ (g)	β
Rock tunnels with poor-to-average construction and conditions	Minor/slight	0.35	0.4
	Moderate	0.55	0.4
	Heavy	1.10	0.5
Rock tunnels with good construction and conditions	Minor/slight	0.61	0.4
	Moderate	0.82	0.4
	Heavy	NA	–
Alluvial (soil) and cut and cover tunnels with poor to average construction	Minor/slight	0.30	0.4
	Moderate	0.45	0.4
	Heavy	0.95	0.5
Alluvial (soil) and cut and cover tunnels with good construction	Minor/slight	0.50	0.4
	Moderate	0.70	0.4
	Heavy	NA	–

Table A 3-29 PGA-based fragility functions of abutments. See Table A 3-27 for damage states. (Source: Argyroudis et al, 2013[389]).

		Ground type C				Ground type D			
		h = 6 m		h = 7.5 m		h = 6 m		h = 7.5 m	
Typology	Damage state	μ (g)	β	μ (g)	β	μ (g)	β	μ (g)	β
Roadway	Minor	0.38	0.70	0.26	0.70	0.20	0.90	0.18	0.90
	Moderate	0.64	0.70	0.52	0.70	0.45	0.90	0.39	0.90
	Extensive/ complete	1.02	0.70	0.97	0.70	0.93	0.90	0.78	0.90

Embankments and Cuts: Argyroudis and Kaynia[390] propose log-normal fragilities for motorway embankments and cuts that are given in Table A 3-30 and

Table A 3-31, respectively. The fragilities are developed for site classes C and D that are described by 180m/s ≤ Vs30 < 360m/s and Vs30 ≤ 180m/s, respectively. The fragilities consider embankments of heights h = 2m and h = 4m whereas the cut heights are h = 4m and h = 6m.

Table A 3-30 PGA-based fragilities of embankments. See Table A 3 26 for damage states. (Source: Argyroudis and Kaynia, 2013[391]).

		Ground type C				Ground type D			
		h = 2 m		h = 4 m		h = 2 m		h = 4 m	
Typology	Damage state	μ (g)	β	μ (g)	β	μ (g)	β	μ (g)	β
Roadway	Minor	0.65	1.00	0.51	0.90	0.47	0.90	0.31	0.70
	Moderate	1.04	1.00	0.88	0.90	0.66	0.90	0.48	0.70
	Extensive/ complete	1.57	1.00	1.42	0.90	0.89	0.90	0.72	0.70

Table A 3-31 PGA-based fragilities of cuts. See Table A 3 26 for damage states. (Source: Argyroudis and Kaynia, 2013 [392]).

		Ground type C		Ground type D			
		h = 6 m		h = 4 m		h = 6 m	
Typology	Damage state	μ (g)	β	μ (g)	β	μ (g)	β
Roadway	Minor	0.59	1.00	0.44	1.00	0.38	1.00
	Moderate	1.09	1.00	0.92	1.00	0.77	1.00
	Extensive/complete	1.90	1.00	1.77	1.00	1.46	1.00

A3.8.4 Oil pipelines

The Baku-Tbilisi-Ceyhan pipeline (BTC pipeline) is discussed here, to assess the earthquake induced risk for oil and gas pipelines in the region. The BTC pipeline has excess capacity today, with 30 billion cubic meters of natural gas a year. The diameter of the pipeline is 42 inches throughout most of Azerbaijan and Turkey. In Georgia the pipeline diameter is 46 inches. The pipeline diameter reduces to 34 inches for the last downhill section to the Ceyhan Marine Terminal in Turkey.

The continuous pipelines cover long distances and their exposure to earthquake threats while crossing active faults in earthquake-prone regions is the main issue in seismic design and vulnerability assessment. This is because such pipes are insensitive to transient strains due to ground shaking but they are vulnerable to permanent on-fault ground displacements (PFDs) at the fault crossings. Given a site of interest the probabilistic PFD hazard can be computed to determine the critical PFD value for certain mean annual exceedance rates (or return periods).

The main pipe-fault crossing of the BTC route in the Mersin and Adana provinces is the Çokak fault segment. The pipeline trench is trapezoidal-shaped and packed with loose to medium granular cohesionless backfill with minimum soil cover. The sketch of a typical trench for fault crossing is shown in Figure A 3-30. Table A 3-32(a) contains information about the location of fault-pipe crossing, pipe-fault crossing angle, etc. The pipe diameter and thickness are 42 inch and 0.8 inch, respectively at the Çokak fault-pipe crossing. The properties of the pipe and soil at the fault-pipe intersection is given in Table A 3-33 and Table A 3-34, which are useful in the calculation of pipeline strains as discussed in the following.

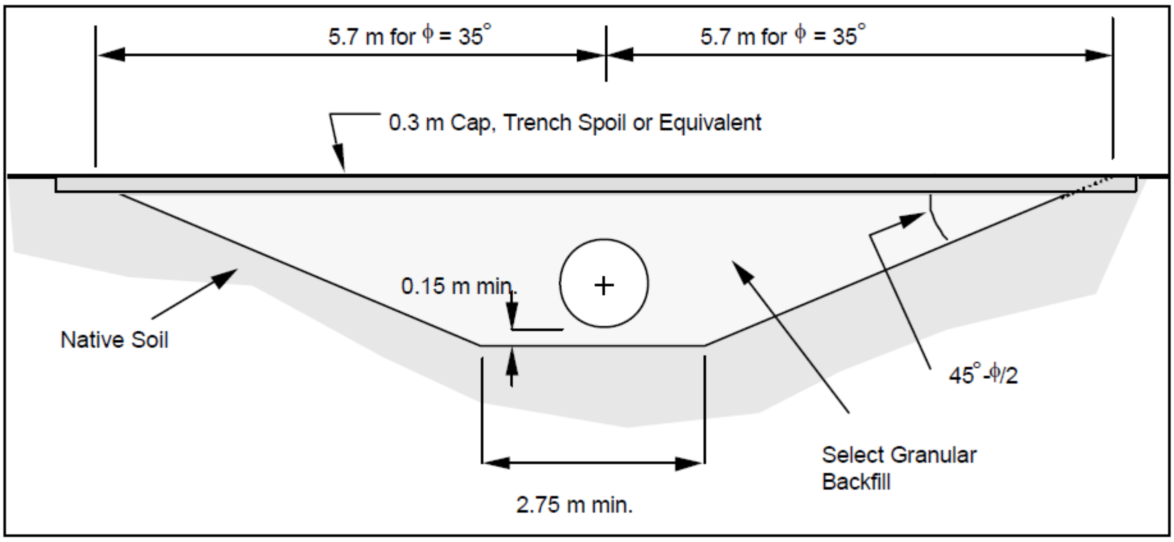


Figure A 3-30 Typical trench for fault crossing

Table A 3-32 (a) fault crossing information and (b) seismological features of the Çokak fault segment for the BTC hydrocarbon pipeline

(a)

Fault			Pipe-fault intersection		
Fault length (km)	Fault Type	Dip Angle (degree)	Long. (degree)	Lat. (degree)	Pipe Crossing Angle (degree)
25	LL - SS	90	36.340	37.734	~90

(b)

Ruptured fault area (km^2) (Wells and Coppersmith, 1996)	Characteristic magnitude range (Wells and Coppersmith, 1996)	Slip rate (mm/yr)	Activity rate (eqk/year)
219	6.15-6.65	10	0.013

Table A 3-33 Properties of pipe and soil at the fault-pipe intersection

Name	Buried depth	Pipe D/t	Pipe property	Soil Type
Çokak Fault Zone	1.5m	52	API 5L Grade X65	Loose-to-Medium sand

Table A 3-34 API5L-X65 steel properties

Yield stress (σ_1)	490MPa
Failure stress (σ_2)	531MPa
Failure strain (ε_2)	4.0%
Elastic Young's modulus (E_1)	210 GPa
Yield strain ($\varepsilon_1 = \sigma_1 / E_1$)	0.233%
Plastic Young's modulus ($E_1 = (\sigma_2 - \sigma_1)/(\varepsilon_2 - \varepsilon_1)$)	1.088 Gpa

At a fault crossing the displacement field changes abruptly because of lateral PGD hazard. As a result of fault offsets, axial strains are induced in the pipes. The amount of strain depends on the orientation of the pipe with respect to the fault trace (crossing angle), slip direction as well as the soil and pipe properties. Rupture of buried and welded steel pipelines (e.g., used in the BTC pipeline) exposed to large fault displacements is the result of severe compressive buckling of the pipe wall or tensile fracture.

The tensile or compressive strains in a pipe originating from permanent fault displacement depend on the relative orientation of the fault and the pipe as well as the fault slip direction. For example, right-lateral strike-slip faulting with a positive pipe-fault intersection angle (if the angle measured in clockwise sense from fault line to pipe is less than 90°) results in axial compression and bending in the pipe. However, left-lateral strike-slip fault with a negative pipe-fault crossing angle (if the angle measured in clockwise sense from fault line to pipe is less than 90°) results in axial tension and bending. At the fault crossing point of concern (i.e., Çokak fault and BTC pipeline crossing), the pipeline alignment promotes tension in the pipe.

Figure A 3-31 presents the Monte-Carlo based PFD hazard curve[393] for the fault-pipe crossing at the Çokak Fault together with four other fault segments along the East and North Anatolian faults where the BTC pipeline crosses. The PFD hazard curves for other pipe-fault crossings serve for comparison. As depicted from the comparative curves, the level of PFD hazard is relatively lower at the Çokak Fault with respect to the other pipe-fault crossings.

Table A 3-35 compares the ALA394 475-year and 2475-year return period PFD values with their counterparts computed from the Çokak Fault PFD hazard curve. The ALA 475-year PFD is computed from Equation (1). The same guideline computes the 2475-year PFD hazard as 2.3 times the 475-year PFD computed from Equation (1).

$\log_{10}(AD) = -6.32+0.9M$ (Equation 1)

The comparisons between ALA PFD hazard levels and those computed from the hazard curves in Figure A 3-31 (

Table A 3-35) suggest that the pipe-fault crossing at the Çokak fault is in compliance with the design hazard levels given in the ALA recommendations.

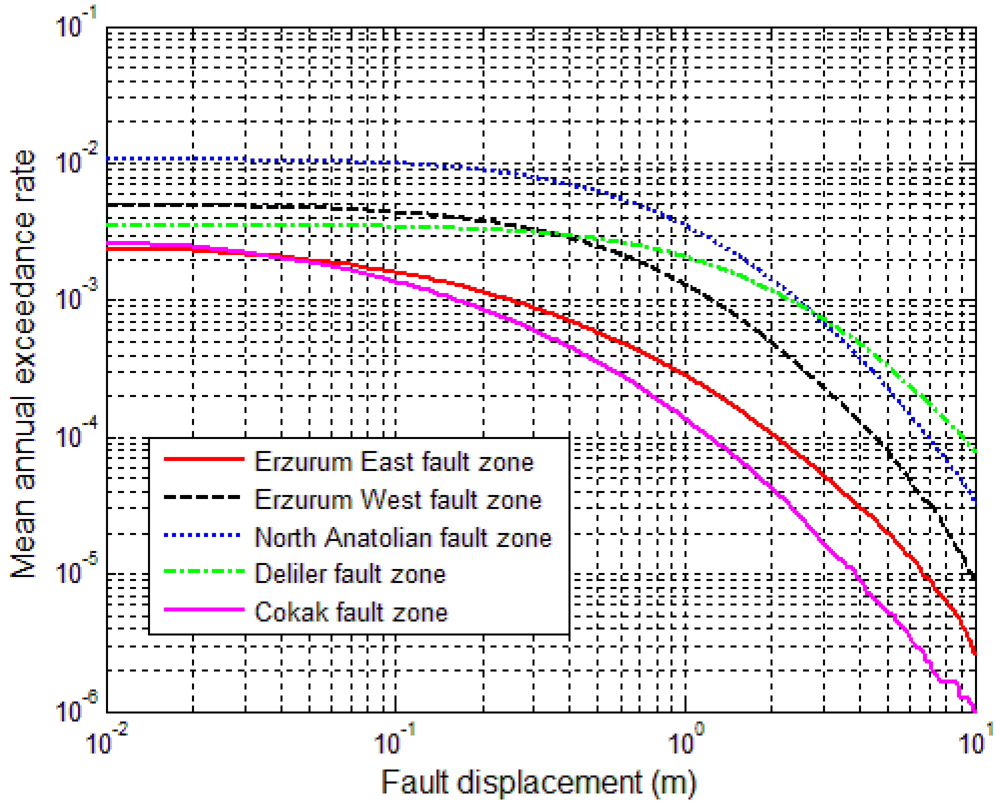


Figure A 3-31 Permanent fault displacement hazard curve at the Çokak fault (cyan) as well as PFD hazard curves at four other pipe-fault crossings where the BTC pipeline crosses the fault segments along North and East Anatolian fault zones. The Çokak fault PFD hazard is computed from the properties listed in the table below. (Source: Cheng and Akkar, 2016395.)

Table A 3-35 Comparison of 475-year and 2475-year PFD hazard with the recommended values in ALA (2005). (Source: Report authors).

	Çokak Fault
475-year fault displacement in ALA	0.28m
475-year fault displacement in this study	0.04m
2475-year fault displacement (ALA I_{Design})	0.63m
2475-year fault displacement in this study ($I_{Assessment}$)	0.44m
Compliance ($I_{Design} \geq I_{Assessment}$)	Yes

Figure A 3-32 shows the log-normal fragility for tensile pipe failure[396] that complies with the tensile failure criteria suggested by Wijewickreme et al[397] which indicate that tensile strains of 3% and 10% would lead to 10% and 90% failure probability for continuous steel pipelines, respectively. Table A 3-36 lists the logarithmic mean (μ) and standard deviation (β) of the log-normal fragility.

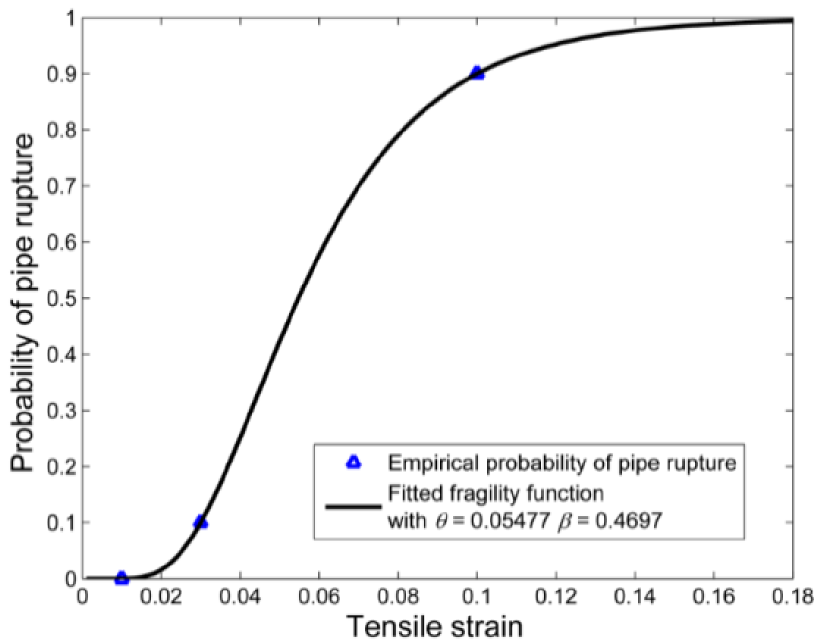


Figure A 3-32 Pipeline fragility for tension failure. (Source: Cheng and Akkar, 2016[398]).

Table A 3-36 Logarithmic mean and standard deviation of pipeline fragility against tension failure

Failure state	μ	β
Tension	0.05477	0.4697

Table A 3-37 shows the pipeline strain estimated from the analytical method proposed by Karamitros et al[399] for 2475-year PFD at the Çokak pipe-fault crossing. The computed tensile strain under the 2475-year PFD value of 0.44m is 0.18% that is below 3% indicating that the probability of failure due to PFD is significantly small for the BTC pipeline crossing the Koçak fault segment according to the tensile failure criteria set by Wijewickreme et al[400].

Table A 3-37 The 2475-year PFD at the Çokak pipe-fault crossing, corresponding tensile strain at the pipe segment and probability of pipe failure due to tension

Pipe-fault crossing angle	2475-year PFD	Tensile strain	Compliance (≤ 3%)
90°	0.44m	0.18%	Yes

A3.9 Sanibey Yedigöze Hydroelectric Power Plant

A3.9.1 Hazards, vulnerability and exposure

The geographical location of the Sanibey Yedigöze HPP and its susceptibility (see Table A 3-2) was used as a basis for selecting the following hazards for the risk assessment: Storm (extra tropical), tornadoes, flood, heat waves, earthquake. The corresponding hazard scenarios used in RiskAPP (see Table A 3-3) cover both the current level of the hazard and, for climate-related hazards that change over time, an estimate of the future hazard level (e.g. heatwaves in 2030s).

The vulnerability of Sanibey Yedigöze HPP to the hazard scenarios is summarised in Table A 3-38. The expected damages are expressed as a percentage or category in relation to the magnitude of the hazard. The corresponding downtime of the HPP is given in days. The information in this table relies on expert knowledge about the relationship between the potential levels of a hazard and the damage this may cause to the HPP. In the case of earthquake vulnerability, this expertise is supplemented by quantitative research. Earthquake fragility curves for Electric Power Plants (EPPs) are used as a proxy[401], where the HPP is assumed to be a medium-large EPP (installed capacity > 200MW) with anchored components (seismic designed) and the substations are assumed to be high-voltage (>350kV). Earthquake damage is classified into 5 categories: 'Slight' and 'Moderate' damage states lead to operation without repair; 'Extensive' refers to an EPP which can only be operational again after repairs, while 'Complete' damage is not repairable. The operational damage classified by 'Slight', 'Moderate' and 'Extensive' leads to a reduction of power flow. (For more information refer to Annex A3.8).

Table A 3-38 Vulnerability of Sanibey Yedigöze HPP to hazards in the region. (Source: Report authors).

Hazard	Intensity Measure	Variable type	Values	Expected damage (% or damage category)	Expected downtime (days)
Earthquake	peak ground acceleration	Continuous	0.10 [g]	Slight – 5%	0
			0.25 [g]	Moderate – 40%	30
			0.52 [g]	Extensive – 70%	200
			0.92 [g]	Complete – 100%[xxxvi]	280
Flood	water depth	Continuous	0 to +9 [m]	<10%	0.5
Storm	wind speed	Category	0-81 [km/h]	0%	1
			81-120 [km/h]	<10%	5

[xxxvi] 100% of damage refers to the financial damage, i.e. the cost of repairs compared to the value of the asset. Since the HPP is designed against earthquakes to limit the damage, the CI will need extensive repairs, compared to the value, but not a complete takedown and rebuild.

Hazard	Intensity Measure	Variable type	Values	Expected damage (% or damage category)	Expected downtime (days)
			121-160 [km/h]	< 15 %	10
Tornado	Fujita scale	Category	0-81 [km/h]	0%	0
			81-120 [km/h]	<10%	0.5
			120-253 [km/h]	20%	15
Heatwaves	Intensity / Temperature	Category	Very Low (< 27 °C)	0%	0
			Low (27-32 °C)	0%	0
			Medium (32-41 °C)	5%	0
			High (41-54 °C)	10%	5 (output reduced by estimated 10% over this period; not complete shut-down)
			Very high (>54 °C)	< 15%	10 (output reduced by estimated 20% over this period; not complete shut-down)

Sanibey Yedigöze HPP is located on the Seyhan river around 50km north of Adana (see Figure A 3-33). Table A 3-4 indicates that loss of service (downtime) of the HPP has an estimated economic impact of USD 6.1m per day.

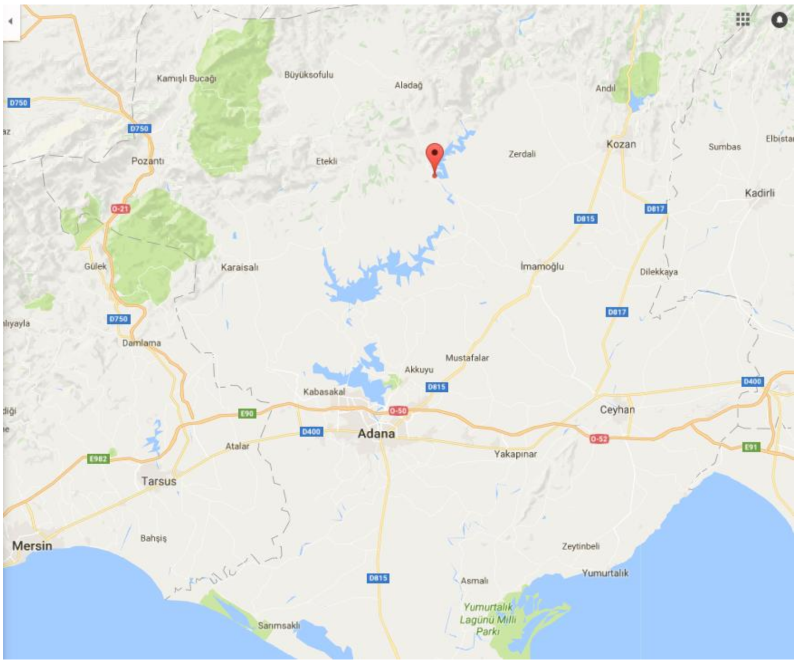


Figure A 3-33 Location of Sanibey Yedigöze HPP. (Source: Google maps).

A3.9.2 Operational and RiskAPP model

A RiskAPP model is developed based on a schematization of the operations at the Sanibey Yedigöze HPP (see Figure A 3-34, top). The Sanibey Yedigöze HPP is an impoundment facility, which are typically large hydropower systems that use a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level. A High-Voltage substation then increases the voltage and delivers the power to the grid. A schematic representation of the RiskAPP model for the HPP can be seen in Figure A 3-34 (bottom).

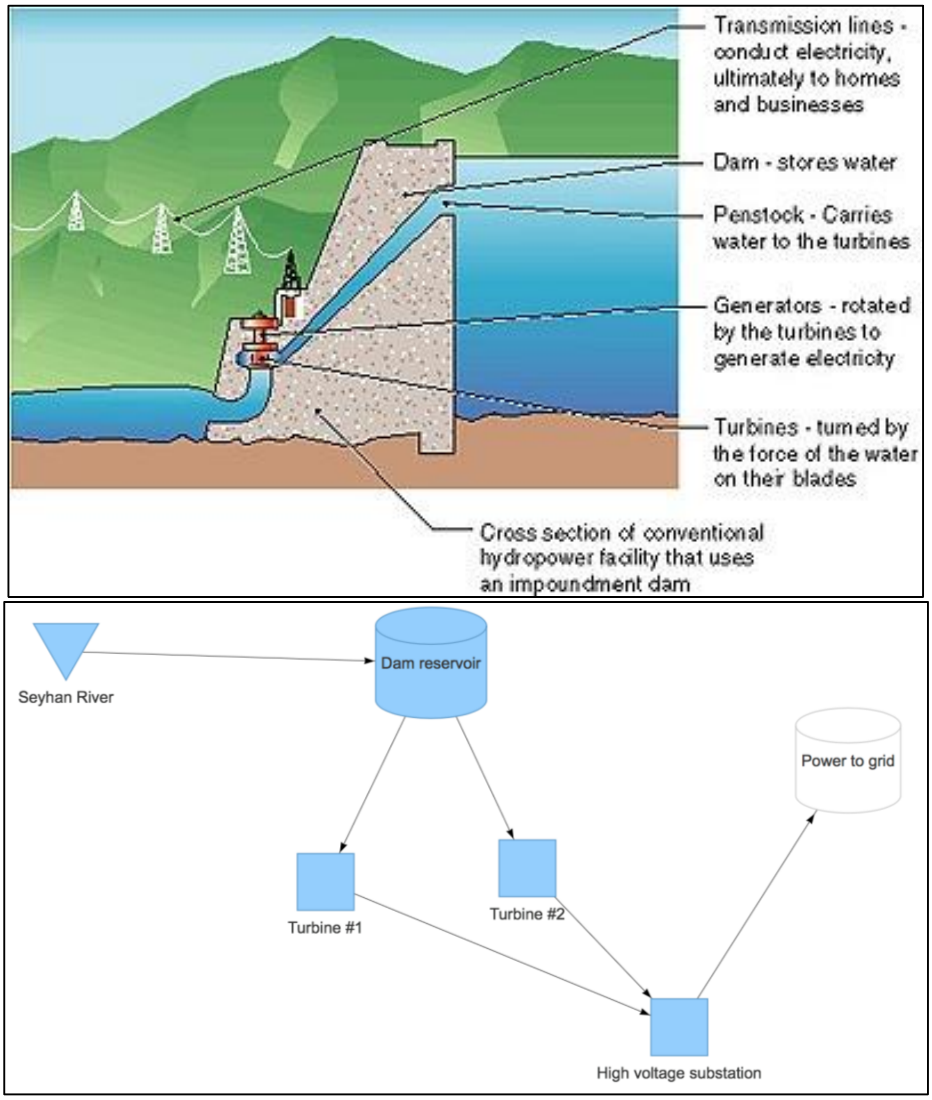


Figure A 3-34 Hydropower plant operational scheme (top)[xxxvii] and operational model in RiskAPP©(bottom).

A3.10 İsken Sugözü Thermal Power Plant

A3.10.1 Hazards, vulnerability and exposure

The geographical location of İsken Sugözü Thermal Power Plant and its susceptibility (see Table A 3-2) was used as a basis for selecting the appropriate hazard scenarios used in RiskAPP (see Table A 3-3), covering both the current level of the hazard and, for climate-related hazards that change over time, an estimate of the future hazard level (e.g. heatwaves in 2030s).

The vulnerability of İsken Sugözü TPP to the hazard scenarios is summarised in Table A 3-39. The expected damage is expressed as a percentage or category in relation to the magnitude of the hazard. The corresponding downtime of the TPP is given in days. The information in this table relies on expert

[xxxvii] For more information https://openknowledge.worldbank.org/handle/10986/22788

knowledge about the relationship between the potential levels of a hazard and the damage this may cause to the TPP. In the case of earthquake vulnerability, this expertise is supplemented by quantitative research. Earthquake fragility curves for Electric Power Plants (EPPs) are used as a proxy[402], where the TPP is assumed to be a medium-large EPP (installed capacity >200MW) with anchored components (seismic designed) and the substations are assumed to be high-voltage (>350kV). Earthquake damage is classified into 5 categories: 'Slight' and 'Moderate' damage states lead to operation without repair; 'Extensive' refers to an EPP which can only be operational again after repairs, while 'Complete' damage is not repairable. The operational damage classified by 'Slight', 'Moderate' and 'Extensive' leads to a reduction of power flow. (See Annex A3.8 for further details).

Table A 3-39 Vulnerability of İsken Sugözü TPP to hazards in the region. (Source: Report authors).

Hazard	Intensity Measure	Variable type	Values	Expected damage (% or damage category)	Expected downtime (days)
Earthquake	peak ground acceleration	Continuous	0.10 [g]	Slight – 5%	0
			0.25 [g]	Moderate – 40%	30
			0.52 [g]	Extensive – 70%	60 (200)*
			0.92 [g]	Complete – 100%[xxxviii]	280
Flood	water depth	Continuous	0 to +9 [m]	<10%	10
Flood	water depth	Continuous	+9 to +11 [m]	15%	15
Storm	wind speed	Category	0-81 [km/h]	0%	1
			81-120 [km/h]	<10%	5
			121-160 [km/h]	< 15 %	10
Tornado	Fujita scale	Category	0-81 [km/h]	0%	0
			81-120 [km/h]	<10%	0.5
			120-253 [km/h]	20%	15
Heatwaves	Intensity / Temperature	Category	Very Low (< 27 °C)	0%	0
			Low (27-32 °C)	0%	0
			Medium (32-41 °C)	5%	0
			High (41-54 °C)	10%	5 (output reduced by estimated 10% over this period; not complete shut-down)
			Very high (>54 °C)	< 15%	10 (output reduced by estimated 20% over this period; not complete shut-down)
Landslides		Yes/no	Yes	5%	20
* The plant could take up to 200 days to repair following extensive (70%) damage but the downtime is capped at 60 days, because a replacement could come online after a maximum of 60 days					

[xxxviii] 100% of damage refers to the financial damage, i.e. the cost of repairs compared to the value of the asset. Since the TPP is designed against earthquakes to limit the damage, the CI will need extensive repairs, compared to the value, but not a complete takedown and rebuild.

İsken Sugözü Thermal Power Plant is located on the coast of Sugözü, some 50 km from the centre of Adana in the city of İsken (see Figure A 3-35). Table A 3-4 indicates that loss of service (downtime) of the TPP can lead to an impact on GDP of USD 84m per day.

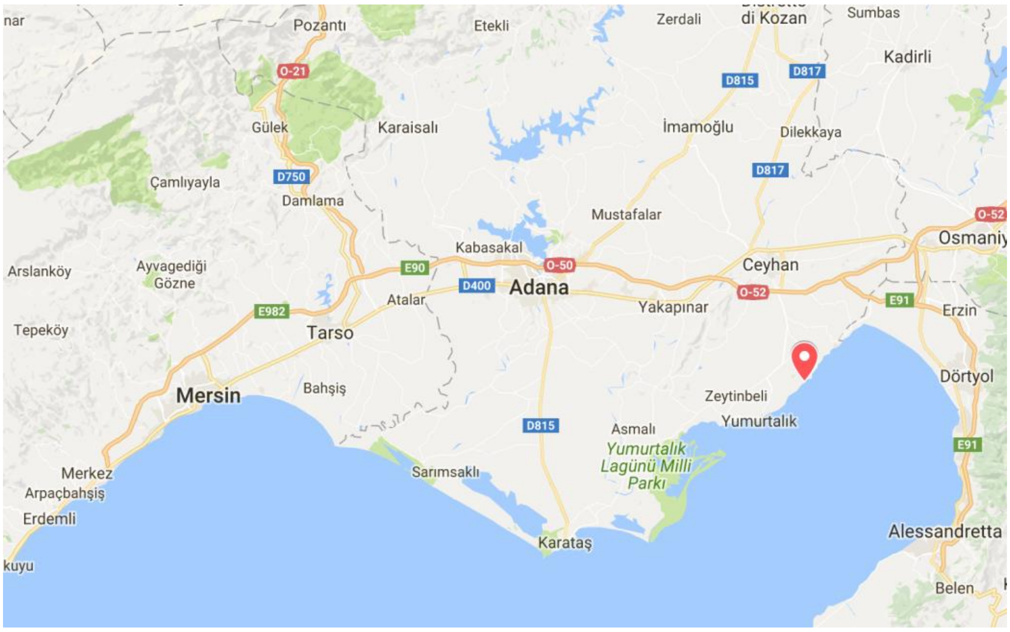


Figure A 3-35 Location of İsken Sugözü TPP. (Source: Google Maps).

A3.10.2 Operational and RiskAPP model

A RiskAPP model is developed based on a schematic of operations at İsken Sugözü TPP (see Figure A 3-36, top). İsken Sugözü TPP uses imported coal that arrives via vessel from Colombia and South Africa, is unloaded from vessels using grab cranes and then stored on site. The coal is crushed and fed into a furnace to create steam for the turbines. A High-Voltage substation then increases the voltage and delivers the power to the grid. A representation of the TPP in a RiskAPP model is shown in Figure A 3-36 (bottom).

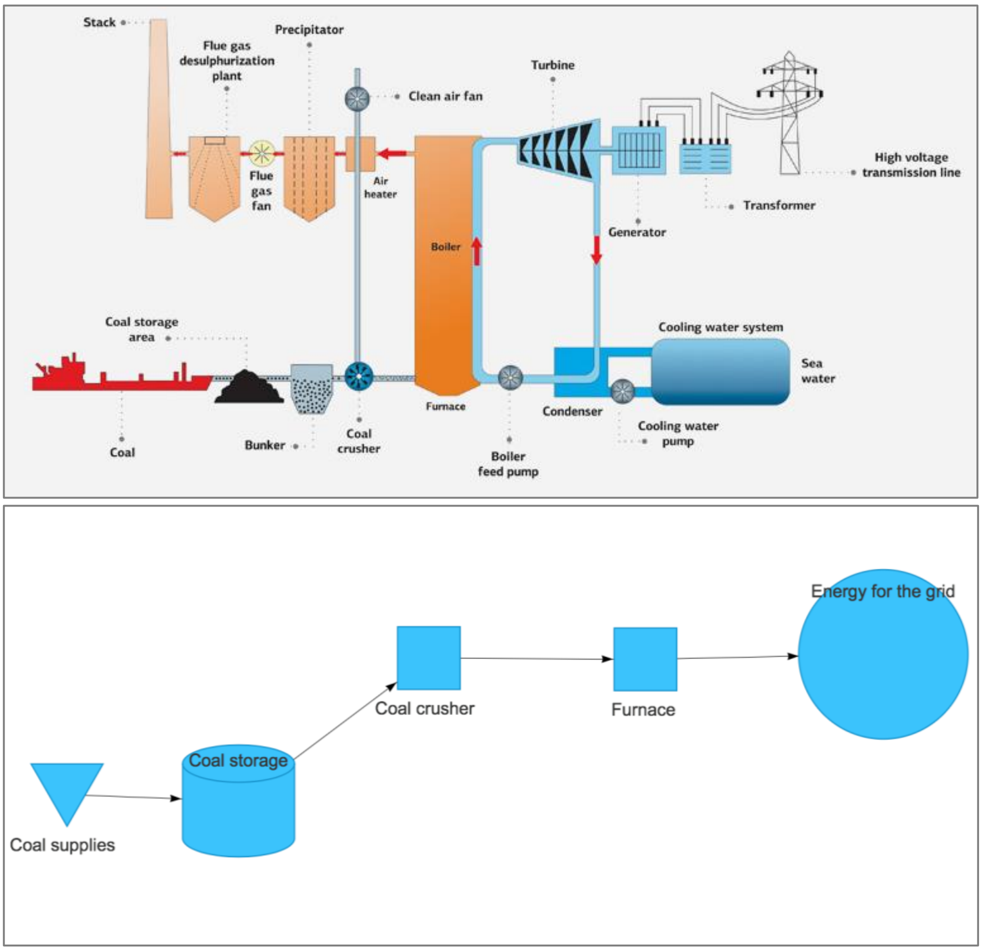


Figure A 3-36 Thermal power plant operational scheme (top)[xxxix] and operational model in RiskAPP (bottom).

A3.11 Yumurtalik-Kırıkkale Oil Pipeline Storage and Pumping Facilities

A3.11.1 Hazards, vulnerability and exposure

The geographical location of the storage and pumping facilities at Ceyhan associated with the Yumurtalik-Kırıkkale pipeline, together with their susceptibility (see Table A 3-2) were used as a basis for selecting the appropriate hazard scenarios used in RiskAPP (see Table A 3-3), covering both the current level of the hazard and, for climate-related hazards that change over time, an estimate of the future hazard level (e.g. heatwaves in 2030s).

The vulnerability of the storage and pumping facilities to the hazard scenarios is summarised in

[xxxix] For more information https://openknowledge.worldbank.org/handle/10986/22788

Table A 3-40. The expected damage is expressed as a percentage or category in relation to the magnitude of the hazard. The corresponding downtime of the storage/pumping facilities is given in days. The information in this table relies on expert knowledge about the relationship between the potential levels of a hazard and the damage this may cause to the storage/pumping facilities at Ceyhan.

Table A 3-40 Vulnerability of storage and pumping facilities at Ceyhan for Yumurtalik-Kırıkkale Oil Pipeline to hazards in the region. (Source: Report authors).

Hazard	Intensity Measure	Variable type	Values	Expected damage (% or damage category)	Expected downtime (days)
Storm	wind speed	Category	0-81 [km/h]	0%	0
			81-120 [km/h]	<5%	1
			121-160 [km/h]	<10%	10
Tornado	Fujita scale	Category	0-81 [km/h]	0%	0
			81-120 [km/h]	<5%	1
			120-253 [km/h]	<10%	10
Flood	water depth	Continuous	0 to +9 [m]	<10%	2
Heatwaves	Intensity / Temperature	Category	Very Low (< 27 ºC)	0%	0
			Low (27-32 ºC)	0%	0
			Medium (32-41 ºC)	5%	0
			High (41-54 ºC)	10%	5
			Very high (>54 ºC)	<15%	10
Earthquake	peak ground acceleration	Continuous	0.10 [g]	Slight – 5%	0
			0.25 [g]	Moderate – 40%	30
			0.50 [g]	Extensive – 70%	60
			0.90 [g]	Complete – 100%	280
Landslides	debris	Yes/no	Yes	5%	20

Table A 3-4 indicates that loss of service (downtime) of the pipeline can lead to an economic impact of USD 11.6 m per day. As noted in Table A 3-4, this figure includes: (1) loss of revenue for the refinery owners associated with disruption of oil supplies via the pipeline, assuming that disruption leads to lost refinery production (2) Loss of tax revenue to the government due to loss of sales of refined products. This figure therefore does not represent a full picture of GDP loss; rather it provides a partial view of the economic impact of pipeline disruption.

A3.12 Mersin International Port

A3.12.1 Hazards, vulnerability and exposure

The geographical location of Mersin International Port (MIP) and its susceptibility (see Table A 3-2) was used as a basis for selecting the appropriate hazard scenarios used in RiskAPP (see Table A 3-3), covering both the current level of the hazard and, for climate-related hazards that change over time, an estimate of the future hazard level (e.g. heatwaves in 2030s). The vulnerability of MIP to the hazard scenarios is summarised in Table A 3-41. The expected damage is expressed as a percentage or category in relation to the magnitude of the hazard. The corresponding downtime of MIP is given in days. The information in this table relies on expert knowledge about the relationship between the potential levels of a hazard and the damage this may cause to the MIP. In the case of earthquake vulnerability, this expertise is supplemented by quantitative research. Earthquake fragility curves for cranes are used as a proxy[403]. Earthquake damage is classified into 5 categories: 'Slight' and 'Moderate' damage states lead to operation without repair; 'Extensive' refers to an MIP which can only be operational again after repairs, while 'Complete' damage is not repairable. (See Annex A3.8 for further details).

Table A 3-41: Vulnerability of Mersin International Port to hazards in the region. (Source: Report authors).

Hazard	Intensity Measure	Variable type	Values	Expected damage (% or damage category)	Expected downtime (days)
Storm	wind speed	Category	0-81 [km/h]	0%	1
			81-120 [km/h]	<10%	3
			121-160 [km/h]	< 15 %	15
Tornado	Fujita scale	Category	0-81 [km/h]	0%	1
			81-120 [km/h]	<10%	3
			120-253 [km/h]	50%	30
Costal Flood	Max wave height	Continuous	0 to +10 [m]	>50%	60[xl]
Flood (Flash)	Water depth	Continuous	*	-	-
Heatwaves	Intensity / Temperature	Category	Very Low (< 27 °C)	0%	0
			Low (27-32 °C)	0%	0
			Medium (32-41 °C)	0%	0
			High (41-54 °C)	10%	2
			Very high (>54 °C)	20%	10
Earthquake	peak ground acceleration	Continuous	0.15 [g]	Slight – 5%	0
			0.35 [g]	Moderate – 20%	5
			0.80 [g]	Extensive – 80%	30
			1.00 [g]	Complete – 100%	90

* There is insufficient information to define the features of this scenario.

As can be seen in Table A 3-41, it was not possible to define a range of hazard values for flash flooding at the port owing to a lack of data. However, it is worth noting that the port experienced a flash flood event on December 28th - 29th, 2016, when 108 mm of rain fell in 24 hours[404]. According to port stakeholders, this led to operations at the port being disrupted for around 12 hours.

MIP overlooks the Mediterranean Sea (see Figure A 3-37). Table A 3-5 indicates that loss of service (downtime) of MIP has an estimated economic impact of USD 21m per day.

[xl] 60 days refers to the time required by port authority to do the cleanup and the minor repairs required by flooding.

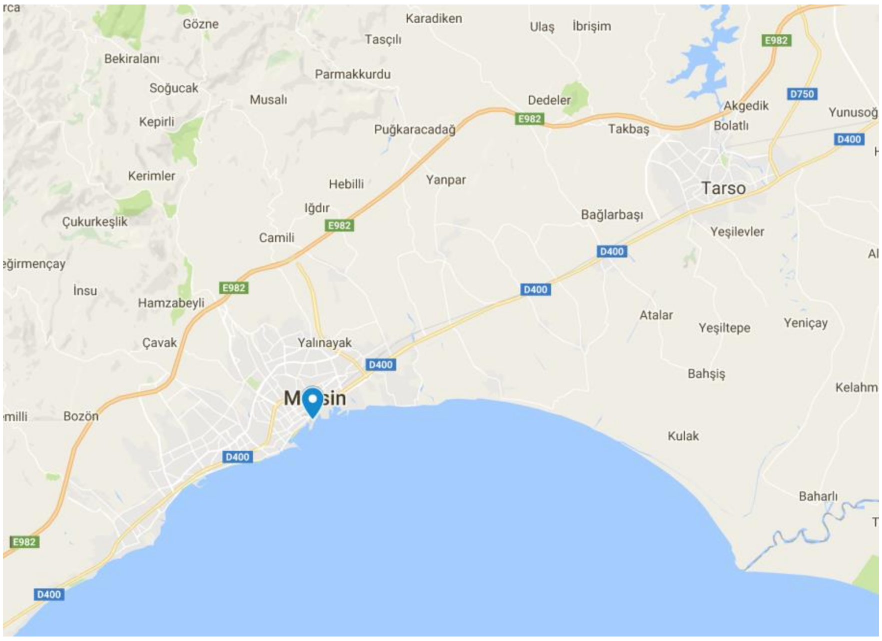
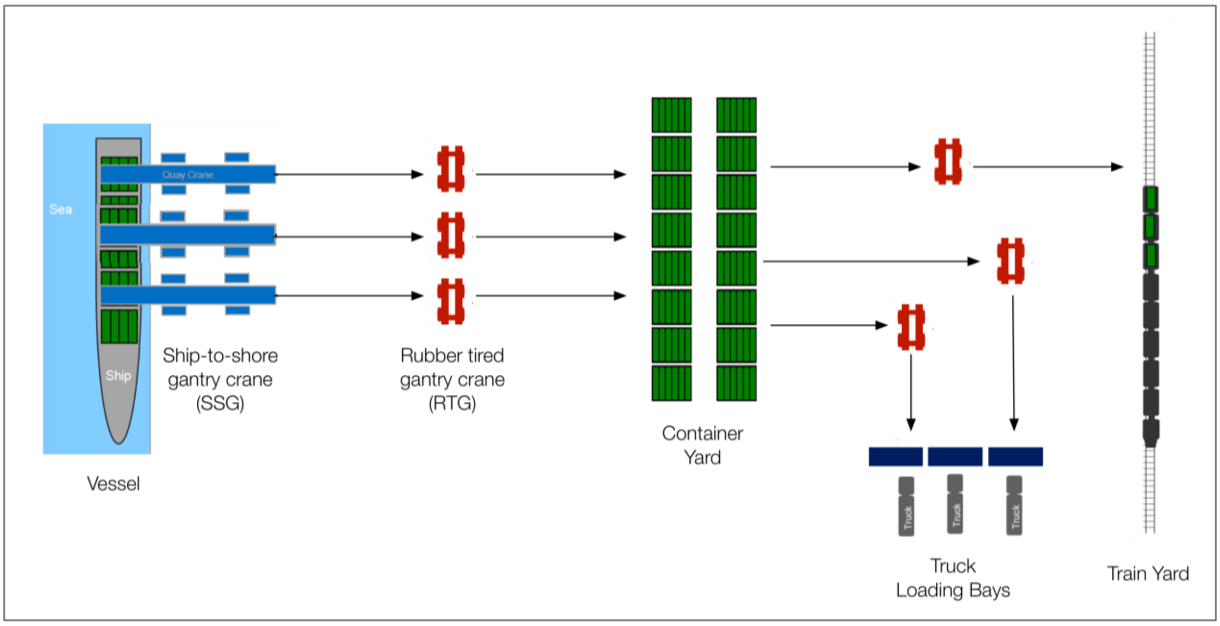


Figure A 3-37: Location of Mersin International Port (MIP). (Source: Google Maps).

A3.12.2 Operational and RiskAPP model

A RiskAPP model was developed based on a schematization of the operations at the MIP (see Figure A 3-38 top). The essence of the port operations is the cargo flow and cargo storage. Every day, vessels arrive at the port, and containers are unloaded by 11 Ship-to-Shore Gantry crane (SSG) and 7 mobile harbour crane (MHC). Then 33 Rubber Tired Gantry (RTG) cranes place the container on the Container Yard. Finally, the containers are taken out by truck and train. A corresponding schematic representation of the RiskAPP model for the MIP can be seen in Figure A 3-38 (bottom).



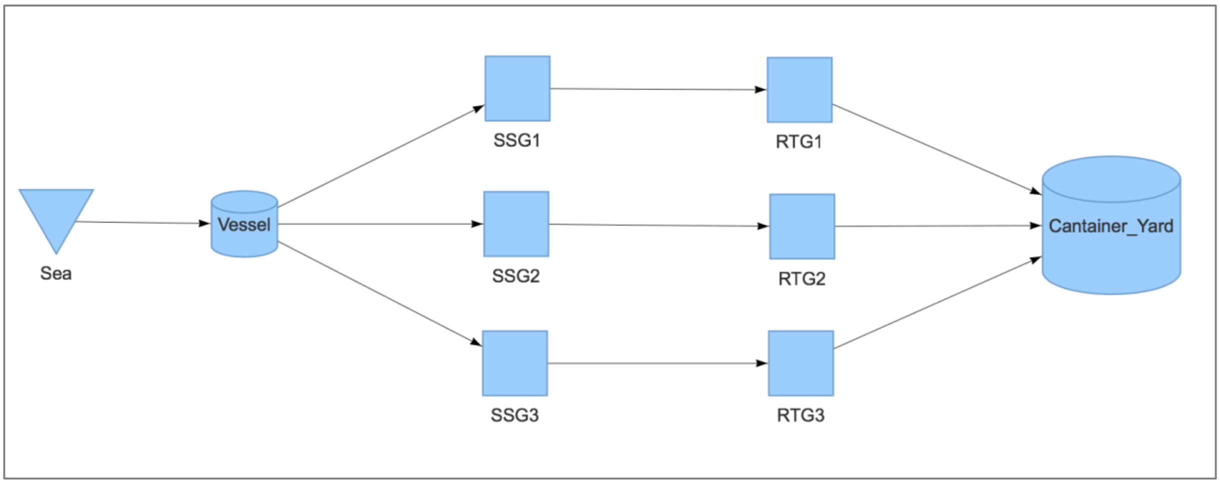


Figure A 3-38: Mersin International Port scheme (top) and operational model in RiskAPP (bottom). (Source: Prem Chhetri, 2014[405] and report authors)

A3.13 Seyhan Viaduct across Seyhan River on E-90 European Highway

A3.13.1 Hazards, vulnerability and exposure

The geographical location of the Seyhan Viaduct and its susceptibility (see Table A 3-2) was used as a basis for selecting the appropriate hazard scenarios used in RiskAPP (see Table A 3-3).

The vulnerability of Seyhan Viaduct to the hazard scenarios is summarised in Table A 3-42. The expected damage is expressed as a percentage or category in relation to the magnitude of the hazard. The corresponding downtime of the Seyhan Viaduct is given in days. The information in this table relies on expert knowledge about the relationship between the potential levels of a hazard and the damage this may cause to the viaduct. In the case of earthquake vulnerability, this expertise is supplemented by quantitative research (see Annex A3.8 for further details).

Table A 3-42 Vulnerability of Seyhan Viaduct to hazards in the region. (Source: Report authors).

Hazard	Intensity Measure	Variable type	Values	Expected damage (% or damage category)	Expected downtime (days)
Flood	water depth	Continuous	0 to 0.5 [m]	No damage (0% of value) **Traffic delays**	0
			0.5 to 1.0 [m]	Low damage (10% of value) **Traffic delays, lane closures**	2
			1.0 to 2.0 [m]	Medium damage (25% of value) **Road closures and traffic delays**	7
			> 2.0 [m]	Severe damage (45% of value) **Road closures, damage to viaducts / bridges, state roads and motorways**	30
Earthquake	Peak ground acceleration	Continuous	Median = 0.11 [g] beta = 0.45	Cosmetic repairs, asset is serviceable	15

Hazard	Intensity Measure	Variable type	Values	Expected damage (% or damage category)	Expected downtime (days)
			(cumulative log-normal distribution)		
			Median = 0.577 [g] beta = 0.40	Repairable damages	30-90
			Median = 0.741 [g] beta = 0.48[xli]	Non-repairable damage	720[xlii]
Landslides (precipitation induced and earthquake)		Category	Low	Low damage	3
			Medium	Medium damage	5
			High	High damage	14
			Very high	Very high damage	30+

The Seyhan Viaduct is located along the Seyhan River in Adana on the E-90 highway (see Figure A 3-39). Table A 3-5 indicates that loss of service (downtime) of the viaduct has an estimated economic impact of USD 5.1m per day.

Figure A 3-39 Location of Seyhan Viaduct on E-90

A3.13.2 Operational and RiskAPP model

A transportation network graphic for Adana and Mersin is presented in Figure A 3-40. The yellow boxes show the traffic flows in each link, expressed in vehicles per day. On the map, the traffic flow for Seyhan Viaduct is highlighted inside the red circle. Some 36,262 vehicles per day are reported to be served by the viaduct (2015 data).

A transportation network can be described using a graphic, which connects specific nodes ('centroids') where vehicles can enter or exit the network to reach another centroid on the network. Transportation modelling is a time-consuming task, beyond the scope of the current high level risk assessment. Therefore, for the purposes of this risk assessment, the redistribution of transportation flows is neglected.

[xli] The reference class is multi-span, single column, skew less than 30°
[xlii] Damage is beyond repairability, the viaduct needs to be taken down and rebuilt.

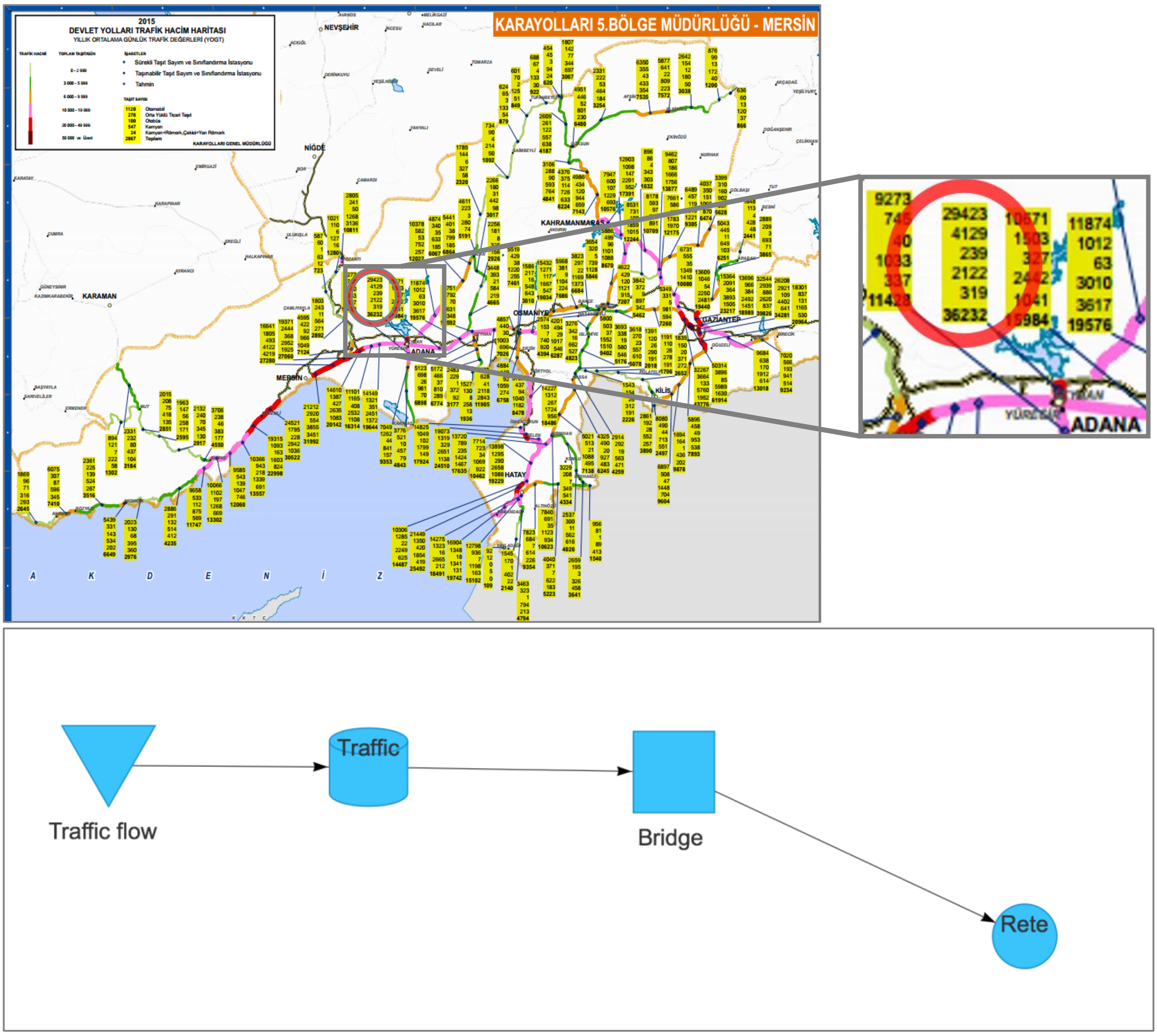


Figure A 3-40 Transportation network for Adana and Mersin (top), functional model in RiskAPP (bottom). (Source: KGM, 2015[406] and report authors).

A4 Current approaches to Critical Infrastructure planning & management - further information

A4.1 Links & resources – national and regional planning in Turkey

- National Development Plans: http://www.mod.gov.tr/Pages/DevelopmentPlans.aspx
- Annual Programs: http://www.mod.gov.tr/Pages/AnnualPrograms.aspx
- Medium Term Programs: http://www.mod.gov.tr/Pages/MediumTermPrograms.aspx
- Medium Term Programs and Main Macroeconomic and Fiscal Targets: http://www.mod.gov.tr/Pages/MainMacroeconomicandFiscalTargets.aspx
- Pre-accession Economic Programs: http://www.mod.gov.tr/Pages/PreAccessionEconomicPrograms.aspx
- Ministry of Urbanization DG Spatial Planning: http://www.csb.gov.tr/gm/mpgmen/
- Environmental Plans (1/25000): http://www.csb.gov.tr/gm/mpgm/index.php?Sayfa=sayfa&Tur=banner&Id=138
- Environmental Plans (1/50000): http://www.csb.gov.tr/gm/mpgm/index.php?Sayfa=sayfa&Tur=banner&Id=365
- Environmental Plans: (1/100000): http://www.csb.gov.tr/gm/mpgm/index.php?Sayfa=sayfa&Tur=banner&Id=37
- Integrated Coastal Plans: http://www.csb.gov.tr/gm/mpgm/index.php?Sayfa=sayfa&Tur=banner&Id=704

A4.2 Legislation directly and indirectly related to climate change adaptation

Category	Legislation Pertaining to Adaptation
Disaster Risk Management	▪ Law pertaining to the Duties and Organization of the Disaster and Emergency Management Presidency (5902): ▪ Law pertaining to the Precautions to be taken and Aids regarding Disasters Effective on Public Life (7269) ▪ Coast Law (3621):
Conservation of Biodiversity	▪ Environmental Law (2872): ▪ Forestry Law (6831), Regulation pertaining to the Implementation of the Forest Cadastre in accordance with the Forestry Law no 6831 (15.07.2004), and Tourism Incentivization Law (2634): ▪ Land Hunting Law (4915): ▪ Forest Management Regulation (05.02.2008 ▪ National Parks Law (2873): ▪ Law pertaining to the Precautions to be taken and Aids regarding Disasters Effective on Public Life (7269): ▪ Agriculture Law (5488): ▪ Pasture Law (4342): ▪ Seed Law (5553): ▪ Decree Law on Organization and Duties of Ministry of Environment and Urbanization ▪ Law No. 5403 on Soil Conservation and Land Use
Water Safety and Security	▪ Environmental Law (2872): ▪ Environmental Impact Assessment (EIA) Regulation: ▪ Regulation on the Protection of Wetlands (17.05.2005): ▪ Regulation on Water Pollution Control (31.12.2004 ▪ Zoning Law (3194): ▪ Renewable Energy Law (5346):
Food Safety and Security	▪ Law pertaining to the Adoption with Amendments of the Decree Law regarding Food Generation, Consumption and Inspection (5179): ▪ Biosafety Law (5977): ▪ Agriculture Law (5488) and Agricultural Basins Regulation (07.09.2010

Figure A 4-1 Legislation directly related to climate change adaptation in Turkey (Source: National Climate Change Adaptation Strategy and Adaptation Plan[407])

Category	Legal Regulations
Disaster Risk Management	▪ Regulation pertaining to Emergency Aid Organization and Planning Principles regarding Disasters (Council of Ministers: 88/12777 - 1.4.1988) ▪ Regulation pertaining to the Norms, Organization, Standards and Principles of Provincial Disaster and Emergency Directorates and Civil Defense Search and Rescue Unions
Conservation of Biodiversity	▪ The Constitution ▪ Law pertaining to the Duties and Organization of the Ministry of Forestry and Water Works ▪ Law pertaining to the Duties and Organization of the Ministry of Environment and Urbanization ▪ Law pertaining to the Adoption with Amendments of the Decree Law regarding to the Duties and Organization of the General Directorate of Forestry ▪ Law on the Mobilization for National Reforestation and Soil Erosion Prevention ▪ Regulation with regard to the Implementation of the Forest Cadastre in accordance with the Forestry Law no 6831 ▪ Circular no 2007/ 28 on the Mobilization of Reforestation ▪ Draft Law on the Protection of Nature and Biodiversity ▪ Cadastre Law ▪ Regulation regarding the Marking of Wood Package Materials in relation with Phytosanitation ▪ Regulation pertaining to Rooting out, Generation and Export of Natural Bulbs ▪ Beekeeping Regulation ▪ Fisheries Law ▪ Fisheries Regulation ▪ Aquaculture Regulation ▪ Fishing Ports Regulation ▪ State's Forest Management and Fluid Capital Regulation
Water Safety and Security	▪ The Constitution ▪ Communiqué on the Identification of Closed Bay and Gulfs which are of Sensitive Nature Where Fish Farms Shall not be Built ▪ Wetlands Communiqués
Food Safety and Security	▪ The Constitution ▪ Veterinary Services, Plant Health, Food and Seed Law ▪ Organic Agriculture Law ▪ Law Pertaining to the Preservation of the Rights of Breeders of New Plant Species ▪ Agricultural Insurances Law ▪ Law on the Protection of Soil and Land Use ▪ Law on Agricultural Reform Pertaining to Land Regulation in Irrigation Fields ▪ Law on the Foundation and Duties of Agricultural and Rural Development Institution ▪ Law on Agricultural Producer Unions ▪ Fodder Law ▪ Law on Animal Health and Inspection ▪ Animal Breeding Law ▪ Statutory Decree on the Foundation and Duties of the Ministry of Agriculture and Rural Affairs ▪ Turkish Food Codex Regulation ▪ Regulation on the Inspection and Control of Food Safety and Quality ▪ Regulation on Good Practices in Agriculture ▪ Law on Aids to be Provided to Farmers Affected by Natural Disasters

Figure A 4-2: Legislation indirectly related to climate change adaptation in Turkey (Source: National Climate Change Adaptation Strategy and Adaptation Plan[408])

A4.3 List of Regional Development Agencies (RDAs) in Turkey

Table A 4-1: Development Agencies in Turkey (as of Nov 2016). (Source: MoD[409]).

Name of DA	Region (Cities)	Head Office Location
Ahiler Development Agency	TR71 (Aksaray, Kırıkkale, Kırşehir, Niğde, Nevşehir)	Nevşehir
Serhat Development Agency	TRA2 Ağrı, Ardahan, Iğdır, Kars	Kars
Eastern Anatolia Development Agency	TRB2 Bitlis, Hakkari, Muş, Van	Van

Name of DA	Region (Cities)	Head Office Location
Middle Black Sea Development Agency	TR83 Amasya, Çorum, Samsun, Tokat	Samsun
Mevlana Development Agency	TR52 Karaman, Konya	Konya
Trakya Development Agency	TR21 Edirne, Kırklareli, Tekirdağ	Tekirdağ
Fırat Development Agency	TRB1 Bingöl, Elazığ, Malatya, Tunceli	Malatya
Eastern Black Sea Development Agency	TR90 Artvin, Giresun, Gümüşhane, Ordu, Rize, Trabzon	Trabzon
Silkroad Development Agency	TRC1 Adıyaman, Gaziantep, Kilis	Gaziantep
Karacadağ Development Agency	TRC2 Diyarbakır, Şanlıurfa	Diyarbakır
İstanbul Development Agency	TR10 İstanbul	İstanbul
Eastern Marmara Development Agency	TR42 Bolu, Düzce, Kocaeli, Sakarya, Yalova	Kocaeli
Bursa Eskişehir Bilecik Development Agency	TR41 Bilecik, Eskişehir, Bursa	Bursa
Southern Aegean Development Agency	TR32 Aydın, Denizli, Muğla	Denizli
South Marmara Development Agency	TR22 Balıkesir, Çanakkale	Balıkesir
Tigris Development Agency	TRC3 Batman, Mardin, Şırnak, Siirt	Mardin
Northeast Anatolia Development Agency	TRA1 Bayburt, Erzincan, Erzurum	Erzurum
Çukurova Development Agency	TR62 Adana, Mersin	Adana
Middle Anatolia Development Agency	TR72 Kayseri, Sivas, Yozgat	Kayseri
İzmir Development Agency	TR31 İzmir	İzmir
West Black Sea Development Agency	TR81 Bartın, Karabük, Zonguldak	Zonguldak
West Mediterranean Development Agency	TR61 Antalya, Burdur, Isparta	İsparta
Eastern Mediterranean Development Agency	TR63 Hatay, Kahramanmaraş, Osmaniye	Hatay
North Anatolian Development Agency	TR82 Çankırı, Kastamonu, Sinop	Kastamonu
Ankara Development Agency	TR51 Ankara	Ankara
Zafer Development Agency	TR33 Afyonkarahisar, Kütahya, Manisa, Uşak	Kütahya

A4.4 The duties and objectives of the RDAs in Turkey

Box A4-1: The duties and objectives of the RDAs in Turkey (Source: Tiftikcigil, 2015[410])

- Supporting the local authorities and providing technical expertise in the area of regional planning.
- Supporting, monitoring, reporting and assessing regional activities that are designed and implemented in the framework of regional plans.
- Supporting rural development in line with the regional development plans.
- Monitoring projects and activities that support regional development which are carried out by regional actors including public and civil sectors.
- Enhancing cooperation between public, private, and civil organizations in order to meet regional development targets.
- Ensure strategic use of resources allocated to the RDA, in line with the national and regional planning strategies.

- Carrying out and supporting research focused on regional development and competitiveness.
- Promoting investment opportunities and providing investment related information to potential investors interested in the region.
- Providing technical assistance to investors in permit and license transactions and all related administrative proceedings.
- Supporting entrepreneurship in various areas including project management, production, marketing, access to technology and finance.
- Promoting effective regional participation in bilateral and multilateral programs Turkey has been attending.

A4.5 Questionnaire: Adaptive Capacity of Energy and Transport & Logistics sectors

Introduction to this questionnaire
This questionnaire will help inform the project of the current level of adaptive capacity in the energy and transport & logistics sectors in the Çukurova Region. Your knowledge of important factors such as regional / government policy, level of awareness and availability of information related to natural hazards, availability of financial and social capital, will be an invaluable contribution to this assessment.
The questionnaire results are confidential and your organisation will not be ranked against others.
Your participation is very important to us. Thank you very much for your time.

SECTION A: YOUR ORGANISATION

1. Name of the organisation:

2. Name of the person filling the questionnaire (optional):

3. Number of years you have worked at the organisation:

4. Your position/title in the organisation (optional):

5. Where does your organisation operate? (You can choose more than one option.)

   ☐ Çukurova Region. ☐ Nation-wide

   ☐ Other. Please specify below:
   [ ]

6. Which sectors does your organisation specifically work in? (You can choose more than one option.)

   ☐ Energy ☐ Transport & Logistics

   ☐ Other. Please specify below:
   [ ]

SECTION B: INFORMATION ABOUT ADAPTING TO NATURAL HAZARDS

1. What is your organisation's level of awareness and understanding about the "Republic of Turkey Climate Change Strategy 2010 2023", the "National Climate Change Action Plan 2011–2023" and AFAD's "Disaster and Emergency Management Presidency 2013 - 2017 Strategic Plan"?

	Climate Change Strategy 2010 2023 / National Climate Change Action Plan 2011–2023	Disaster and Emergency Management Presidency 2013 - 2017 Strategic Plan
Very high awareness / understanding	☐	☐
Fairly high awareness / understanding	☐	☐
Fairly low awareness / understanding	☐	☐
Very low awareness / understanding	☐	☐
No awareness / understanding	☐	☐

2. Overall, do you feel that your organisation has enough information to know whether you should change any of your plans because of geophysical hazards and a changing climate?
   - ☐ Yes, definitely
   - ☐ Yes, probably
   - ☐ No, probably not
   - ☐ No, definitely not
   - ☐ Don't know
3. What is the technical capacity of staff in your organisation to understand and analyse geophysical and climate change risks and prioritise actions that need to be taken to address the risks?
   - ☐ Very strong / high capacity
   - ☐ Fairly strong / medium capacity
   - ☐ Fairly weak / low capacity
   - ☐ No capacity

4. Which of these statements best describes how much your organisation has thought about natural hazard risks and opportunities?
   - ☐ We haven't thought at all about natural hazards
   - ☐ We haven't thought about it, but plan to in the future
   - ☐ We have begun looking at it, but are just getting started
   - ☐ We have assessed present and future natural hazard risks and opportunities
   - ☐ We have assessed present and future natural hazard risks and opportunities, identified priorities and have started acting on these
   - ☐ We have comprehensively assessed current and future natural hazard risks and opportunities, and have fully planned actions, are taking action on priorities and made this part of the way we plan generally
   - ☐ Don't know

5. How do you view the importance of the following enablers that can help your organisation understand and take action to adapt to natural hazards (please tick relevant boxes)?						
	Very important	Somewhat important	Neutral	Of little importance	Not important	Don't know / No opinion
Information is easy to obtain, understand and targeted to my organisation's needs						
Good understanding of how current and future natural hazards may affect my organisation						
Sufficient staff (numbers, expertise and time) and budget to understand and manage natural hazard risk						
Good understanding of the benefits of adapting to climate change and other natural hazards						
Better access to finance that could help my organisation prepare and take action						
Better management, distribution and use of natural resources that can support adaptation (e.g. land use, water resources, biodiversity etc), both at the regional level as well as within my own organisation.						
Better information about technological solutions and strategies for increasing resilience						
Unified, clear and robust climate change and disaster risk policy & governance, cascading from national through to regional government						

A4.6 Central / regional infrastructure planning case studies

A4.6.1 Case Study 1: İsken Sugözü Thermal Power Plant (TPP)

Overview

Located in Adana, İsken Sugözü Thermal Power Plant (hereafter Sugözü TPP) is the first imported coal fired power plant to be built and operated by the private sector in Turkey. Annually, it provides approximately 9 billion kWh electrical energy to the grid. In 2015, total electricity generated by Sugözü TPP was equal to 117.8% of Adana city's total consumption and almost 3% of Turkey's total electricity consumption for the same year. The plant has 1210 MW Net Installed Capacity and received USD 1.5 billion foreign direct investment.

The plant is operated by İSKEN (İskenderun Energy Generation and Trade Co.) which was established in 1998. İSKEN is a subsidiary of and affiliated by OYAK Group in 2004. The plant was developed within the framework of the Build-Operate model and commissioned in November 2003. Most important milestones of the plant are shown in Figure A 4-3.

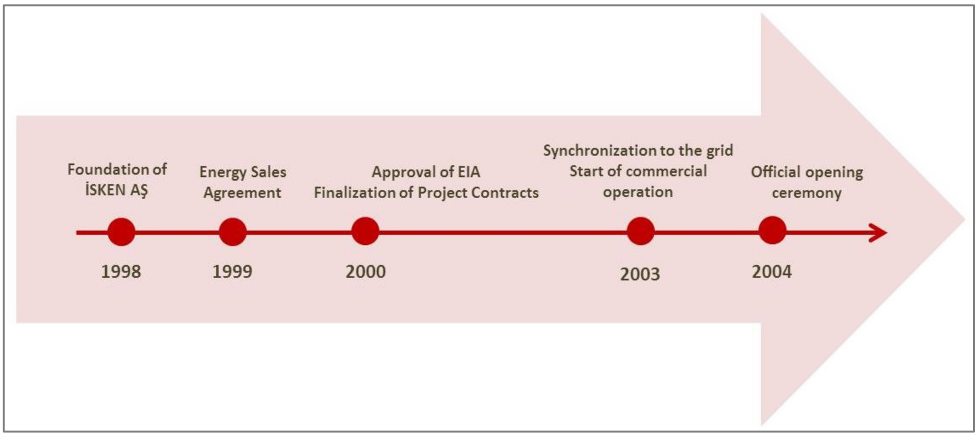


Figure A 4-3: Milestones of İSKEN Sugözü TPP (Source:Report authors)

Drivers for investment

When focusing on the drivers behind this investment decision it is clear that growing domestic energy demand in Turkey in the last decades is a significant driver of energy infrastructure development. Over the past decade, energy demand in Turkey has grown along with economic and social development, driven by industrialization and urbanization. According to the IEA, Turkey's total primary energy consumption rose considerably between 1973 and 2011, from 24.4 million tons of oil equivalent (Mtoe) to 114.1 Mtoe, at a compound annual growth rate (CAGR) of 4%. Turkey's share of global energy consumption increased from 2.5% to 5.2% during the same period. Recent electricity consumption trends and forecasts send strong signal regarding future demand. The Turkish electricity market is one of the fastest growing in the world, with a CAGR of 5.8% over the period 2002 to 2013, and the Turkish Electricity Transmission Company (TEİAŞ) estimates that national electricity demand will increase by 7% annually till 2023. These market factors are the driving force behind almost every investment decision in the energy sector, including Sugözü TPP.

Another important driver is the energy security agenda. The 10th Five-year Development Plan and the MENR (Ministry of Energy and Natural Resources) Strategic Plan for the period 2015-2019 set out the ambition for the country to realize its own energy security by diversifying energy resources and increasing the share of coal (see Figure A 4-4). This strategic direction in combination with the liberalization of the energy sector provided additional incentives to investors.

Among the regional drivers in Çukurova, proximity to imported coal trade routes, availability of appropriate land and water resources, and mild climate were influential in site selection. These factors explain why Çukurova region has become an attractive location for TPP investors in the last decade.

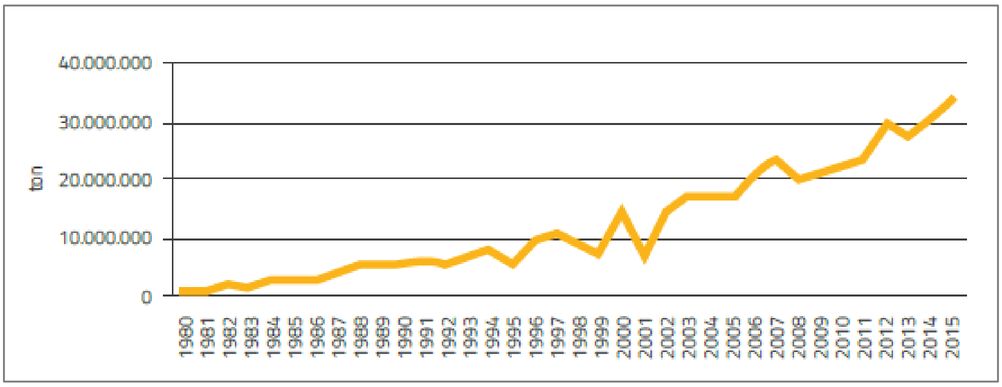


Figure A 4-4: Volume of imported coal in Turkey (Source: TKI, 2016)[411]

Approval process

An understanding of the approval process for infrastructure investments can help to identify how to effectively include resilience within the process.

As any typical energy infrastructure investor does in Turkey, İSKEN A.Ş. had to deal with a number of permissions and licenses in order to develop the project. In the TPP context, this process (and relevant actors) can be summarized in four stages: project development, licensing, obtaining permissions and project application (see Figure A 4-5).

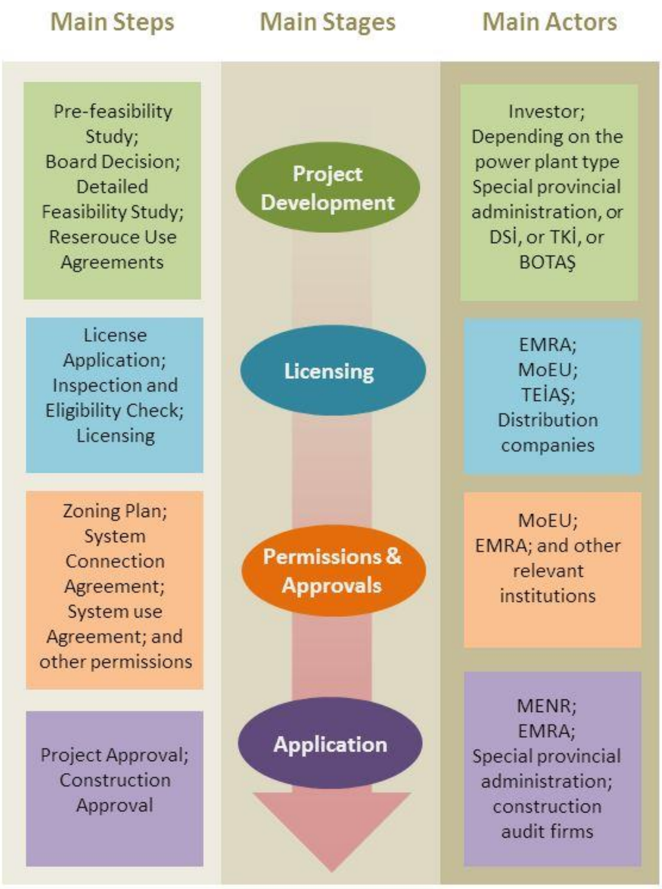


Figure A 4-5: Main stages of energy infrastructure investment. (Source: Report authors, adapted from YÖİKK guidelines[412])

Further details on the permissions and approvals for thermal power plant investments are presented in Table A 4-2.

According to the World Bank, in 2017, dealing with constructing permits in Turkey takes approximately 103 days (for completing 18 procedures)[413]. This is shorter than the average time required in Europe, Central Asia and OECD High Income Countries to obtain the same permits[414]. However, in late 1990s, when İSKEN were developing Sugözü TPP, the process was more complex and fragmented. Therefore, it took longer to obtain the relevant permissions and approvals. It should also be noted that EIA regulations have been revised[415] multiple times and İSKEN was subject to older versions[416]. The updated EIA report process[417] consists of nine steps: scope analysis (to identify whether the investment is subject to EIA regulation or not); eligibility check (whether application of EIA is required or not); start of EIA process; public participation; scope and format identification; development of EIA report and presentation to the Ministry; EIA report examination and evaluation; decision; monitoring and control. For thermal power plant investments, there is a particular EIA guideline which requires the investor to prepare a detailed analysis on site selection and risk assessment, with an explicit focus on geological risks.

Table A 4-2: Permissions and Approvals Required for Thermal Power Plant Investments in Turkey (Source: Report authors)

Permissions and Approvals Required at the Pre-Investment and Investment Stage	
Permission / approval	**Responsible body**
Trade registry	Ministry of Customs and Trade
Trade registry gazette announcement	Trade registry gazette directorate (The Union of Chambers and Commodity Exchanges of Turkey
Registration to a taxation authority	Taxation authority
Obtaining EIA Report	Ministry of Environment and Urbanization
Location selection and facility permit process	Special provincial administration or municipality
Flotation permit	Special provincial administration or municipality
Permissions and Approvals Required at the Operational Stage	
Operation permit	Special provincial administration or municipality
Capacity report	Chamber of Trade and Commerce
Industrial registry certificate	Provincial Directorate of Science, Industry and Technology
Calibration and sealing of facility equipment	Provincial Directorate of Science, Industry and Technology
Temporary activity certificate	Provincial Directorate of Environment & Urbanization
Environmental permits	Provincial Directorate of Environment & Urbanization
Environmental licenses	Provincial Directorate of Environment & Urbanization
Water connection	Municipality
Electricity connection	Provincial Directorate of Electrical Power Resources Survey and Development
Natural gas connection	Municipality
Highway connection permit	Regional Directorate of DG Highways or municipality
Permissions and Approvals Required for Thermal Power Plant Investments	
License	EMRA (Energy Market Regulatory Authority)
Project approval	Ministry of Energy and Natural Resources
Integrated Environmental Permits	Ministry of Environment and Urbanization

A4.6.2 Case Study 2: Mersin Container Port Expansion

Photo 1. Mersin International Port by air (Source: MIP)

Overview

Mersin Port has a long history dating back to 1880s. With the launch of the Adana-Mersin railway in 1886 there was an increase in the number of ships in Mersin Bay. Seeking faster loading and discharging of vessels, first the "Stone Pier" and then the "Customs Pier" were constructed by Mersin Municipality. A lack of experienced port management was addressed by the establishment of the Mersin Port Company in 1927. The company was taken over by the government in 1942 and assigned to Turkish State Railways (TCDD) in the framework of Turkish National Security Law. The construction of the modern Mersin Port began in 1954 and it started modernised operations in 1962. The port is still owned by TCDD but, in 2007, operating rights were assigned to Mersin International Port Management Inc. (MIP)[xliii] for 36 years, by the Privatization Administration and TCDD.

The port has consistently increased capacity and operations since 2007 as trends signalled continuous growth in demand. It has a significant hinterland and connections to Anatolia, the Black Sea and Middle East. MIP is known as one of the most important ports in Turkey, the Middle East and the East Mediterranean region.

Drivers for investment

The transport sector in Turkey is expanding rapidly, in parallel with the country's strong economic and population growth. As already noted, every year, about 30% of the total government budget is dedicated to transport infrastructure. The country has an overall vision to reduce the budget deficit and public debt, and the infrastructure requirements/plans will require a significant amount of investment. The privatisation of the transport sector is therefore accelerating, primarily through Public-Private Partnerships (PPPs) and the 'Built-Operate-Transfer' models which are more and more encouraged through new law and financial/tax incentives, especially as regards rail and maritime transport[418]. The share of maritime freight transport in Turkey is of importance and on an upward trend, and over half of the country's foreign trade is moved via the sea. The 2023 long term objectives envisage an accelerated trend in the coming years. Port capacity is therefore likely to increase. Currently, there are 33 projects on track, related to increasing the capacity of existing ports or the development of new ports. Of these, 19

[xliii] MIP was established by the PSA-Akfen Joint Venture Group in the same year.

relate to container ports, including the new container port at Mersin with an expected capacity of 11.4 million TEU.

A study conducted in 2007 (Transport infrastructure needs assessment for Turkey, also known as TINA study) outlined forecasts for the transport sector in Turkey. The TINA study anticipated robust growth over the period to 2020 and one of the priority projects identified in the TINA Study was Mersin Container Port. The proposal is to adjoin the new container port to the existing Port of Mersin, to consolidate the existing Port of Mersin as a gateway for import-export traffic and a trans-shipment hub in the region. The expected increase in traffic and capacity projections were convincing (see Figure A 4-6). Five-year Development Plans, National Ports Master Plan Study (2000) and TINA demand forecasts played a driving role behind the BOT-type tender decision.

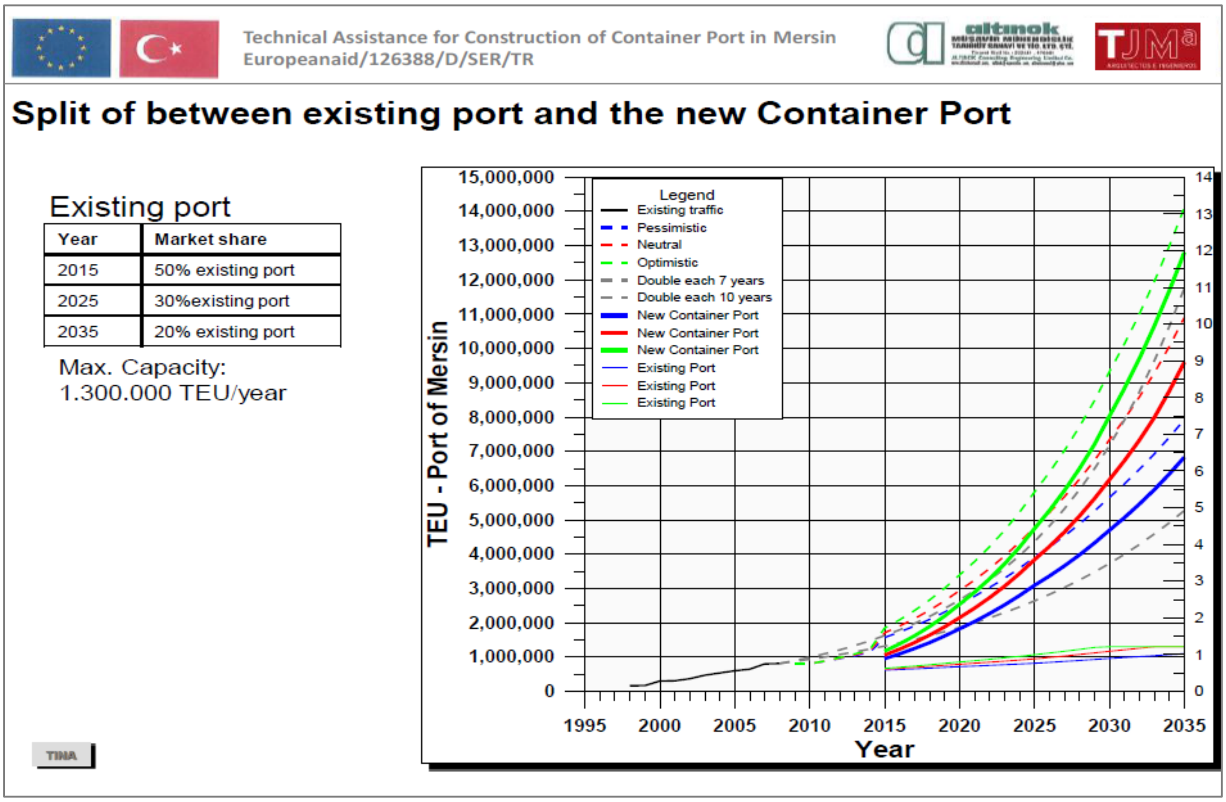


Figure A 4-6: The capacity (TEU) split between the existing Mersin port and the new container port (Source: TINA Study, 2007)[419]

Mersin Container Port comprises an important component of the international multimodal transportation system[420]. It was planned to be constructed in two 'packs', under a BOT Model[421] (First pack: Phases 1, 2 and 3; second pack: Phases 4 and 5):

- Phase 1: 1.7 million TEU/Year (BOT)
- Phase 2: 3.4 million TEU/Year (BOT)
- Phase 3: 5.7 million TEU/Year (BOT)
- Phase 4: 8 million TEU/Year (BOT)
- Phase 5: 12 million TEU/Year (BOT).

The expansion finally started in 2014 and was completed in 2016.

This case study provides a useful example of state owned privately operated critical infrastructure investments driven by Turkey's strategic vision, linked with the 2023 objectives and mega projects agenda.

Approval process

The investment followed similar steps to the previous case study for İsken Sugözü TPP, though with different motivations and drivers, as noted above.

The port owner, TCDD, completed the EIA and zoning development plans. The EIA application included a risk assessment section with a particular focus on geological risks (see Figure A 4-7). Meteorological data was briefly discussed in the application but neither longer term climate-related data nor climate change projections were taken into account.

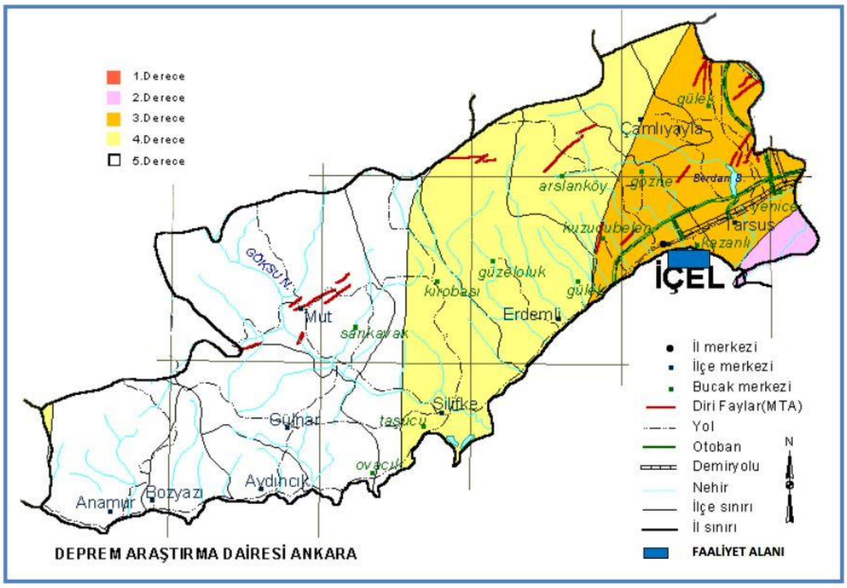


Figure A 4-7: Seismic risk map of Mersin included in the EIA application for Mersin Container Port (source: DLH, 2009)[422]

A5 Risk management policy and best practice - further information

A5.1 Informing policy guidance recommendations through CIRA deliverables

Table A 5-1 shows on how the recommendations in the policy guidance have been informed by CIRA deliverables. Sections A5.1.1 and A5.1.2 presents reflections from the analysis of the decision-making processes used for regional planning and infrastructure investment, on how to improve the integration of risk assessments within these processes. These reflections have guided the development of the CIRA policy guidance presented in Section 7.

Table A 5-1: How the recommendations in this policy guidance have been informed by earlier CIRA deliverables. (Source: Report authors).

CIRA deliverable	Key messages from the deliverable of relevance to the policy guidance note	Recommendation in the policy guidance note for Çukurova Region	Recommendation in policy guidance note for national government - which are needed to support resilience measures at the regional level
Critical infrastructure definition and criteria	In Turkey, **CI assets have neither been identified nor categorized** according to criticality	Regional and local authorities and private sector representatives should **cooperate with central government** to **re-evaluate the state's initial list of CI assets** and potentially identify further assets that are critical for the region.	The State should carry out a **first identification of most relevant CI assets in each sector**. An *a priori* **criticality scale should be defined** to categorize the critical assets.
Sectoral analysis	There is **close cooperation** between Turkey and the EU on the development of energy and transport infrastructure	ÇKA should ensure it **learns from good practice guidance** and requirements in the EU on **how to build resilience into CI planning**, and **how to engage on resilience with CI developers, owners and operators.**	The State should ensure it **learns from good practice guidance** and requirements in the EU on **how to build resilience into CI planning and investment decision-making for CI projects**.
	Turkey is embracing an **ambitious agenda of large-scale infrastructure investments** in energy and transportation	ÇKA should **ensure that resilience of CI is incorporated into the regional development plan** and should **engage with CI developers on the importance of building resilience against present-day and future natural hazards during early stages of project planning and design.**	The State should ensure that **sector strategic / master plans** (e.g. MENR Strategic Plan and the National Transportation Master Plan) **incorporate resilience aspects**.
	Turkey's energy and transportation investments **agenda emphasises Public Private Partnership** (PPP) models. Yet Turkey's PPP and BOT legislation **makes no reference to the changing climate risk landscape**.	ÇKA should **engage with private sector CI owners / operators** on the benefits of incorporating resilience, **learn** from their existing experience on the topic, and **emphasize the importance** that ÇKA places on it.	The State should **encourage the incorporation of a changing risk landscape in PPP / BOT legislation** and contracts to ensure **public sector partners are not taking on excessive future Force Majeure liabilities if clauses and risk allocations are being based on a historic / non-stationary climate only**. Government should **harness private sector adaptation expertise** for introducing climate risk and resilience into the infrastructure they design, build and operate.

CIRA deliverable	Key messages from the deliverable of relevance to the policy guidance note	Recommendation in the policy guidance note for Çukurova Region	Recommendation in policy guidance note for national government - which are needed to support resilience measures at the regional level
Planning, Infrastructure Investment and Risk Management	ÇKA **involves most of the stakeholders** in the region in **its governance structure.**	ÇKA should establish a "**regional CI resilience coordination committee"** (comprising key stakeholders from infrastructure sectors, local authorities, the private sector, NGOs and academia, etc.) for accelerating capacity building on CI resilience in the region. ÇKA should **bring different actors to the table** to increase awareness on the concept of CI resilience. ÇKA could also **trigger formation of new networks** focusing on the relationships between climate change, infrastructure, the local economy and competitiveness and/or related topics.	
	There is a **lack of policy** requiring risk assessments within infrastructure investment planning to **address all natural hazards**.	ÇKA should **promote conducting multi-hazard risk assessments** as part of CI investment planning to provide evidence to regional and national government bodies. Provincial administrations involved at the Project Development stage, as well as bodies with regional directorates (e.g. DSI) can facilitate **early interaction** between regional and national / state bodies on the **need for multi-hazard risk assessments**.	The State should ensure that policy governing the project planning, licencing and permitting **lifecycle includes the requirement for an all-hazards approach** to risk assessment and management. Policy should identify that Feasibility Studies and Environmental Impact Assessments are **key entry points for these assessments**. Policy should **be introduced to drive existing operators or developers of CI to undertake robust multi-hazard assessments.**
	Hazard / risk information exchange between governmental institutions and project applicants is **limited.**	The Region can benefit from **improved hazard / risk information exchange** between ÇKA, governmental institutions, research institutions and project applicants/developers. ÇKA should **establish a close collaborative partnership** with all stakeholders and an **information sharing mechanism** ÇKA should **promote research and development** on regional hazards and risks for CIs and **communicate the outcomes** to government authorities and project developers to provide a sound basis for integration of resilience into planning and design decisions.	The State can benefit from **increased hazard / risk information exchange** between governmental institutions, research organisations, regions and project applicants/developers.

CIRA deliverable	Key messages from the deliverable of relevance to the policy guidance note	Recommendation in the policy guidance note for Çukurova Region	Recommendation in policy guidance note for national government - which are needed to support resilience measures at the regional level
Planning, Infrastructure Investment and Risk Management	A **lack of planning, particularly in the transport** sector, was flagged up as a weakness by participants at the 1st CIRA workshop	Regional development plans should provide **clear and robust signals on climate change and disaster risk policy and governance**.	The State should ensure **clear and robust policy and governance of climate change and disaster risk, cascading from national to regional government**.
	There is a growing concern on the **lack of dialogue** on CI planning between central and regional actors	To fill the gap ÇKA can act as **regional moderator and facilitator**	A **systems-based approach to planning and regulation from national down to regional level** should be considered fundamental in ensuring that regions can operate (and recover) successfully not in isolation, but as an integral part of Turkey.
	Low technical capacity and expertise within the region on **how to build resilience** was identified by participants at the 1st CIRA workshop.	ÇKA could use its "**Support for calls for project proposals**" and "**guided project support**" mechanisms to **accelerate research** and **provision of regional hazards and impacts information**. ÇKA should **look to international studies, guidance and best practice** to help build awareness and capacity on resilience within the region. ÇKA should promote **participation in international knowledge exchange activities** ÇKA can **organize dedicated events** to draw upon external knowledge for addressing regional specific CI resilience needs	
	Knowledge of regional and local conditions and natural hazards is often **stronger at regional/ local levels** than it is at national level.	Based on local / regional knowledge of hazards and impacts, ÇKA can **emphasise the need for an all-hazards risk management approach** for CI up to **Ministry of the Interior** (legal risks) and the **Ministry of Development** (planning, implementation and operational risks).	Ministries should **encourage a two-way exchange of knowledge and data** in the drive for CI projects to incorporate an all-hazards risk management approach.

CIRA deliverable	Key messages from the deliverable of relevance to the policy guidance note	Recommendation in the policy guidance note for Çukurova Region	Recommendation in policy guidance note for national government - which are needed to support resilience measures at the regional level
Planning, Infrastructure Investment and Risk Management	The physical (spatial) planning hierarchy in Turkey has the objective to "**ensure guidance in terms of determining investment locations**". Physical plans exist at various spatial scales with varying spatial resolution - from coarse through to fine scale.	Physical (spatial) plans can offer an **effective tool for better integration of risks posed by natural hazards at various levels of planning**. Coarser-scale plans, e.g. Regional Plans and Metropolitan Master Plans are better suited to considering systems-based thinking, accounting for management of interdependencies and cascading impacts. Finer-scale plans such as Urban Master Plans, Urban Implementation Plans and Rural Development Plans can be used to map natural hazards and to zone areas at high risk which may be unsuitable for certain types of development, including CI.	The State should **require that physical (spatial) plans incorporate information on natural hazards** and the implications of natural hazards for planning decisions.
	Environmental Plans are traditionally used to **facilitate decision making on land use and development** that duly considers the natural environment, and to provide an holistic framework to achieve sustainable outcomes.	The sub-regional Environmental Plan offers an **entry point within which to incorporate natural hazard risk assessment and management**, for example, addressing hydrological risks (drought, flood), how they may change in the future due to climate change, and the consequential impacts on energy generation or transport accessibility.	The State should **require that environmental plans incorporate information on natural hazards** and the implications of natural hazards for planning decisions.
	Climate change will **intensify competition for shared resources** such as water, which is vital for energy production and for many other sectors of the economy. The perception I the region at present is that these resources are plentiful.	ÇKA should work with other regional decision-makers to examine **demographic trends and future demand** for infrastructure in the Çukurova Region, and assess the future competition for shared resources such as water in light of climate change projections.	

CIRA deliverable	Key messages from the deliverable of relevance to the policy guidance note	Recommendation in the policy guidance note for Çukurova Region	Recommendation in policy guidance note for national government - which are needed to support resilience measures at the regional level
Risk assessment	CI faces risks from a **wide range of natural hazards** - geological and climatological.	ÇKA should **promote an all-hazards approach** to CI resilience.	The State should **adopt an all-hazards approach** to CI resilience.
	Future changes in both average and extreme climate conditions can lead to **CI damage and downtime**.	ÇKA can work with data providers to **establish a central open-data portal on natural disasters observed in the region and future risk profile**. This should include best available scientific findings on **future climate change parameters** for the region.	The state should **emphasize incorporating data and information on future climate projections for CI design, construction and operating standards, site selection decisions, feasibility studies and EIAs**, to ensure CI assets can provide services effectively and efficiently over their lifetimes.
	Disruption to CI is likely to occur more frequently in the future due to climate change, unless forward-looking risk management measures are implemented	ÇKA can promote **diversification of power generation types and development of more solar and wind energy facilties** as a sound risk management strategy, as other generation types are more exposed to changing climate hazards.	
	Disruption to CI within the region can have **regional, national and transnational impacts**.	ÇKA can work with CI owners and operators to **identify key dependencies and interdependencies** of CI in the region and map how CI assets, system, or network failures could impact other socio-economic systems; **mapping potential cascading effects** from infrastructure disruptions regionally, nationally and transnationally.	The state should **address sector dependencies and inter-dependencies** in the national development agenda so that regional efforts can be guided.
	According to a survey of participants at the 1st CIRA workshop, most participants reported having **'weak' or 'no' technical capacity to understand geophysical and climate risks and prioritise needed actions.**	ÇKA can **organize training workshops** on conducting vulnerability and climate risk assessments for decision-makers in the region. They can guide decision-makers on where to access risk assessment and scenario planning tools and data, to help stakeholders **make risk-informed decisions**.	

A5.1.1 Approaches to improve integration of risk assessment in regional planning, and interactions with central level planning

National-level development planning in Turkey is informed to some extent by policy for disaster risk reduction / management, and, more recently by climate change adaptation policy. In turn, national strategic planning and policy provides clear directions for regional plans. Hence, whereas regional planning benefits highly from localized knowledge of current socio-economic and physical conditions, it often requires a strong platform from national planning objectives in order to be successful. Within this context, integration of natural hazard risk assessment and resilience in national and regional planning processes which influence critical infrastructure can help to ensure the infrastructure will provides its needed services, now and in the future.

Risks faced by critical infrastructure can be amplified or mitigated by a number of external and internal factors (institutional, natural, societal and technological), so attention should also be paid to such factors to enable and promote enhanced resilience. For instance, critical infrastructures should not be assessed in isolation from others as cascading impacts can be underestimated. A “systems” based approach to planning and regulation from national down to regional level should be considered fundamental in ensuring that regions can operate (and recover) successfully not in isolation, but as an integral part of Turkey’s national and transnational economy. Management of risks posed by climate change face some additional complexities compared to geological risks, because they are very diverse, uncertain and evolve with time and context. Hence, planning responses to such risks should also be context-specific, diversified and flexible.

In recent decades, through the MoD, Turkey has embraced a new regional development approach through the promotion of horizontal development and establishment of RDAs. This provides a channel through which national planning objectives can cascade through to the regional/local level. Turkey has also started to build capacity, assess risks, provide information for decision making processes and introduce new regulations and standards to increase resilience of critical infrastructures. Regional and local administrations have also started to undertake new initiatives to assess risks in order to be able to prepare for them.

The physical (spatial) planning hierarchy in Turkey has the objective to “ensure guidance in terms of determining investment locations”. As such, physical plans can offer an effective tool for better integration of risks posed by natural hazards at various levels of planning. Physical plans exist at various spatial scales with varying spatial resolution - from coarse through to fine scale. Coarser-scale plans, e.g. Regional Plans and Metropolitan Master Plans are better suited to considering systems-based thinking, accounting for management of interdependencies and cascading impacts. Finer-scale plans such as Urban Master Plans, Urban Implementation Plans and Rural Development Plans can be used to map natural hazards and to zone areas at high risk which may be unsuitable for certain types of development, including critical infrastructure.

The sub-regional Environmental Plan also offers an entry point within which to incorporate natural hazard risk assessment and management, for example, addressing hydrological risks (drought, flood) which may impact on energy generation or transport accessibility. Environmental Plans are traditionally used to facilitate decision making on land use and development that duly considers the natural environment, and to provide an holistic framework to achieve sustainable outcomes. Hence, they are typically concerned with ensuring that the impact *of* built development (including infrastructure) *on* the environment is managed appropriately to ensure environmental outcomes. However, the interaction between the environment and built development is a ‘two-way street’ – and in a changing climate, the environment can increasingly impact on built development, with climatic events that are changing in frequency and magnitude. This in turn can erode, or exceed safety margins related to asset design, operation and maintenance, putting at risk its successful environmental, economic or social performance. This concept of the ‘two-way street’ is increasingly recognized in environment plans in other jurisdictions.

In the Turkey context, apart from the national efforts, municipalities and private sector actors have been focusing on developing localized climate change strategies and action plans. The progress is significant but yet limited as there are few studies/initiatives on vulnerability and resilience to climate related risks. This gap also applies to critical infrastructure risk assessment and resilience studies as the concept is relatively new subject to governmental and non-governmental actors in Turkey. A number of studies with terrorist and cyberattack aspects have been conducted on certain infrastructures that have national and international energy security focus (such as pipelines)[423] but there are fewer climate related studies. One example of such a study is climate change impacts on certain state owned thermal power plants which are considered strategic in terms of their operational size[424].

As part of the 1st CIRA Risk Assessment Workshop conducted for this project (January 2017), participants undertook a Strengths, Weaknesses and Opportunities (SWOT) assessment of the region's current ability to achieve resilience in the energy and transport & logistics sectors. The analysis suggested that the participants considered a lack of planning, particularly in the transport sector, as a weakness. They also considered clear and robust climate change and disaster risk policy & governance, cascading from national to regional government as being important in risk management. The participants also indicated that generally low levels of awareness about climate change related risks also contribute to the weaknesses of the region. They recognized licensing and permitting as an important factor. However, participants rated the recently updated earthquake regulations as a strength, implying that national regulations have an important part to play in the more localized management of risks. Although workshop participants identified a moderate level of awareness amongst institutions of information related to adapting to natural hazards, the overall technical capacity and expertise to act was considered lacking. Better access to finance to help organizations prepare was ranked by participants as an important enabler.

RDAs in Turkey are ultimately accountable to the Ministry of the Interior for legal issues and the Ministry of Development for planning and implementation issues. They can therefore drive a bottom up approach for risk management requirements from a regional scale up towards national scales. Within RDAs themselves, the typical governance structure (see Section 6.2.1.1) also provides entry points for driving CI risk management within a region. For example, the legal & compliance, planning, programming and monitoring and evaluation units can all encourage the inclusion of multi-hazard risk assessment and management in CI projects.

"Support for calls for project proposals" and "controlled project support" (see Section 6.2.1.1: Figure 6-8) are also two mechanisms by which research and availability of regional information on natural hazards can be driven forward to assist those stakeholders who are contributing to regional development objectives. These ties heavily back to the need for information availability which is tailored to be relevant to sectors and the spatial and time scales relevant for infrastructure planning and asset lifetimes. ÇKA, through its knowledge reports and information portal could also look to international studies, guidance and best practice to help drive awareness raising on resilience within the region. This could in turn act as a knowledge support model for other RDAs to adopt.

A5.1.2 Approaches to improve integration of risk assessment in infrastructure investment, and interactions with regional level planning

In general, based on the information provided by stakeholders through consultations undertaken for this project, Çukurova Region can be considered to be relatively resilient as the region's economy is diversified, and business stakeholders' adaptive capacity to external factors is high where they can easily move from one sector (e.g. agriculture) to another (e.g. construction) depending on economic conditions. The region has many favorable features and advantages such as its relatively mild climatic conditions, its proximity to logistics hubs and connections, etc. and there are strong institutions that have deep roots in the region. For instance, Adana Chamber of Commerce, an institution that is one of the oldest Chamber of Commerce and Industry in Turkey, was founded in 1894; Mersin piers and port have been active since the launch of the Adana-Mersin railway in 1886. The region is increasingly a center of attraction both due to external and internal dynamics such as population and business influx from other regions due to ongoing geopolitical crises, its relative cost effectiveness when compared to other metropolitan regions such as Marmara, and high level political priorities assigning a logistics and energy hub role for the region. Macroeconomic indicators underline that the region has not yet reached its full potential and it can create more added value, jobs, and prosperity. There is strong stakeholder will to achieve this and local players put much emphasis on increasing competitiveness and exports. Although stakeholders may not have any particular awareness on the concept of critical infrastructure, they are aware of the essential services these physical assets provide and interlinkages through to the wider physical and socio-economical infrastructures of which they are an integral part.

Based on stakeholder consultations conducted for this project, it is concluded that stakeholders strongly believe in the importance of continuity and reliability of essential services provided by critical infrastructure, such as electricity and logistical accessibility. They are also aware of particular risks and due to awareness and legislations, they have plans for mitigating and managing risks such as seismic or industrial hazards. Stakeholders are aware of meteorological risks to a certain extent but participants at the 1st CIRA Risk Assessment Workshop indicated a lack of technical capacity and available information to address longer term climate change risks (and also opportunities).

Many of the stakeholders interviewed in this project underlined that risk perceptions in the region could be re-shaped by prominent and influential actors. From a socio-cultural perspective, this approach is expressed as the best solution. Investment decisions are influenced by different motivations and factors, but longer-term climate related risks that could jeopardize investment decisions remain largely unaccounted for. There is little evidence that climate risks are being explicitly considered in critical infrastructure projects financed/commissioned either by the public or the private sectors. To better understand the decision-making dynamics, the 21 national and regional stakeholders who were interviewed for the CIRA were mapped to show the actor composition and information exchanges (Figure A5-1).

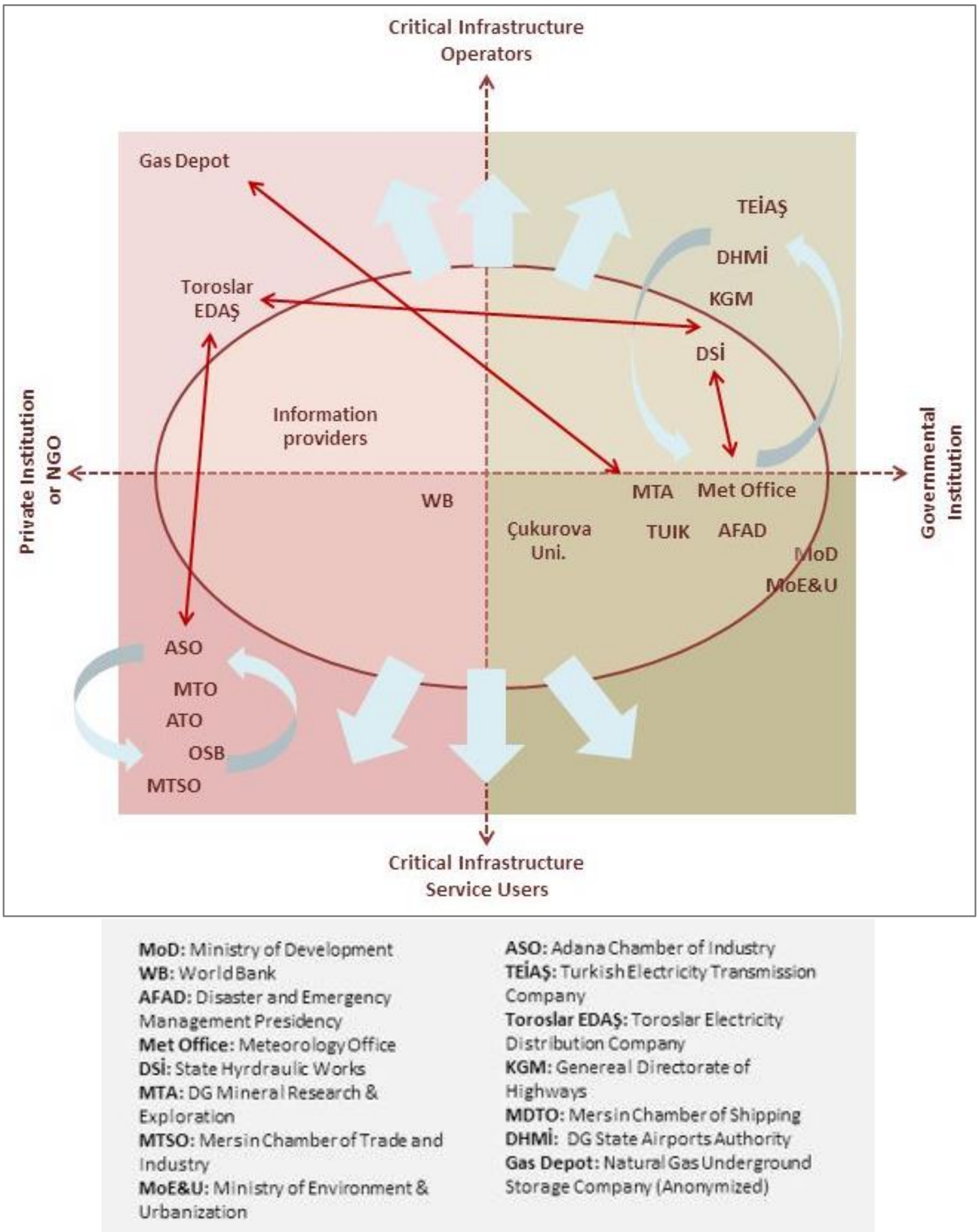


Figure A5-1: Stakeholders interviewed in Çukurova Region for this project and their roles with respect to each other. (Source: Report authors).

There are number of bottlenecks noted, some of which can be addressed at the regional level whereas some can only be addressed at the national level. Climate risk experience and expertise in the context of critical infrastructures is low at the Çukurova Region level and capacity building activities would provide added value and facilitate new collaborations among stakeholders. Current legislations and regulations do not particularly encourage existing operators or developers of new critical infrastructure to undertake a detailed multi-hazard assessment that includes a changing climate.

Climate resilience is becoming increasingly mainstreamed in country policies such as spatial planning, technical and economic regulations which influence critical infrastructure operations. Despite there being a national climate change adaptation plan and strategy, in Turkey there is no requirement for infrastructure operators to assess and implement adaptation action plans. Turkey's existing regulations could be revised from this perspective. Public policy and regulations provide relevant levers to support governmental and private stakeholders to integrate climate resilience in critical infrastructure planning and management. Furthermore, in Turkey, there is currently no perceived interest by the government and the financial sector in disclosure of climate risk. This is not surprising as progress in this area is at an early stage in many parts of the world, but progress in other countries, especially Turkey's key trading partners, should be closely monitored at the national and regional levels within Turkey.

There is no systematic data generation and research on climate change at the regional or local level, which is a barrier to evaluating impacts on specific sectors and infrastructure systems or assets. These are important areas to focus on, as without a scientific basis and data, climate risk and vulnerability assessments cannot be undertaken in an informed manner. At the national level, there are ongoing research and projects, but there is a need for models, projections and scenarios at the region level and sectoral level. As the planning and budgeting process is highly centralized, the influence of local actors such as the RDAs remains limited. There is a limited knowledge on the best practices and working practice about incorporating climate resilience into infrastructure design. Entry points to address these gaps include:

- supporting localized data and research efforts in the region and turning to the state Met Office for assistance;
- enhancing capacity on climate risk assessment and resilience, and promoting tools and methods among stakeholders;
- promoting integration of climate risk assessments into project feasibility studies and environmental impact assessments;
- providing feedback and evidence to central governmental institutions on the importance, relevance of climate resilience in critical infrastructures as well as on the costs of not adapting or maladapting[425] to climate change.

Considering ÇKA's intermediary position at the regional level and the limited level of influence of regional administrations generally in Turkey, the institution could create most added value if it focuses on its facilitating role. As ÇKA involves most of the stakeholders in the region in its governance structure, it can bring different actors to the same table to increase awareness on the concept of critical infrastructure and climate resilience. In addition, ÇKA could mobilize some of its financial incentives to encourage new project and research ideas tailored to the region's context. ÇKA could also trigger formation of new networks focusing on the relationship between climate change, infrastructure, the local economy and competitiveness and/or related topics. By setting up a regional level "climate change research and coordination steering committee" consisting of actors ÇKA already works with (such as academia, chambers, municipalities etc.) the region could accelerate capacity building in the region. Such a catalyzing structure would be a first of its kind in Turkey and can lead others by example. In the light of comments collected during the interviews, these efforts could address the lack of dialogue and data gaps.

Figure A 4-5 (Annex A4.6) presents the main stages in energy infrastructure investment, provincial administrations are involved at the early Project Development stage, as well as bodies such as BOTAŞ and DSI who themselves have regional directorates. This early interaction between regional and national / state bodies provides an entry point at which the need for multi-hazard risk assessments which include climate change should be considered by the investment project. A resilience requirement at this early stage would filter through to other project stages such as licensing and permissions & approval, effectively working the issue up the decision chain to project approval where national governing / regulatory bodies are heavily involved.

For infrastructure investments in Turkey, a risk assessment element is a part of all Environmental Impact Assessment and project Feasibility Studies. But despite meteorological and seismic hazards being considered in detail, risks from a changing climate are usually not addressed. ÇKA's 2016 work plan envisages developing an understanding on the issue of climate change risks at the regional level through this project. Being the first of its kind in Turkey, it can be used to inform other sectors, actors and stakeholders about the need for, and approach to, this important topic.

It is also prudent to encourage the incorporation of a changing risk landscape in PPP / BOT legislation and contracts. Conventionally, PPP contracts are a method for driving private sector investment into projects which deliver wider socio-economic benefits, allocating specific risks to be borne by either party. One example is Force Majeure risk which is commonly borne by the public sector. The baseline and return periods against which weather related Force Majeure risks are being assessed is changing, and extreme events that were once considered infrequent but acceptable within business models, may in the future become more frequent and increasingly unacceptable[426]. This places public sector partners increasingly at risk of bearing the consequences of downtime or outright failure unless trends in, and future projections of, changes in frequency and magnitude of extreme weather-related events are better understood and considered by project designers and operators. This also ties into consequences for environmental protection whereby EIAs should incorporate consideration of a non-stationary climatic baseline.

ÇKA could also focus on the motivations and dynamics of the region's very own actors which seem in line with high level policies and projections for the region: striving to be a logistics and energy hub, competitive regional economic power, increased exports and prosperity. ÇKA can promote climate resilience as an enabling factor to achieve these aims, and make climate resilience a part of its agenda. There are a number of approaches to incorporating climate resilience into infrastructure which have been developed in other jurisdictions. A simple framework (such as that shown in Figure A5-2) can be promoted by ÇKA and case studies can be produced in cooperation with critical infrastructure operators. Such studies would allow others to make the connection between concepts, methods and practical examples for resilience-building.

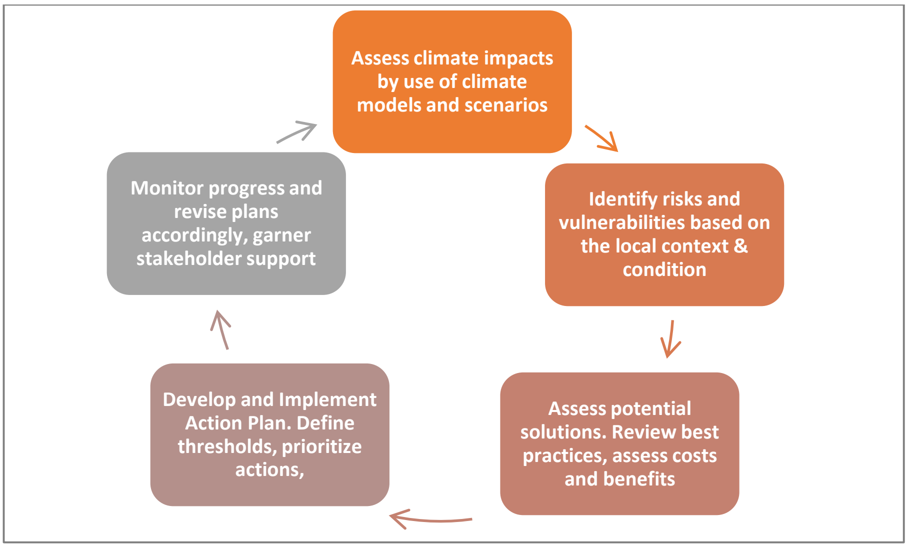


Figure A5-2: A 5 step approach to climate resilience. (Source: Report authors).

A5.2 Selected international best practice cases on CI resilience

A5.2.1 Rockefeller 100 Resilient Cities Initiative, Mexico City (Mexico)

Mexico City 100 Resilient City[427] is part of the 100 Resilient Cities (100RC) Project which is funded by the Rockefeller Foundation, with the aim of developing a comprehensive ***"Resilience Strategy"***. This strategy was recently launched in autumn 2016 and attracted considerable attention from the planning perspective.

In the last few years, Mexico City has started exploring new ways to increase resilience. The government has implemented strategies, programs and projects to address resilience issues in various sectors. These actions provided a basis for implementing comprehensive risk management, improved development planning, and institutional responses to climate change as priorities and contributed to building and improving resilience.

The strategy development process was a participatory process that consulted with stakeholders in public and private sectors, NGOs, and the scientific community in order to include various perspectives, priorities, and information sources. This process enabled multi-stakeholder exchange of local knowledge and facilitated the identification of resilience priorities. Further information about the individual steps of the methodology is illustrated in Figure A 5-.

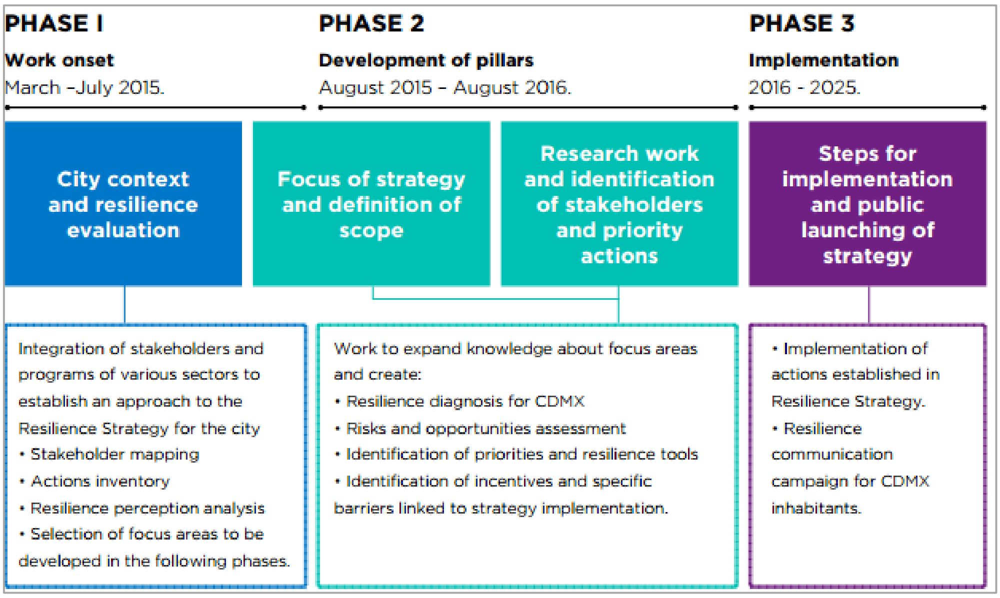


Figure A 5-3: Mexico City resilient strategy development phases. (Source: CDMX, 2016[428])

Before starting the implementation phase, a SWOT-type analysis was carried out to identify weaknesses, opportunities, the relationship between shocks and stresses, and required actions. From this process, five relevant pillars were determined. **Most pertinent to the CIRA Project is the pillar addressing how to foster regional coordination.**

Box A5-1: Mexico City Resilience Strategy Pillar 01. Foster Regional Coordination

*"**Goal 1.1. Create resilience through institutional coordination and regional strategic communication***

***Action 1.1.1.** Foster resilience integration in regional programs: Integrating resilience into regional programs allows for priority issues to be addressed in a way that strengthens projects and policies. By considering resilience principles from a regional view, this action would strengthen state capacities for risk prevention.*

***Action 1.1.2**. Drive and support the creation of a national resilience agenda with Mexican cities belonging to 100RC Network: The creation of a national resilience agenda would allow for consideration of resilience principles in sectoral plans. This approach would favor comprehensive planning in the long term.*

Goal 1.2. Drive and support regional projects that contribute to resilience

[...]"

The development and implementation of the Resilience Strategy was driven by a newly established Resilience Steering Committee. The ***"Resilience Steering Committee"*** is made up of different sector representatives who have contributed to the development of the Resilience Strategy with review and validation of documents, activities, and strategy design (see detailed structure in Figure A 5-). One of the innovative approaches in that project is providing support to hire a ***"Chief Resilience Officer (CRO)"***. The CRO is a high-level advisor who leads the steering committee and reports to the mayor of the city. The person's expected role is to establish a compelling resilience vision for the city to maximize innovation and minimize the impact of unexpected events. The CRO has the responsibility of working across local government organizations and the sectors of society so that key decision-makers connect important strands of work. **This established structure can serve as a model for the CIRA Project.**

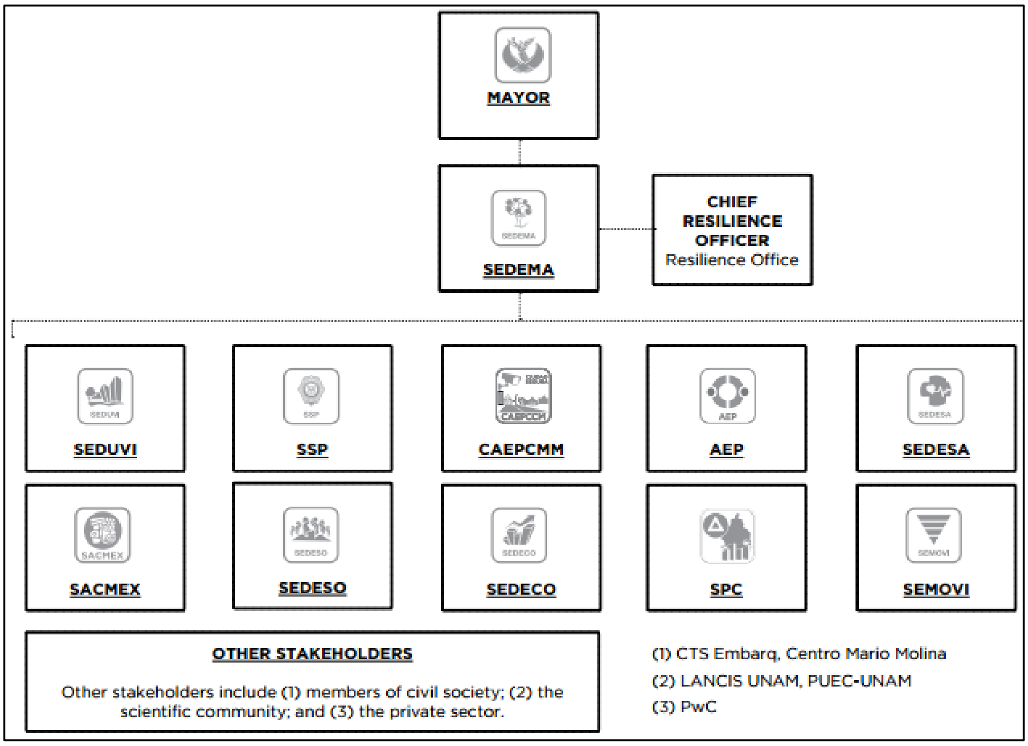


Figure A 5-4: Structure of the resilience steering committee for Mexico City's Resilience Strategy. (Source: CDMX, 2016[429])

A5.2.2 Resilience of New York State's Infrastructure, NYS 2100 COMMISSION, (United States)

After recent severe weather events (Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee) NY State government established three commissions through an executive order of the governor to help prepare NY State for future extreme weather events. One of these commissions, the New York State 2100 Commission (NYS 2100 Commission), was tasked to examine and evaluate key vulnerabilities in the State's CI systems, and to recommend actions that should be taken to improve their resilience[430]. Following this evaluation, the Commission developed specific recommendations for implementation in five main areas: transportation, energy, land use, insurance, and infrastructure finance. The following box illustrates those recommendations:

Box A5-2: NYS2100 Resilience Recommendations

"The strategies are aimed to:

- *Identify immediate actions that should be taken to mitigate or strengthen existing infrastructure systems – some of which suffered damage in the recent storms – to improve normal functioning and to withstand extreme weather more effectively in the future;*
- *Identify infrastructure projects that would, if realized over a longer term, help to bring not only greater climate resilience but also other significant economic and quality of life benefits to New York State's communities;*
- *Assess long-term options for the use of "hard" barriers and natural systems to protect coastal communities;*
- *Create opportunities to integrate resilience planning, protection and development approaches into New York's economic development decisions and strategies; and*

- *Shape reforms in the area of investment, insurance and risk management related to natural disasters and other emergencies."*

Additionally, the Commission identified nine further crosscutting recommendations. These include steps to improve the State's infrastructures, institutions, and information systems. Both day-to-day functioning of critical systems and efficiency of normal operations are thereby enhanced, thus doubling the benefit of the recommended investments. The following selection and summary illustrated in Box A5-3 is considered most relevant in the strategy development context of the CIRA Project.

Box A5-3: NYS2100 Crosscutting Recommendations Relevant for the CIRA Project

- *"Promote integrated planning across agencies and authorities and develop criteria aligned with relevant and practical resilience assessments for integrated decision-making for capital investments*
- *Enhance institutional coordination with the creation of a new Chief Risk Officer or unit to coordinate all the stakeholders and activities.*
- *Create new incentive programs to encourage resilient development and reduce vulnerabilities including longer-term smart growth strategies. In that context the Commission recommends programs designed to expand green storm-water infrastructure; promote energy efficiency and alternative fuels; and reinforce or mitigate vulnerable assets, equipment, or buildings, or homes.*
- *Expand education, job training and workforce development opportunities to ensure the availability of skilled professionals in critical resilience building activities."*

The NYS 2100 Commission efforts also include sector-specific considerations. The following box presents the transport and energy sectors as examples:

Box A5-4: NYS2100 Sector-specific recommendations

"Transportation sector:
Develop a risk assessment of the State's transportation infrastructure
Strengthen existing transportation networks
Strategically expand transportation networks in order to create redundancies
Build for a resilient future with enhanced guidelines, standards, policies, and procedures
Energy sector:
Strengthen critical energy infrastructure:
Accelerate the modernization of the electrical system and improve flexibility
Design rate structures and create incentives to encourage distributed generation and smart grid investments
Develop long-term career training and a skilled energy workforce"

There were also efforts on strategy and legislation development in response to extreme weather events to build the region in a more resilient way against the risks posed by climate change (Hurricane Sandy Rebuilding Task Force, 2013). In addition to the recommendations presented in Box A5-2, Box A5-3 and Box A5-4, **one of the notable proposed strategies on "building local governments' capacity for long term resilience planning" could be beneficial for Çukurova Region considering the importance of the regional resilience building efforts. Another related recommendation could be on "facilitating the development of infrastructure resilience performance standards via a participatory approach with all relevant stakeholders and using those standards for infrastructure investments for the affected region and furthermore considering applying nation-wide".** The Rebuild by Design competition was also part of this task and attracted world-wide attention.

A5.2.3 Addressing Critical Infrastructure Protection in Austria

The developments of the European Commission on establishing a European Program for Critical Infrastructure Protection (EPCIP) in 2006 led Austria to work on national adoption of the program. A first master plan was presented in 2008, introducing the Austrian Program for Critical Infrastructure Protection

(APCIP) concept. There is clear emphasis in this program that natural hazards and in particular changing climatic conditions as well as cyber security, criminality and terrorism are threatening the continued functionality of infrastructures. Protecting the most critical infrastructures is therefore of increasing importance, and an all-hazards approach needs to be implemented. It is acknowledged that CI protection can only be successful in trust-based public private partnership cooperation between central government authorities and CI owners and operators.

Anchored in the Austrian Security Strategy framework, protection of CI under APCIP is considered an important contribution to the country's holistic approach to increasing resilience. In 2014, a revised master plan was presented, documenting already completed work and improving the conceptual framework based on new knowledge. This includes, e.g., the setup of a national technical information sharing platform CIWIN-AT, building on the European CIWIN (Critical Infrastructure Warning and Information Network) portal.

In the CIRA project context it is particularly relevant that the Austrian central government empowers its provinces, i.e. the regional level, to develop their own adaptations to the overarching APCIP plan. This specifically acknowledges the importance of regional knowledge and varying prioritization across the hierarchical levels. State and provincial authorities regularly exchange experiences in joint workshops which ensures the complementarity of APCIP and the provincial adoptions thereof. Furthermore, frequent training exercises are organized to support coordination between all relevant stakeholders. The state supports regional programs in implementation of actions, distributing available resources according to levels of risk.

International collaboration activities are encouraged due to the transnational character of many CIs, which puts emphasis on the importance of international networks. Austria is promoting its national and sub-national/regional experiences to the European level in order to contribute to improvement of the EPCIP[431].

A5.2.4 Climate Risk Management Study for the Port of Manzanillo (Mexico)

The Port of Manzanillo, Mexico, is one of the main containerised cargo ports in the world. Nationally, it is the main port for the management of containerised cargo, accounting for 60% of this type of cargo on the Mexican Pacific coast and 46% of all the containerised cargo in the country.

Recognising the potential significance of climate change to ports, a Technical Cooperation was established between the Inter-American Development Bank (IDB) and the Administracion Portuaria Integral de Manzanillo S.A. de C.V. (API Manzanillo) to promote sustainability practices at the port (IDB, 2015). The study involved a comprehensive climate risk assessment evaluating the port's entire value chain and the development of an adaptation plan. Where possible, financial analysis was undertaken of current and future climate-related risks and opportunities. Risks with the highest financial impacts for the port were identified as:

- Increased surface water flooding of the port entrance/access road, where the likelihood of flooding events was estimated to almost double by 2050,
- Increased sedimentation of the port basin, leading to increased costs for maintenance of drains and dredging,
- Impacts of climate change on the global economy, and the economies of the port's main trading partner countries, which could affect trade through the port.

Various adaptation measures to address these risks were appraised using cost-effectiveness analysis. Detailed financial analysis was undertaken for upgrades to the drainage system (installation of sediment traps and increasing drain capacity), to manage increasing surface water flood risk and sedimentation. The analysis found that the drainage system investments are financially worthwhile.

The Port of Manzanillo became a pioneer, as this is the first climate risk management study performed on a full port in Latin America and the Caribbean.

Most relevant for the CIRA project are the steps of **risk assessment accounting for changing climate conditions**, followed by **adaptation plans** and proposed **financial instruments** to address these risks. This example refers to the detailed analysis of one particular critical asset, which could indicate the necessary next step following the current system-wide analyses in CIRA.

A5.2.5 Goods Movement Plan in New York and New Jersey (United States)

Each year, port and airport facilities in the New York metropolitan area move more freight than any other metropolitan region in the country to, from and through the region. Ports move 3.4 million cargo containers annually, and the area's five airports handle more than 2.1 million tons of cargo. At the same time, the nation's largest consumer market and many businesses depend on goods carried via densely-trafficked regional roadways and railways that must accommodate expanding demands. The movement of freight often lacks a comprehensive approach. It is simply assumed that goods and commodities will be available when and where they are needed. Following Super storm Sandy, ports in the New York metropolitan area suffered heavy damage. Facilities were inundated with salt water; cargo containers toppled from stacks; access roads and rail track were washed out; and barges and debris were tossed about, damaging piers. Less visible, but perhaps more serious, was damage to the ports' electrical infrastructure. The storm shut down the freight network, and disrupted the region's supply chain for weeks. What happened to New York-area ports affected the nation.

To plan for more efficient and resilient freight movements, The Port Authority of New York and New Jersey, The New York State Department of Transportation, and the New Jersey Department of Transportation completed a comprehensive Goods Movement Plan. The plan includes a system-wide assessment of supply chain needs and current deficiencies for improving reliability and redundancy. The plan takes a phased approach with early-action operational and regulatory initiatives and major infrastructure investments over a 20-year span. Capital investments are both corridor-based (e.g., Interstate-95) and functional (e.g., innovative technologies), advancing a unified, regional approach to improve freight reliability and attract both Federal aid and private investment[432] [433]. **This practical example could be a useful tool for transportation planning to increase resilience of Çukurova Region's critical assets and serve as a guidance for establishment of PPPs.**

A5.2.6 The UK Government Policy on Climate Resilient Infrastructure

In the UK, a broad range of stakeholders from government, industry, and regulators are involved in climate risk assessment and resilience planning for infrastructure. The "Government Vision and Action Plan for a Climate-Resilient Infrastructure" outlines the main aspects relevant for the transport, energy, water and Information and Communications Technology sectors. This action plan promotes linkages between the UK National Adaptation Programme and ongoing efforts to improve CI resilience to current natural hazard conditions, including the CI Resilience Programme and Sector Resilience Plans (SRPs)[434]. It is thereby defined that government can help facilitate progress through:

- access to climate information, disclosure of risk and evidence;
- improving understanding of the risk of cascade failures;
- monitoring progress on adaptation of infrastructure;
- embedding climate risks and resilience in regulatory frameworks;
- the planning system for nationally significant infrastructure.

The UK government requires its respective departments to produce annual SRPs, evaluating CI resilience of the most important infrastructure assets to the relevant risks identified in the National Risk Assessment. Following the Government policy on infrastructure adaptation, the National Adaptation Programme contains policy objectives and specific actions on infrastructure resilience. It describes actions for the Government, industry and regulators that can be broadly categorized as:

- infrastructure operators to implement the actions set out in their reports under the Adaptation Reporting Power;
- lead departments to factor in climate change when developing or implementing policy;
- encouraging coordination and joint working;
- continuing existing resilience-building initiatives and research programs; and
- setting out new research to inform infrastructure resilience.

This practice can serve as an example for CIRA in the following domains: embedding climate risk and resilience in the policy framework; promoting better risk understanding; a functioning role distribution among stakeholders; and monitoring and evaluating progress in adapting to climate change.

A5.2.7 CLIMADAPT - Climate Resilience Financing Facility (Tajikistan)

The Tajikistan Climate Resilience Financing Facility, CLIMADAPT, is developed by the European Bank for Reconstruction and Development (EBRD) under the Climate Investment Funds' (CIF) Pilot Program on Climate Resilience (PPCR). It is dedicated to **investments in improved climate resilience technologies** to help make the Tajik private sector more resilient to current and projected effects of climate change. **CLIMADAPT will provide loans** up to US$ 10 million **through local partner financial institutions** (Bank Eskhata, Humo MFI and IMON International) for investments in climate change resilience.

CLIMADAPT offers **climate resilience assessments which support clients in recognising climate risks and finding appropriate technical solutions**. Since financing climate resilience technologies is new to local financial institutions, CLIMADAPT will support partner financial institutions adding this activity to their banking operations. This specific support on technical assistance is funded by UK's Department for International Development (DFID) and the EBRD's Early Transition Fund.

This case provides an example of **financing climate resilience operations through a partnership of national and international financing institutions**. Additionally it **combines financing with appropriate technical assistance**.

A5.2.8 Mitigating the Impact of Drought on Energy Production and Fiscal Risk (Uruguay)

Uruguay's electricity need is mainly met by hydropower. During periods of drought, when rainfall is scarce, hydroelectric generation falls short of demand. When there is a shortage in energy generation, the state-owned electricity company, Administración Nacional de Usinas y Trasmisiones Eléctricas (UTE) needs to purchase alternative fuels (such as oil and natural gas) that increase the cost of electricity generation significantly (particularly due to high oil prices at the time of study). This high cost impacts the fiscal position of the Government of Uruguay in terms of increased fiscal deficit.

The Government of Uruguay established a **comprehensive risk management strategy** to reduce the impact of drought on government and electricity utility finances. Along with **adopting policies to diversify the energy matrix**, a **financial risk management strategy** was also set up. As part of this strategy, an **energy stabilization fund**, Fondo de Estabilización Energética (FEE), was created in 2010.

In 2012, during a severe drought event, UTE had to purchase other sources of energy due to lack of water. The cost of supplying demand for electricity exceeded the initial estimations. To cover the gap, UTE borrowed funds from the market and withdrew $150 million from FEE and ultimately increased consumer utility rates. To manage the financial risk to low rainfall and high oil prices, the Government of Uruguay asked for technical support of the World Bank. The World Bank executed a $450 million **insurance transaction (coverage) to the FEE with technical support for UTE against combined risk of drought and high oil prices**. This transaction provided **cost certainty to the energy company, budget stability to the government, and price stability to consumers**. This program created an important fiscal buffer which allowed management of risk in a proactive way. The Bank acted as UTE's counterpart for the transaction, offsetting its risk with the re-insurance companies Allianz and Swiss Re. UTE paid a premium up-front (WB, 2014).

This case can serve as an example for **securing stable-cost operations for a public utility company via financial risk management** where the World Bank serves as insurance facilitator to the national government.

A5.2.9 Assessing adaptation challenges and increasing resilience at Heathrow Airport (UK)

In 2011, Heathrow Airport Limited (HAL) was asked by the UK government to prepare a climate change adaptation report and update it every five years. Based on the Climate Change Adaptation Act (2008), the government has the power to request adaptation reports from the facilities which are identified as being of particular importance in adapting the UK to the changing climate. Heathrow Airport is considered as a priority reporting authority. The report involved a comprehensive risk assessment of climate related risks to the direct and indirect operations of Heathrow. The approach adopted incorporated climate modelling, literature review, and concerted consultation with HAL external partners. Eventually it provided priority adaptation solutions for the identified areas to increase resilience[435].

This practice shows a good example for necessary climate change adaptations over time in response to the changing nature of climate induced events. It could provide an important input for establishing the climate change legal framework.

A5.2.10 Sea-level Rise at Lake Macquarie City Council (Australia)

Because of the growing concern among many Australian local governments regarding the evidence of sea-level rise together with the lack of a clear policy framework, the Lake Macquarie Council undertook a risk assessment to identify the potential risks from sea-level rise (and other climate change related risks).

The council adopted one of Australia's first sea-level rise preparedness and adaptation policies in 2008 and incorporated sea-level rise considerations into planning decisions, such as placing restrictions on new development areas, and increasing requirements for floor levels and other structural adaptations in existing development areas. The Lake Macquarie City Council was then identified by the National Climate Change Adaptation Research Facility as an adaptation champion[436]. **This practice presents a good example in terms of adopting policies and implementing adaptations as a risk mitigation activity by local authorities.**

A5.2.11 Managing CI Risks in Victoria (Australia)

CI protection arrangements in the Australian state of Victoria have until now only being addressed under the 2003 Terrorism Community Protection Act. A recent review recommends that Victoria's CI resilience strategy needs to be extended to include all risks and also non-legislative mechanisms to manage these risks. It suggests to guide and monitor performance of government and industry stakeholders more effectively in order to be better prepared for the future.

A new dedicated strategy for CI Resilience is now being developed to extend the CI framework arrangement. First, a roadmap will outline the vision and reform proposals. Releasing the roadmap before a new legal strategy will provide stakeholders direction and allow time for the presented reforms to take effect. The roadmap and strategy will retain strengths of the current arrangement and complement it with actions for more comprehensive and forward-looking resilience. Key features of the newly proposed arrangements in the roadmap are:

- a move to an all-hazards resilience model while recognising the ongoing importance of managing tism risks
- providing a new definition for Victorian CI and a consistent and transparent method of assessing the value and criticality of individual assets
- more flexible partnerships between government and private sector
- clearer roles and responsibilities for all sectors
- adopting a risk-based approach to CI resilience in legislation, and
- a robust performance measurement and assurance framework.

Victoria's new approach to CI risk management is part of a nation-wide commitment to the issue. The new strategy therefore needs to be in line with national arrangements such as the 2011 CI Resilience Strategy policy and other regional efforts, e.g. regarding the involvement of the private sector. There should be a joint approach across the various scales of government authorities to develop consistency, cooperation and shared goals for CI resilience[437].

The Victorian CI resilience practice could serve as a planning guideline for the CIRA Project.

A5.2.12 Planning for Sea-level Rise in California (United States)

The California Department of Transportation formally guides its staff on how to incorporate consideration of the risks of sea-level rise when planning and developing transportation projects. Staff are directed to consider the project's design life; the availability of alternative routes; criticality of the route; the amount of investment; the added cost of incorporating adaptations to sea-level rise; and environmental constraints. Projects have to be evaluated considering interim sea-level rise projections as adopted by the state Ocean Protection Council in 2011[438].

Similar guidelines considering region specific risks could be developed for the energy and transportation infrastructure investment projects in the Çukurova Region in collaboration with local relevant authorities.

A5.2.13 Building Capacity for Adaptation and Interdepartmental Collaboration in North-Rhine Westphalia (Germany)

Small municipalities in North-Rhine Westphalia in Germany have limited resources and expertise for climate change adaptation. In response, training for municipal employees, along with private sector representatives and environmental science students, was organized by a local network of municipalities in cooperation with the Training Centre on Utilities and Waste Management. The main purpose was to enhance competence in climate change adaptation and facilitate interdepartmental exchange within and across municipalities. As a consequence of the training, participants were able to exchange ideas on their daily adaptation work and to build a peer network across departments and municipalities. Later on, key outcomes were highlighted at the International Resilient Cities Congress, including an example of how the lessons learned were applied to improve urban planning considering climate change in the City of Datteln[439].

This case could serve as an example for the CIRA Project on awareness raising and institutional capacity building through local level collaboration.

A6 Risk management options and strategies - further information

A6.1 Overview of risk management frameworks

The UK's Cabinet Office is charged with developing a cross-sector resilience-building program, working across government departments and other public and private sector bodies to define and deliver shared goals. The Cabinet Office's Sector Security and Resilience Plans set out the resilience of "critical sectors" to risks identified in the UK's National Risk Assessment. Critical sectors include energy (electricity, oil and gas) and transport (ports, roads, rail and aviation).

In their 2016 summary document[440], the Cabinet Office defines infrastructure resilience as being "the ability of assets and networks to anticipate, absorb, adapt to and recover from disruption". Resilience is described as a combination of four principal components" shown in Figure A 6-1.

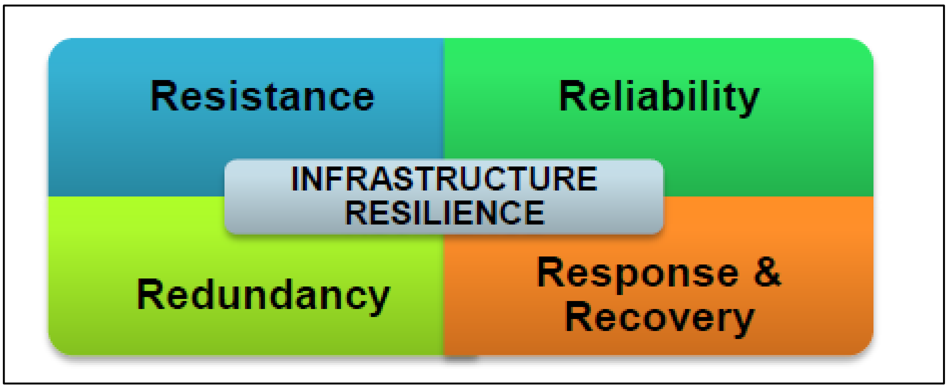


Figure A 6-1: The components of infrastructure resilience. (Source: Cabinet Office, 2016[441]).

The principal components of resilience are defined as:

- **Resistance**: direct physical protection, e.g. the erection of flood defenses
- **Reliability**: capability of infrastructure to maintain operations under a range of conditions, e.g. electrical cabling can operate in extremes of heat and cold
- **Redundancy**: adaptability of an asset or network, e.g. the installation of back–up data centers
- **Response and Recovery**: organization's ability to respond to, and recover, from disruption.

A similar framework has also been suggested by the UK's Construction Industry Research and Information Association, CIRIA, for critical infrastructure flood resilience and resistance[442]. The framework recognizes that numerous techniques can be used to manage a flood hazard and presents these in a flood risk management (FRM) hierarchy, shown in Figure A 6-2.

FRM measure	Example
Assess	Flood risk assessment for a network of inter-connected CI systems commissioned by a partnership of asset owners and undertaken as an extension to a strategic flood risk assessment undertaken for a local authority
Avoid	Ensure that the critical components of the asset system are not unacceptably exposed to the flood hazard by removing them from areas that are likely to flood
Substitute	Where facilities are found to be at unacceptable risk, ensure that the essential services they provide can be substituted with alternatives during the period of disruption
Control	Adopt structural measures to make the asset flood resistant or flood resilient using temporary, demountable or permanent flood defences
Mitigate	Adopt measures, such as flood forecasting, warning, incident management and emergency response procedures and business continuity plans, to mitigate residual risks

Figure A 6-2: Flood risk management hierarchy. (Source: CIRIA, 2010[443]).

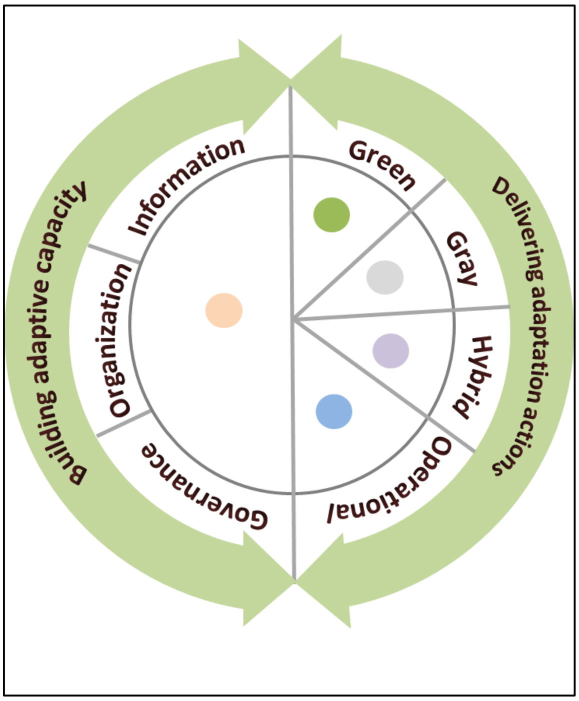
The components of Cabinet Office framework can be mapped to CIRIA's hierarchical FRM resilience components as shown in Table A 6-1.

Table A 6-1. Mapping of CIRIA to Cabinet Office resilience framework components. (Source: Report authors).

Framework source	
CIRIA	Cabinet Office
Avoid	Reliability
Substitute	Redundancy
Control	Resistance
Mitigate	Response and recovery

A related framework approach was adopted in a climate risk management study for a port in Latin America[444]. The framework was organized around the following primary and secondary components (see Figure A 6-3):

- **Building adaptive capacity**, with the following non-structural components:
    - Information actions
    - Organization actions
    - Governance
- **Delivering adaptation actions**, with the following structural and non-structural components:
    - Green measures
    - Gray measures
    - Hybrid (green and gray) measures
    - Operational measures



Categories of non-structural measures which 'build adaptive capacity':

- Informational actions: Data collection, research, monitoring and awareness raising
- Organizational actions: Assigning responsibilities for risk management, working in partnership
- Governance: Policy, regulations, standards and codes, and their enforcement.

Categories of actions which 'deliver adaptation actions':

- Gray measures: engineered/hard structural solutions, e.g. making structures more resistant to earthquake
- Green measures: ecosystem-based adaptation, e.g. sustainable drainage systems
- Hybrid: a combination of green and gray measures
- Operational: (non-structural) changes in processes and procedures.

Figure A 6-3: Types of climate change adaptation measures for a port study. (Source: IDB, 2016[445]).

A6.2 Prototypical energy assets

This section defines prototypical energy assets for the following types of CI:

- Hydropower plants,
- Thermal power plants,
- Oil pipelines.

Hydropower plants

Figure A 6-4 presents a prototypical impoundment HPP which relies on dammed storage of river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level. A High-Voltage substation then increases the voltage and delivers the power to the grid. The key components comprise of:

- dam,
- turbine and generator,
- high voltage substation and transmission lines.

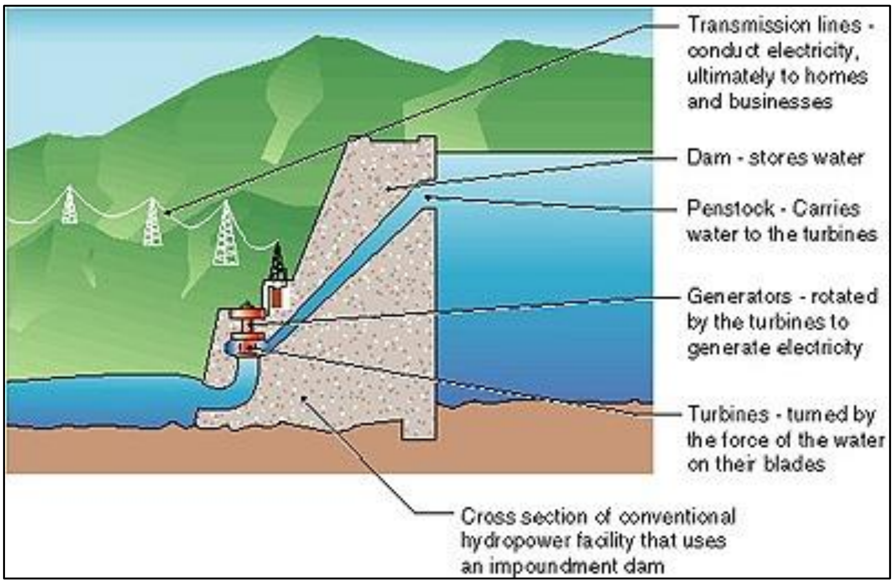


Figure A 6-4: Prototypical HPP

Thermal power plants

Figure A 6-5 presents a prototypical TPP, using coal stored on site which is crushed and fed into a furnace. Steam is generated for the turbines and a high-voltage substation increases the voltage and delivers power to the grid. The key components comprise of:

- coal storage,
- coal crusher,
- furnace,
- high voltage substation and transmission lines.

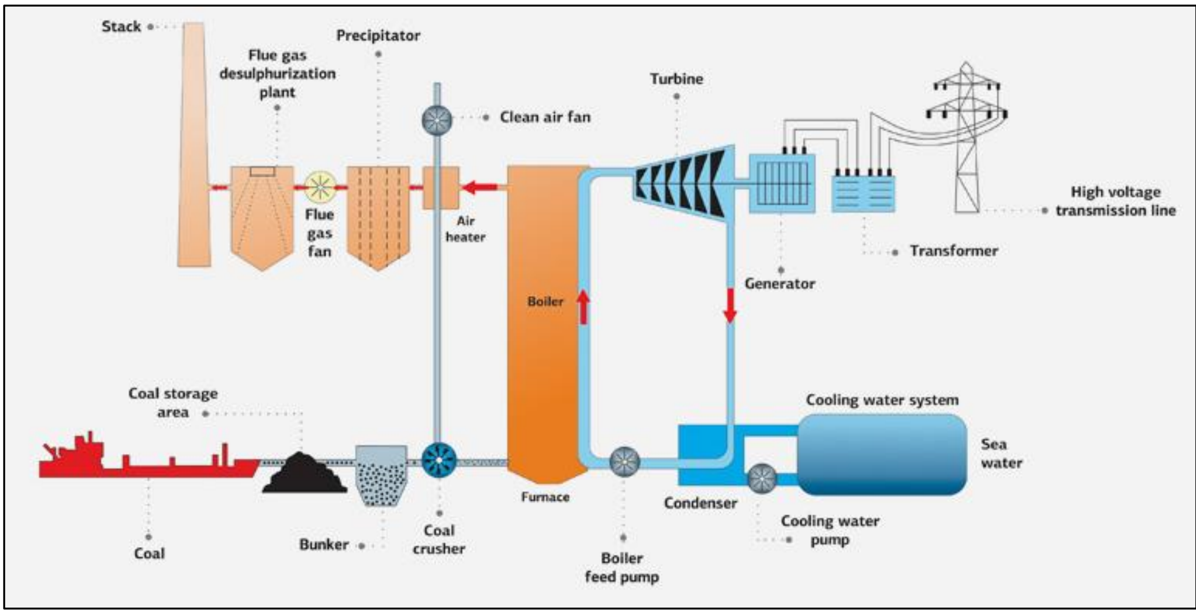


Figure A 6-5: Prototypical TPP

Pipeline storage and pumping

Figure A 6-7 presents a prototypical pipeline with storage and pumping facilities.

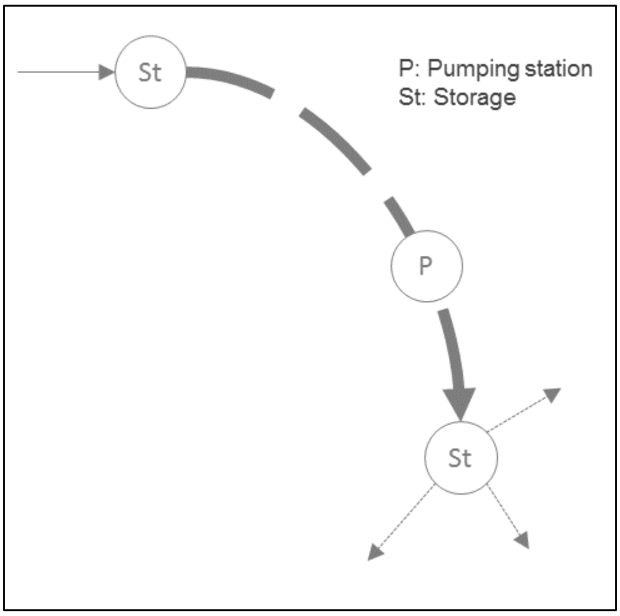


Figure A 6-6: Prototypical pipeline. (Source: Report authors).

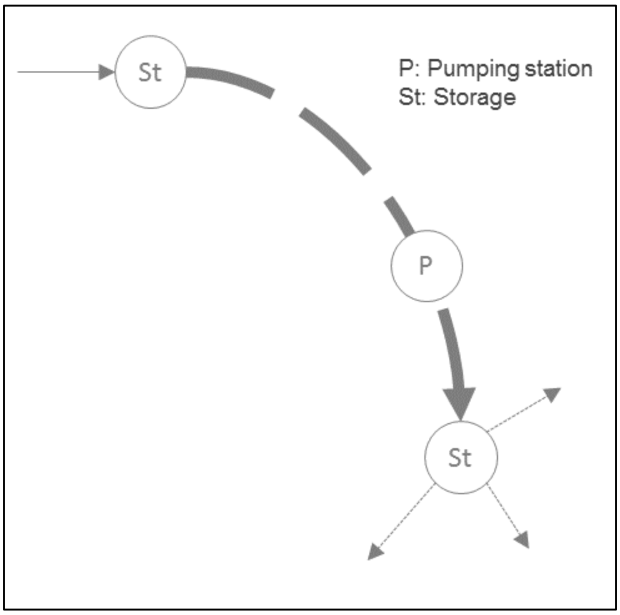


Figure A 6-7: Prototypical pipeline. (Source: Report authors).

A6.3 Prototypical transport & logistics assets

This section defines prototypical transport & logistics assets for the following types of CI:

- Port,
- Viaduct (road bridge).

Port

Figure A 6-8 presents a prototypical port with operations that include vessel unloading, container movements and storage and re-loading for onward road / rail transport. The key components comprise of:

- ship-to-shore gantry crane (SSG),
- rubber tired gantry crane (RTG),
- container yard,
- loading bay,
- road / rail yard.

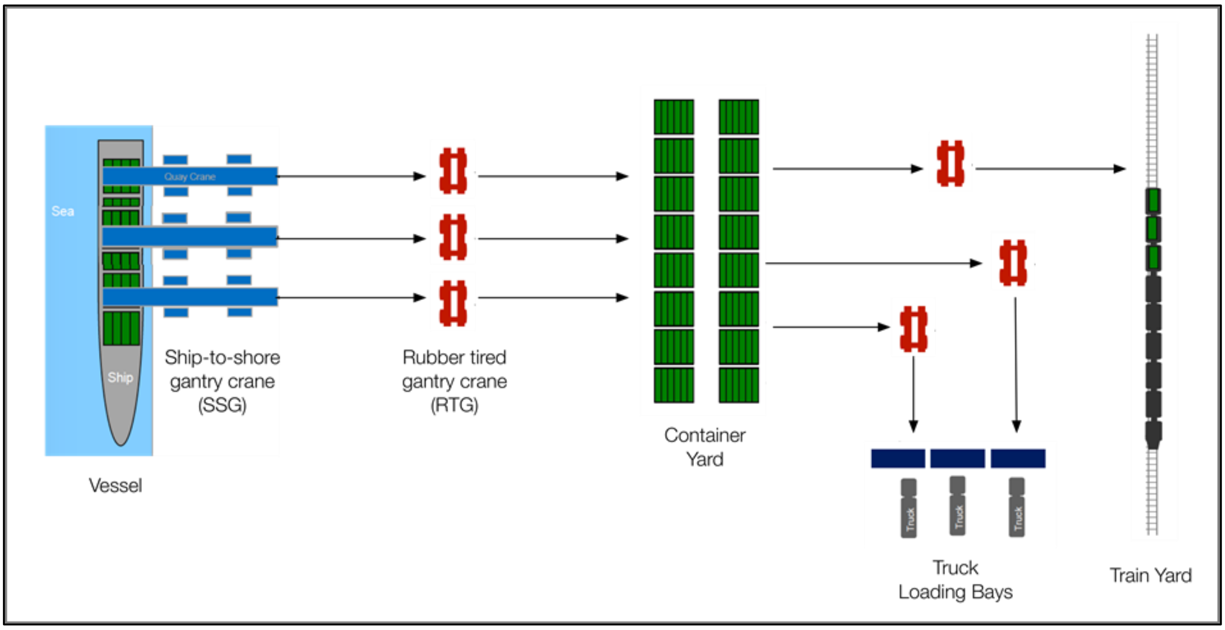


Figure A 6-8: Prototypical port. (Source: Prem Chhetri, 2014[446])

Viaduct (road bridge)

Figure A 6-9 presents a prototypical viaduct (road bridge) as a node, with inputs and outputs being the flow of traffic.

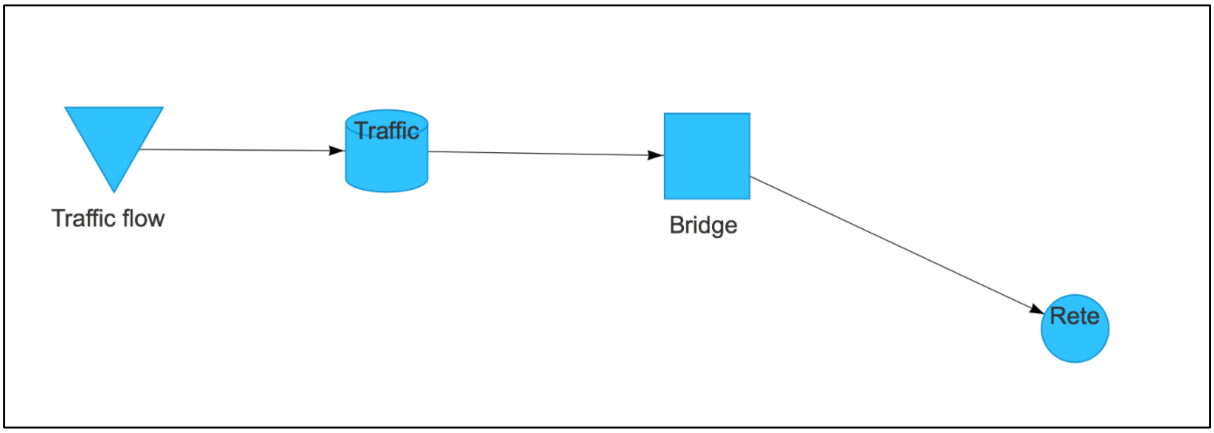


Figure A 6-9: Prototypical viaduct (road bridge). (Source: Report authors).

A6.4 Sector specific non-structural options

A6.4.1 Hydropower plants

Table A 6-2 presents non-structural options specific to HPPs.

Table A 6-2: HPP non-structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[a]
Risk prevention			
Operational efficiency	• Improve operating efficiency and increase storage and hydro-generation capacity through improved operating rules that are more responsive to reduced flows and changes in seasonality.		ADB (2016)
Monitoring and analysis	• Undertake on-going analysis of flood safety and reservoir bathymetry. • Monitor reservoir sedimentation to confirm operational lifetime is correctly assessed. • Analyze correlation of transmission line efficiency with air temperature.		Expert team
Risk identification and mapping	• Ensure reservoir operation incorporates basin-wide threats from expected impacts of climate change on the timing and severity of flood hazards and sedimentation rates.		Expert team, CIRIA (2010)
Adaptive management	• Employ adaptive reservoir management to ensure that levels of performance for energy production, water supply and environmental flows can be sustained under future climate regimes.		Expert team
Allowances and design factors	• Ensure that infrastructure design factors in climate change allowances (e.g. for the number, design and dimensions of spillways, or the scenarios/ techniques used to estimate the Probable Maximum Flood under climate change).		Expert team
Financial protection			
Weather derivatives / index based insurance	• Consider index-based reservoir insurance to hedge against inability to produce energy due to decreased water availability. • Consider Heating Degree Day and Cooling Degree Day contracts.		Expert team, IFoA (undated)
Preparedness			
Emergency response / management plan	• Develop working plans for HPPs under emergency situations where drastic reduction in reservoir inflows is forecast or projected.		Expert team, ADB (2016)

Type of option	Key actions	Relevant to hazard type	Source[a]
Forecast / early warning / rapid response systems	• Monitor river flows with more comprehensive and responsive stream gauging systems • Alter the timing of hydropower generation to more closely mimic a river's natural ebb and flow.		Expert team

(a) References:
CIRIA (2010). Flood resilience and resistance for critical infrastructure. CIRIA C688
ADB (2016). Economics of Climate Change in Central and West Asia.
IFoA (undated) European Weather Derivatives. URL: https://www.actuaries.org.uk/documents/european-weather-derivatives

A6.4.2 Thermal power plants

Table A 6-3 presents non-structural options specific to TPPs.

Table A 6-3: TPP non-structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[a]
Risk prevention			
Operational efficiency	• Improve operating efficiency through improved operating rules that are more responsive to changes in seasonality of climatic conditions.		ADB (2016)
Monitoring and analysis	• Analyze flood and heatwave risk. • Analyze correlation of transmission line efficiency with air temperature.		Expert team
Risk identification and mapping	• Assess hazardous material (HAZMAT) storage (e.g. fly ash) for risk of environmental release and explosion during earthquakes or extreme rainfall events. • Ensure cooling water requirements incorporate basin-wide threats from expected impacts of climate change on seasonal precipitation and temperatures.		Expert team, SeDIF (2013), CIRIA (2010)
Adaptive management	• Employ adaptive management to ensure that levels of performance for water supply, energy production and cooling water discharge to the environment are sustainable even under future climate regimes.		Expert team
Financial protection			
Weather derivatives / index based insurance	• Consider index-based insurance to hedge against inability to produce energy due to decreased cooling water availability. • Consider Heating and Cooling Degree Day contracts.		Expert team, IFoA (undated)
Preparedness			

Type of option	Key actions	Relevant to hazard type	Source[a]
Emergency response / management plan	• Develop working plans for TPPs under emergency situations where drastic reduction in cooling water availability is forecast or projected.		Expert team
Forecast / early warning / rapid response systems	• Monitor cooling water river flows with a more comprehensive and responsive stream gauging system.		Expert team, ADB (2016)

(a) References:
CIRIA (2010). Flood resilience and resistance for critical infrastructure. CIRIA C688
SeDIF (2013). Earthquake Damage and Fragilities of the Industrial Facilities. Mustafa Erdik, Eren Uckan. International Conference on Seismic Design of Industrial Facilities, Aachen University, 26-27 September 2013
ADB (2016). Economics of Climate Change in Central and West Asia.
IFoA (undated) European Weather Derivatives. URL: https://www.actuaries.org.uk/documents/european-weather-derivatives

A6.4.3 Pipelines

Table A 6-4 presents non-structural options specific to pipeline storage and pumping.

Table A 6-4: Pipeline storage and pumping non-structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[a]
Risk prevention			
Operational efficiency	• Maintain adequate headroom in storage capacity to manage downstream disruptions. • Ensure alternative onsite electricity generation and fuel stocks are maintained.		Expert team
Monitoring and analysis	• Review and adjust maintenance program to ensure maximum storage capacity is always available to manage downstream disruptions to flow.		Expert team
Risk identification and mapping	• Assess connection and anchorage point design standards against earthquake design codes.		Expert team, SeDIF (2013)
Financial protection			
Insurance	• Check business continuity insurance for loss of power to electrical pumps during power outages.		Expert team
Preparedness			
Emergency response / management plan	• Develop working plans for emergency situations where earthquakes and climatic events may result in damage to storage areas.		Expert team, SeDIF (2013)
Forecast / early warning / rapid response systems	• Monitor earthquake, landslide and storm risk.		Expert team

(a) References:
SeDIF (2013). Earthquake Damage and Fragilities of the Industrial Facilities. Mustafa Erdik, Eren Uckan. International Conference on Seismic Design of Industrial Facilities, Aachen University, 26-27 Sep 2013.

A6.4.4 Port

Table A 6-5 presents non-structural options specific to ports.

Table A 6-5: Port non-structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[a]
Risk prevention			
Operational efficiency	• Update dredging programs and schedules to reduce loss of draft clearance due to sedimentation of the port. • Review and adjust frequency of sediment trap clearance to maintain efficiency. • Implement procedures which are informed by forecasting systems for handling materials under adverse climatic conditions. • Implement traffic management measures which are informed by forecasting systems to minimize bottlenecks during extreme events. • Review and adjust maintenance program to ensure that maximum capacity of drainage systems is achieved e.g. frequency of drain clearance. • Account for sea level rise in inventories for replacement and refurbishment of infrastructure.		IDB (2015)
Monitoring and analysis	• Implement regular review of vulnerabilities of competitor ports, and update risk management strategy to maintain comparative advantage or more competitive resilience.		IDB (2015)
Risk identification and mapping	• Assess hazardous material (HAZMAT) storage for risk of environmental release and explosion during earthquakes or extreme rainfall events. • Review susceptibility of harbors and jetties to earthquake-induced sub-marine landslides or liquefaction. • Review operating thresholds for critical handling equipment. Incorporate potential impact of increase in peak wind speeds on maintenance and renewal schedule. • Review design thresholds for crane tie-down systems, belts, lighting systems etc. in relation to extreme storm event wind speeds. • Carry out operability assessments for berthing and maneuvers to understand		Expert team, SeDIF (2013), IDB (2015)

Type of option	Key actions	Relevant to hazard type	Source[a]
	operational thresholds to reflect potential changes in storminess and sea level rise.		
Adaptive management	• Increase diversity of clients from regions less subject to natural hazards.		IDB (2015)
Financial protection			
Weather derivatives / index based insurance	• Consider index-based insurance to hedge against inability to berth ships, store and transfer cargo off-site.		Expert team, IFoA (undated)
Pricing structure	• Review pricing relationships with customers i.e. evaluate whether costs of climate impacts (e.g. increased refrigeration / cooling costs) can be passed on to customers.		IDB (2015)
Preparedness			
Emergency response / management plan	• Develop working plans for emergency situations where earthquakes, submarine landslides, storms and storm surge may result in large scale damage. • Ensure direct communication channels with shipping companies in the event that berthing needs to be delayed. • Create safe zones for anchoring ships offshore during extreme storms.		Expert team, SeDIF (2013)
Forecast / early warning / rapid response systems	• Monitor earthquake, submarine landslide, wave height and storm surge risk and alter timings of shipping berth.		Expert team

(a) References:
IDB (2015). Port of Manzanillo: Climate Risk Management. Action Plan.
SeDIF (2013). Earthquake Damage and Fragilities of the Industrial Facilities. Mustafa Erdik, Eren Uckan. International Conference on Seismic Design of Industrial Facilities, Aachen University, 26-27 Sep 2013.
IFoA (undated) European Weather Derivatives. URL: https://www.actuaries.org.uk/documents/european-weather-derivatives

A6.4.5 Viaduct (road bridge)

Table A 6-6 presents non-structural options specific to viaducts / road bridges.

Table A 6-6: Viaduct / road bridge non-structural risk management options. (Source: Report authors).

Type of option	Key actions	Relevant to hazard type	Source[a]
Risk prevention			
Operational efficiency	• Implement traffic management measures and alternative routes to minimize bottlenecks during extreme events. • Undertake review and adjust maintenance program to ensure that maximum capacity of existing drainage system is being achieved e.g. frequency of drain clearance.		Expert team, IDB (2015)

Type of option	Key actions	Relevant to hazard type	Source[a]
Risk identification and mapping	• Mainstream risk management into the engineering design and planning of new and existing bridges and associated infrastructure (e.g. tunnels, roads, etc.). For example, ensuring that surface water drainage, attenuation and outfall systems are designed to cope with projected volumes of water under climate change scenarios. • Undertake research on the climate/ disaster vulnerability of transport networks to identify highly vulnerable locations.		Expert team, IDB (2015)
Financial protection			
Weather derivatives / index based insurance	• For toll roads and bridges, consider index-based insurance to hedge against inoperability during weather events.		Expert team, IFoA (undated)
Pricing structure	• Review pricing i.e. evaluate whether costs of climate impacts (e.g. drainage and surface maintenance) can be passed on to customers.		Expert team
Preparedness			
Emergency response / management plan	• Develop working plans for emergency situations where earthquakes and storms may result in large scale damage and disruption to transport networks. • Ensure direct communication channels with maintenance and debris clearance teams.		Expert team
Forecast / early warning / rapid response systems	• Monitor earthquake risk and extreme rainfall and wind events to allow advance closure and redirection of traffic.		Expert team

(a) References:
IDB (2015). Port of Manzanillo: Climate Risk Management. Action Plan.
IFoA (undated) European Weather Derivatives. URL: https://www.actuaries.org.uk/documents/european-weather-derivatives

A6.5 Cost Benefit Analysis (CBA) steps

Step 1: Define the objective and boundary

A risk management objective must be clearly defined and be quantifiable in monetary terms. The ‘boundary’ defines the direct and indirect impacts and the stakeholders that should be included in the options appraisal. Risk assessments should have identified current and future natural hazard risks and the extent of their potential impacts. In large scale infrastructure projects, the risk assessment results should also have identified the magnitude and likelihood of impact of the various (non-mitigated) risks.

Step 2: Define the forecast period and discount rate

The forecast period should reflect the economic life of the investment as a whole, and include asset renewals for those components with a shorter life. For PPP investments, a discount rate may be set nationally.

If none are prescribed, declining rates over time can be considered. In environmental projects, including those managing or mitigating climate change risks, this approach helps attach more importance to the longer-term where risks and consequences may be inherited by subsequent generations.

Step 3: Establish baseline(s)

A baseline should be defined which reflects the 'do-nothing' situation where no risk management is carried out. The resultant situation with successful risk management should also be defined to allow comparison of the costs and benefits of the two situations.

At least one scenario incorporating future climate change should be established, and for long-lived assets more scenarios should be evaluated using relevant future time horizons. The number of future climate projections and emissions scenarios used will depend on the risk tolerance level of the decision-maker(s) (see Section 7.2.4.6). This will help in understanding the implications of uncertainty across a range of possible future climates.

Step 4: Quantify and aggregate costs and benefits

Feasible options for this stage of the CBA should also include the 'do nothing' option. The options development strategy should consider:

- whether risks are gradually increasing over time only, in which case a time-phased implementation strategy, with gradually increasing risk protection levels (quasi-options), becomes more cost-efficient. The infrastructure design may also have built-in flexibility for later upgrades,
- if the options are to hedge against increasing climate extremes, in which case high levels of protection as well as cost-efficient ones are preferable early on in the implementation phase,
- if design flexibility is limited, risk management measures will need to be implemented early on.

The CBA can also include other market impacts (costs and benefits) of the investment as well as secondary and non-market impacts within the boundaries of the selected scenario(s):

- risk protection from the options should result in avoided future costs for the investors / infrastructure developers and other stakeholders reliant on the services,
- negative impacts on other stakeholders should be considered,
- whether use and non-use values of the investment are to be included should also be addressed (commonly undertaken in environmental projects).

Step 5: Value costs and benefits of risk management options

The investment and operating costs of the options are normally established at this stage. This may not be feasible when risk management measures are an integral part of the infrastructure design. In these cases, the lifecycle costs of options with differing protection levels may be examined to determine the level of risk reduction vs. cost trade-off (see Step 8).

Unit values for other costs as well as project benefits should be established. The benefit-transfer method can also be used for estimating benefits to the investor or developer in the form of avoided future costs and market impacts on other stakeholders. Non-market impacts, using standard methodologies used for environmental projects, can also be valued.

At this stage, the economic Net Present Value (eNPV) of the various options/option mixes in the identified scenario(s) over the project life can be calculated, applying the standard incremental approach to compare the costs and benefits with and without the risk management measure.

If the options strategy includes quasi-options with deferred implementation, the valuation should be based on a decision tree approach. This should include the likelihood that further risk management measures are needed in the future, requiring their timings to also be estimated. The weighted average cost of risk management now, and in the future, can then be determined.

Step 6: Assess hedging effectiveness and certainty of impact of options
The options/option mixes under consideration should be reviewed as to whether they are all equally effective in terms of reducing exposure to risks (i.e. 'hedging effectiveness') together with the certainty of their risk-reducing impact. The following should be considered:

- For options that are not likely to be equally effective, an eNPV assessment alone is not sufficient for selection,
- Structural options in the control of the decision-maker through investments or operational improvements are likely more certain in their benefits than non-structural options.

Compare the hedging effectiveness and certainty of impact with the associated costs, if the trade-off between risk reduction and the cost of an option shows there to be excessive residual risk, supplementary risk management measures for the option may be introduced. If none are feasible, the option is not attractive and should not be further considered.
If the certainty of option effectiveness relative to costs is not acceptable, then the option could be excluded from further appraisal.

Step 7: Assess equity (distributional impacts)
Distributional impacts should be assessed separately and decisions made on whether they are of a magnitude such that they should be explicitly considered in the decision rule for option selection. If included, determine how the distributional issues should be incorporated by:

- assigning (subjective) weights to the costs and benefits for the wider stakeholders in the eNPV calculation, or
- having distributional impacts as an explicit (and subjective) decision-making criterion.

Step 8: Determine the decision rule for option selection
Regardless of the infrastructure type or size, the most important single issue when performing CBA for natural hazard risk management measures is considered to be establishing the decision rule for selecting options (see Section A6.8). This recognizes risk-averse decision makers will tend to select options as part of a risk-return trade-off strategy, rather than those that offer the maximum economic efficiency (which is the focus of a conventional CBA).

Based on the pre-established decision rule, the risk management options/option mixes can be ranked and the 'best' option selected for implementation, noting that the 'do nothing' option may be the top-ranking outcome.

A6.6 Cost Effectiveness Analysis (CEA) steps

Step 1: Define the objective and boundary
A risk management objective must be well-defined and its fulfilment measurable. It can either be defined in terms of reducing vulnerability or achieving a certain level of adaptive capacity or resilience. The options identified must be expected to reasonably achieve the objective.
The 'boundary' defines the direct and indirect climate-related impacts and the stakeholders that should be included in the options appraisal. Risk assessments should have identified current and future natural hazards risks and the extent of their potential impacts. In large scale infrastructure projects, the risk assessment results should also have identified the magnitude and likelihood of impact of the various (non-mitigated) risks.

Step 2: Define the forecast period and discount rate
The forecast period should reflect the economic life of the investment as a whole, and include asset renewals for those components with a shorter life. For PPP investments, a discount rate may be set nationally.

If none are prescribed, declining rates over time can be considered. In environmental projects, including those managing or mitigating climate change risks, this approach helps attach more importance to the longer-term where risks and consequences may be inherited by subsequent generations.

Step 3: Establish baseline(s) and indicators
A baseline should be defined which reflects the 'do-nothing' situation where no risk management is carried out. In addition, a set of indicators must be agreed for evaluating and tracking benefits in non-monetary terms over time against the baseline.
At least one scenario incorporating future climate change should be established, and for long-lived assets more scenarios should be evaluated using relevant future time horizons. The number of future climate projections and emissions scenarios used will depend on the risk tolerance level of the decision-maker(s) (see Section 7.2.4.6). This will help in understanding the implications of uncertainty across a range of possible future climates.

Step 4: Quantify and aggregate costs
All costs of each option, including direct and indirect costs, should be quantified and aggregated over the life-time of each option. All costs should be discounted to their present value by using an agreed discount rate.

Step 5: Determine the cost-effectiveness
The definition of effectiveness depends on the risk management objective and the established baseline, for example, realizing a pre-defined level of protection.

Step 6: Compare the cost effectiveness of the different options
Cost-effectiveness can either be compared overall or in incremental terms. An overall cost effective analysis compares the cost per unit of effectiveness for each risk management option. In contrast, an incremental cost effectiveness analysis considers the difference in costs divided by the difference in effectiveness that result from comparing one option to the next most effective one (or a baseline situation).

An incremental cost effectiveness ratio can be expressed as:

(Cost Option A – Cost Option B) / (Effectiveness of A – Effectiveness of B)

where A is the most effective measure and B is the second most effective.

A6.7 Multi-Criteria Analysis (MCA) steps

Step 1: Define the objectives and boundary
MCA requires multiple objectives and associated criteria to be defined. This can take into account not only the objectives related to the infrastructure asset, but other needs such as wider development priorities.
The 'boundary' defines the direct and indirect climate-related impacts and the stakeholders that should be included in the options appraisal. Risk assessments should have identified current and future natural hazards risks and the extent of their potential impacts. In large scale infrastructure projects, the risk assessment results should also have identified the magnitude and likelihood of impact of the various (non-mitigated) risks.

Step 2: Agree on the decision criteria
Each criterion should be described, including the unit and span of possible scores to ensure all that those involved in the assessment process have a shared understanding and consensus. Criteria can include

‘importance’, ‘urgency’ and whether co-benefits such as mitigating against greenhouse gas emissions can be realized.

Step 3: Score the performance of each risk management option
Each option should be scored against each of the pre-defined criteria. The scoring should then be standardized in case scores across criteria differ in units; for example use of absolute quantitative values in some criteria and ranges in another. Standardization into similar units allows true effective comparison across the criteria.

Standardization, or z-scoring, results in scores losing their dimension as well as their measurement unit, using the following formula:

$$z = \frac{X - \mu}{\sigma}$$

X: a score within a set of scores
μ: the mean of all scores in the set
σ: the standard deviation of all scores in the set.

Step 4: Assign weightings to criteria to reflect priorities
In case some criteria are perceived to be more important than others and the priorities are known, criteria can be assigned different weights, thus indicating their relative importance.

Step 5: Rank the options
A total score for each option can be calculated by multiplying the standardized scores with their appropriate weight. The weight adjusted scores can then be aggregated and compared. The main result of an MCA will be a ranked order of risk management options and a wider understanding of the strengths and weaknesses of each of the options.

A6.8 Decision rules for option selection

A main distinction in setting up a decision rule is whether the decision-makers’ objective for option selection is purely an economic decision, or whether other aspects such as environmental and social benefit also play a role, and to what extent. If the options under consideration are not all equally effective in managing risks, this requires detailed consideration of all contributory aspects informing the final decision. This includes ‘win-win’ options, ones which provide benefits in other areas as well as managing natural hazard related risks. Wider consideration also applies if not all costs and benefits associated with economic feasibility can be implicitly valorized.

Single objective adaptation decisions

In cases where economics is the sole objective, the selected option should have a positive net present value (NPV), otherwise, the ‘do nothing’ option is economically better.

Options with short time frames

Some risk management options may have short economic lifetimes. In these cases, observed trends in climate based on recent records provide a good indication of the hazardous conditions to be expected over the lifetime of the option. In these cases, it would be sufficient and cost-effective to perform a calculation of the estimated net benefits of the various options and to select the one with the highest positive NPV. If no measure has a positive NPV, the ‘do nothing’ option remains valid. This approach can be considered to correspond to decision-making using Cost Benefit Analysis (CBA) with a built-in assumption of a level of certainty.

Risk tolerance level

Risk-loving decision-makers tend to exclusively select the option with the highest NPV, equating to a 'maximax' decision rule.

Risk neutrality in decision-making would, for probabilistic assessments, be consistent with selecting the option with the highest weighted mean, the expected NPV (eNPV). In a non-probabilistic assessment, risk neutrality would be the simple mean of a Bayes criterion decision rule.

Risk-averse decision-makers will aim at selecting options that perform robustly in terms of net benefits across a range of future scenarios. If the level of net benefits is not relevant, then the option providing maximum resilience is selected. In real terms, it is expected that risk-averse decision-makers would look at the returns of an option as well as the expected net benefits relative to the level of resilience it provides, i.e. accepting more risk if the return is also potentially higher.

In a probabilistic assessment, this risk-return trade-off may be expressed by the coefficient of variance, i.e. the standard deviation divided by the mean (eNPV). The option with the lowest coefficient becomes the most attractive. The standard deviations can also be used for calculating a risk premium for each option to include as a cost in the eNPV calculation, then conducting a Risk Benefit Analysis (RBA) in place of a CBA.

In a non-probabilistic risk assessment, the decision-maker would first establish their own preferences for action against current and future natural hazard risk, and then select the option that conforms to their selection criterion.

Multiple objectives adaptation decisions

Decision rules with multiple objectives should include targets other than maximum economic return, with the conventional approach being a multi-criteria analysis (MCA). An MCA should be performed in all cases where:

- not all costs and benefits can be valorized,
- a cost effectiveness analysis (CEA) for options with the same level of benefit cannot be carried out,
- if the options under consideration are not equally effective.

As MCA, or at a minimum a qualitative risk assessment, should also be undertaken for win-win options to ensure that the benefits over and above current and future natural hazard management are sufficient and not being dominated by other benefits.

MCA will also allow separate weight to be attached to options with design flexibility, reversibility features (regret options) and to differences in effectiveness and 'certainty of impact' of options, notably applying to soft vs. hard measures.

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