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TOWARDS A CLIMATE ADAPTATION ROADMAP FOR THE TURKISH CONSTRUCTION INDUSTRY

FINDINGS FROM A PARTICIPATORY WORKSHOP WITH INDUSTRY STAKEHOLDERS

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FOREWORD

Climate change is a global threat impacting all aspects of life, including the construction industry. As weather patterns become more unpredictable and the frequency of extreme weather events become more frequent, the construction industry should not only work to mitigate climate risks through decarbonization efforts and sustainable practices but also ensure its resilience to adverse climate events.

Questions that need to be addressed at company, industry and national levels include;

- How will climate change impact health and safety, project duration, and costs in construction projects ?

- Are current design methods, project management principles, construction technology, and existing infrastructure delivery methods ensure resilience to future climate scenarios ? If changes are needed, what would be the challenges and costs in the short and long term ?

- How will climate-driven global market uncertainties reshape the Turkish construction industry's dynamics? What are the risks and opportunities for construction companies due to climate change ?

We invited construction professionals to attend a workshop to search answers to these questions in the Turkish construction industry and brainstorm about climate adaptation pathways. The "Climate Adaptation Workshop" conducted on 19th November 2024 in Ankara brought together 27 participants representing stakeholders from private companies, governmental and non-governmental institutions. Participants with varying roles and experiences ensured that the perspectives of diverse stakeholders were heard.

The workshop concluded with an atmosphere that reinforces the critical role of the construction industry for climate adaptation, emphasizing the positive role of construction projects and infrastructure for a resilient future, along with the negativities of the sector due to high carbon emissions and waste which require urgent actions towards climate risk mitigation.

We were particularly encouraged by the high level of interest, commitment, and innovative thinking demonstrated by all participants. The participatory approach adopted in this workshop highlighted the value of diversity, multi-sectoral and multi-disciplinary interactions in addressing grand challenges such as the climate change. We hope that the insights and findings on adaptation pathways presented in this report will inform ongoing policy development, support industry-led initiatives, and contribute to the broader efforts to strengthen climate resilience in the Turkish construction industry.

We would like to express our sincere gratitude to all participants for their valuable contributions, and to University of Reading and METU Technopark for their support in making this workshop possible. We are looking forward to continuing industry-academia dialogue between the countries and fostering collaborations for a climate resilient built environment.

The Project Team, March 2025
Reading, UK and Ankara, Turkiye

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EXECUTIVE SUMMARY

Climate change increases the frequency, severity, and intensity of natural disasters, hence the built environment is becoming more vulnerable to extreme weather events calling for urgent adaptation actions and climate resilient infrastructure systems are becoming more critical to minimize the adverse impacts of climate hazards.

As a country in the subtropical Mediterranean climate zone with medium to high climate risk, Türkiye faces significant challenges. There is an urgent need for climate monitoring, vulnerability and risk assessments, and national adaptation measures to mitigate these impacts and enhance resilience.

The Climate Change Adaptation Strategy and Action Plan (2024-2030) that was recently published by the Republic of Turkiye Environment, City and Climate Change Ministry, composed of 11 main sections, including Urban, Water Resources Management, Agriculture and Food Security, Biodiversity and Ecosystem Services, Public Health, Energy, Industry, Tourism and Cultural Heritage, Transport and Communication, Social Development, and Disaster Risk Reduction, as well as cross-cutting issues.

While the Strategy and Action Plan has clear adaptation objectives, strategies and priorities for action at the national level, a holistic and integrated outlook for the construction industry with specific actions is urgently needed to operationalize climate adaptation strategies.

While the built environment is vulnerable to the impact of climate change, it is also a major contributor to climate change through building energy use, greenhouse gas emissions, and material extraction. A key challenge relates to the increasing demand for the heating and cooling of buildings, which contributes significantly to carbon emissions.

Much of the climate-focused research in the built environment focuses on mitigation. The emphasis lies on measuring, controlling, and reducing carbon and greenhouse gas emissions. Yet the scientific consensus indicates that anthropogenic emissions are leading to an inevitable change in climate irrespective of future actions (IPCC, 2022). Hence an agenda for climate adaptation as well as efforts in mitigation is required for the built environment.

Notwithstanding the above, there is a clear need for a more integrated approach to sustainable development within the context of the Turkish built environment. This is crucially dependent upon improved stakeholder engagement and a more sophisticated approach to the analysis of uncertainty due to climate change.

Recognizing this gap, a participatory workshop was held to raise awareness, facilitate dialogue among key industry stakeholders, and co-produce a preliminary roadmap for climate adaptation in the Turkish construction sector.

Representatives from public institutions, private companies, NGOs, and academia participated in the workshop, contributing diverse perspectives across the construction value chain. The workshop featured presentations on global and national climate adaptation strategies, interactive brainstorming sessions to identify sector-specific challenges, and collaborative group work to propose adaptation pathways across governance, finance, infrastructure, and project management.

KEY ACTIONS FOR STAKEHOLDER INCLUDE

INTEGRATION

Integrating climate adaptation into design standards, technical regulations, and project management processes.

CLIMATE RESILIENT INFRASTRUCTURE

Developing climate-resilient infrastructure, particularly for water and transport networks, through enhanced asset management, digitalization, and technology deployment.

CENTRALISATION

Establishing a centralized Climate Change Authority to coordinate policy, facilitate data sharing, and ensure the alignment of sectoral adaptation actions.

INNOVATION

Creating innovative financial mechanisms, such as climate resilience bonds, to fund adaptation investments and de-risk private sector participation.

ENHANCING AWARENESS

Enhancing awareness and capacity across all levels of the sector, from project teams to senior leadership, through targeted training, improved risk assessment tools, and clear climate adaptation guidelines.

The workshop outputs emphasize the need for a holistic and cross-sectoral approach that aligns climate adaptation actions with broader national strategies while addressing the specific vulnerabilities and capabilities of the construction industry.

The vulnerabilities within the built environment are found to stem from lack of governance systems, including knowledge, data and regulations for climate risk-informed decision-making.

By embedding climate resilience into sectoral planning to minimize vulnerabilities, exposure and impact, Turkish construction industry can play a proactive role in safeguarding the built environment, reducing future costs and losses due to climate change, and enabling sustainable and climate resilient development.

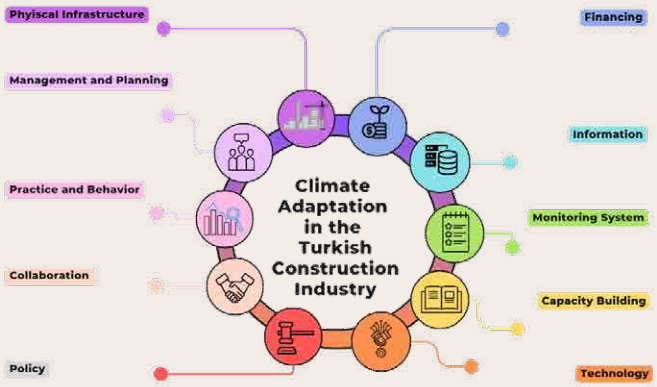


Figure 1. Adaptation strategies for the Turkish construction industry

INTRODUCTION

The increasing frequency and severity of climate-related hazards, including heatwaves, floods, droughts, and extreme storms, pose significant risks to Türkiye's built environment and construction industry. As a climate-vulnerable country situated in the Mediterranean Basin, Türkiye's construction sector must adapt to increasingly unpredictable conditions while continuing to meet growing demand for infrastructure and housing. At the same time, the sector has a significant environmental footprint, contributing substantially to national greenhouse gas emissions through energy-intensive processes, material extraction, and construction activities.

The concept of climate adaptation, preparing for and adjusting to the impacts of climate change, is gaining traction globally as scientific evidence underscores the inevitability of certain climate impacts, even if mitigation targets are met. In Türkiye, adaptation has been integrated into national climate strategies, but to date, there has been no comprehensive, sector-specific roadmap for the construction industry. Addressing this gap requires a multi-stakeholder, cross-disciplinary effort to identify risks, develop feasible solutions, and align sectoral actions with broader adaptation and development goals.

This report presents the findings of a participatory workshop held to explore these issues and co-produce initial recommendations for climate adaptation pathways in the Turkish construction industry. The workshop brought together 27 stakeholders, including representatives from public authorities, construction firms, professional associations, NGOs, and academia. Participants contributed insights on climate risks, existing adaptation practices, barriers to action, and opportunities for enhancing resilience across the construction lifecycle.

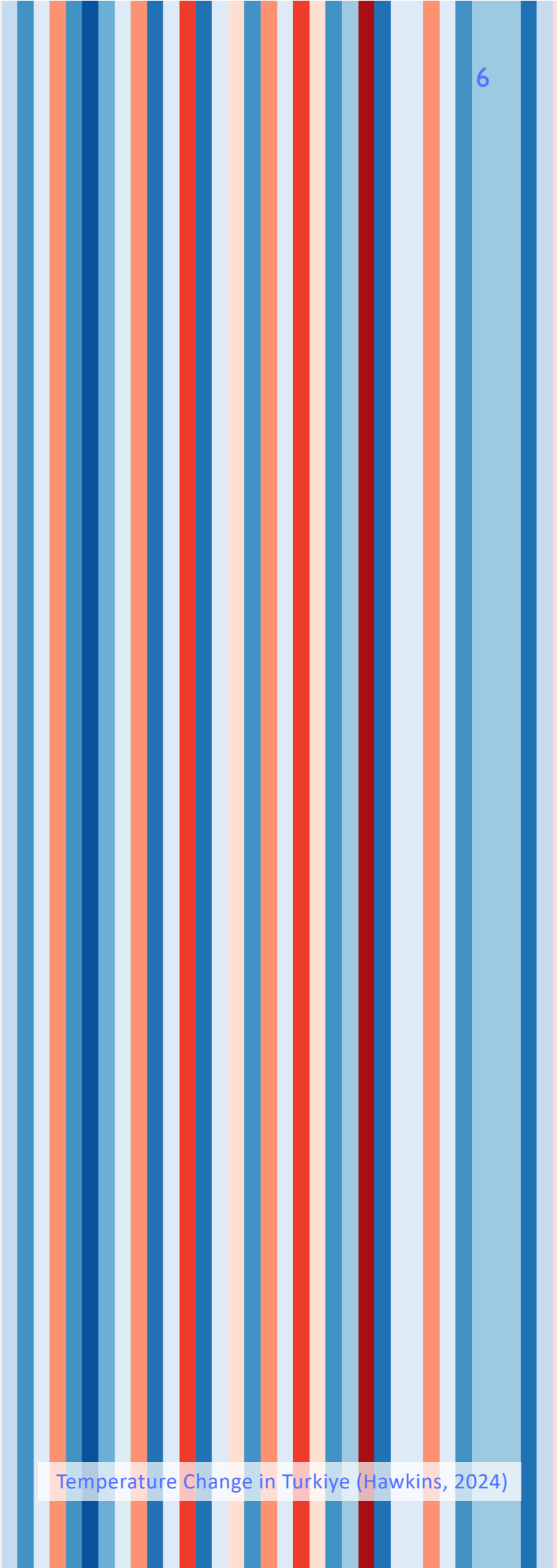
The outputs of the workshop have been synthesized into a preliminary sectoral roadmap, highlighting priority actions across governance, infrastructure, project management, and financing. The aim is to inform ongoing policy development, enhance industry awareness, and foster coordinated action towards a climate-resilient construction sector in Türkiye.

Section 2 sets the scene for the interaction of climate change and the construction industry towards climate resilient development. Section 3 gives an overview of the Turkish context in terms of climate risks, regulatory and policy-level status.

Section 4 details the design of the participatory workshop, including the demographics of the participants and the workshop sessions.

Section 5 presents the main findings of the workshop in terms of clusters of key topics discussed.

Section 6 depicts the summary of findings highlighting 10 clusters for sectoral adaptation pathways.



Temperature Change in Turkiye (Hawkins, 2024)

SETTING THE SCENE

Climate Change and The Construction Industry

As the consequences of climate change continue to intensify, delays, unforeseen costs, and quality implications caused by severe weather conditions are likely to increase within the built environment, leading to further disruptions" (Source: IPCC, 2022).

The impact of climate change, adaptation, and mitigation

"Infrastructure is key to many sectors including transportation, telecommunications, water, and energy. It also plays an important role within agriculture and health. Strong interdependencies mean that damages to a single infrastructure asset may cause a domino effect of failures across systems, known as cascade failure.

These damages have increasingly been caused by more extreme weather events linked to climate change – leading to billions of dollars of repair, loss of life and security for millions of people around the world" (Source: Green Climate Fund).

In cities, climate change has harmed public health, livelihoods, and infrastructure, with extreme heat and weather events disrupting transport, water, sanitation, and energy systems, leading to economic losses and reduced well-being (IPCC Synthesis Report, 2023).

Infrastructure is widely recognised as vulnerable to extreme weather events caused by climate change. The broader built environment is similarly impacted by changing ambient conditions, not least those relating to air temperature, precipitation, wind velocity, and humidity. Buildings and their occupants are also vulnerable to heat waves, rising sea levels, and development in hazard-prone areas. Infrastructure in coastal and flood-prone areas is particularly at risk.

Disruptions due to climate change can also impact the construction supply chain, with significant implications for investment in capacity building. The implications of climate change for the construction industry are further exacerbated by increased insurance premiums (Botzen et al., 2010). Such uncertainty serves as a further disincentive to investment, therefore diminishing long-term resilience. Increasing awareness of the tangible impacts of climate change has led to growing recognition of the need for more effective climate adaptation measures.

Adaptation plays a crucial role in reducing the vulnerability of the built environment against climate change. Yet, to date, there is relatively little research on the barriers to climate change adaptation in the Turkish construction sector.

Notable impediments include lack of awareness, the use of inconsistent and unclear language, perceived unaffordability, and lack of financial incentives (Hurlimann et al., 2018).

Construction firms are also often constrained by clients who are unwilling (or unable) to make the necessary investment. Endemic short-termism is

not so easily overcome. And yet taking decisive action is in the long-term interests of all parties. Prevarication is the enemy of all. Yet the long-term implementation of effective climate mitigation cannot be allowed to be impeded by short-term imperatives.

It is increasingly recognised that the risks associated with climate change must be addressed through both mitigation and adaptation. Buildings are vulnerable to climate change risk and are also the source of a significant proportion of greenhouse gas emissions which contribute to climate change.

The construction industry has significant potential to facilitate adaptation through actions that both reduce its contribution to greenhouse gas emissions across the construction and building lifecycle, and through physical adaptation of buildings and settlements to withstand present and future changes. (Source: Hurliman et al., 2018)

Climate adaptation refers to the process of adjusting to actual or expected climate change to moderate harm or exploit beneficial opportunities.

Climate mitigation measures refer to the technologies, processes or practices that contribute to reducing emissions through human intervention. (IPCC, 2022)

Towards climate resilient development (CRD)

Figure 2 from the Intergovernmental Panel on Climate Change (IPCC) Climate Change 2023 Synthesis Report illustrates how global surface temperatures have changed over the past century and how they are projected to evolve through the rest of the 21st century. It tracks temperature changes relative to pre-industrial levels (1850-1900) and shows both historical data (1900-2020) and future projections (2021-2100) under five different greenhouse gas emissions scenarios, ranging from very low to very high emissions. The figure highlights how the climate future of different generations, those born in 1950, 1980, and 2020, depends heavily on current and near-term climate action.

The colour stripes represent global temperature changes, with future generations facing very different climate conditions depending on emission pathways. The projections reflect human-caused warming, influenced by natural climate variability, and are based on socio-economic and policy assumptions. These are scenarios exploring possible futures rather than precise predictions.

Higher emissions lead to faster warming and more severe impacts, while lower emissions can stabilize temperatures over the long term. This visual emphasizes that choices made today directly shape the climate experiences of current and future generations.

The Intergovernmental Panel on Climate Change (IPCC, 2022) emphasises the importance of building resilience to climate change while at the same time pursuing sustainable development pathways.

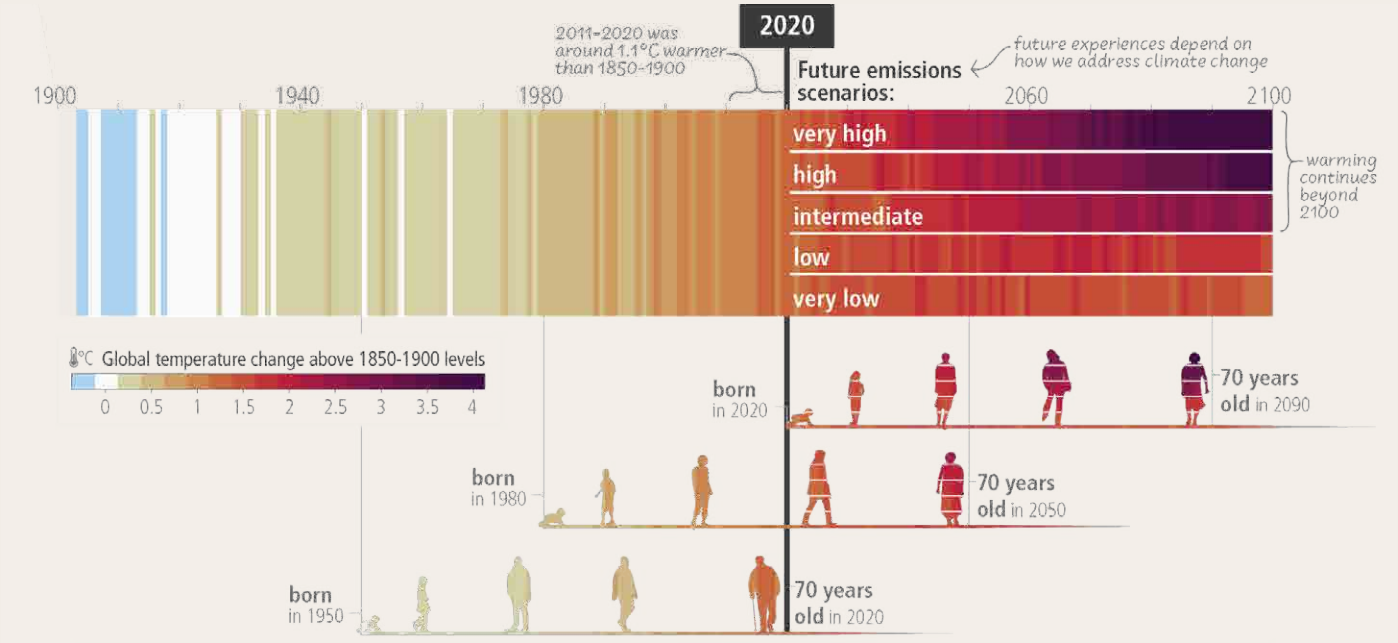


Figure 2. Alternative climate scenarios across generations (Source: IPCC Synthesis Report, 2023)

The guiding concept is 'climate resilient development' (CRD) which refers to a strategy of integrating climate change adaptation and mitigation actions into a broader framework of sustainable development. CRD is seen to be dependent on effective policy frameworks, adequate financing, institutional capacity, and continued investment innovation in science and technology. It is also seen to depend on continued international cooperation.

Notwithstanding current initiatives, there is a clear need for a more integrated approach to sustainable development within the context of the Turkish construction industry. The necessity is to strengthen and better coordinate adaptation and mitigation actions to enhance the potential of local and regional development pathways to support CRD.

Meaningful action, however, is crucially dependent upon improved stakeholder engagement and a more sophisticated approach to the analysis of uncertainty (Sarıcıoğlu and Ayçam, 2021; Dino and Akgül, 2019).

Climate adaptation efforts in the built environment

There remains little consensus regarding the most appropriate adaptation strategies relating to the built environment. Hence there is little certainly within the construction industry in terms of how best to position themselves for the future. Nevertheless, important insights can be gained from the literature.

Many adaptation strategies are based on the recommendations of international organisations such as the IPCC, the European Environment Agency, the Committee on Climate Change and the World Bank.

There is then a need to tailor the generic recommendations to the specifics of the target industry or geographical location, ideally in accordance with the objectives outlined by the United Nations Framework Convention on Climate Change (UNFCCC, 2011).

In the context of the built environment, current discourse is focused on ensuring a climate-resilient urban infrastructure. Innumerable studies have been conducted to model the impact of climate

change, but relatively few have explored the effectiveness of real-world climate adaptation strategies. And the criteria against which 'effectiveness' might meaningfully be assessed will undoubtedly vary in accordance with geographical location and the needs and aspirations of identified stakeholders.

While climate change may increase the frequency or intensity of certain natural hazards, resilience is determined by socioeconomic development and human decision-making. Hence there is scope for improving the resilience of designed infrastructure, and for investing in our capacity to make better decisions in accordance with local needs.

In the next section, the contextual factors for Turkiye will be presented to point out the location specific risks and needs for adaptation action.

BACKGROUND

The Turkish Context

"Türkiye, as a developing country located in the Mediterranean Basin, which is one of the most vulnerable regions in the world to the adverse impacts of climate change, faces significant investment needs for mitigation and adaptation actions." (Source: National Communication 2023)

Vulnerability to climate change

Türkiye has a high level of vulnerability to climate change. Since 2000, there has been a marked rise in extreme meteorological events. Figure 3 displays the spatial distribution of natural disasters that occurred in Türkiye in 2020 and 2021 (Source: AFAD 2022).

In 2022 alone, there were 1,030 reported meteorological natural disasters according to the eighth national communication of Türkiye under the UNFCCC (National Communication, 2023). The breakdown of these events is indicated in Figure 4.

Longitudinal data from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP, n.d.) indicate that floods in Türkiye between 1970 and 2021 caused $2.8 billion in damages and claimed 758 lives.

Meanwhile, droughts have led to economic losses equivalent to 1.2% of Türkiye's Gross Domestic Product (GDP) (MoEUCC, 2024). UNESCAP projections estimate that annual economic losses due to climate-induced disasters currently amount to 2.2% of GDP. Türkiye is hence highly disaster-prone, with direct damages from disasters potentially reaching 3% of GDP.

This figure is likely to be even higher once indirect losses are accounted for (National Communication of Turkiye,2023).

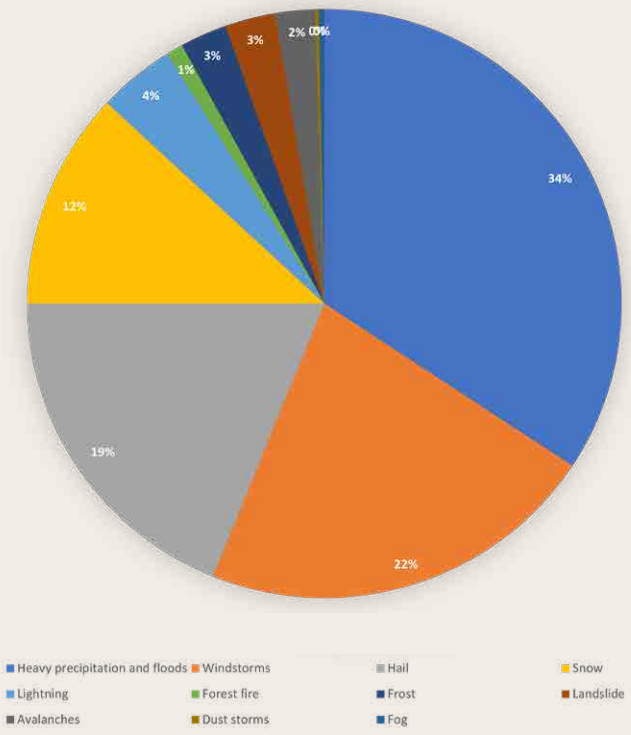


Figure 4. Percentage of extreme events recorded in 2022 (Source: National Communication of Turkey, 2023)

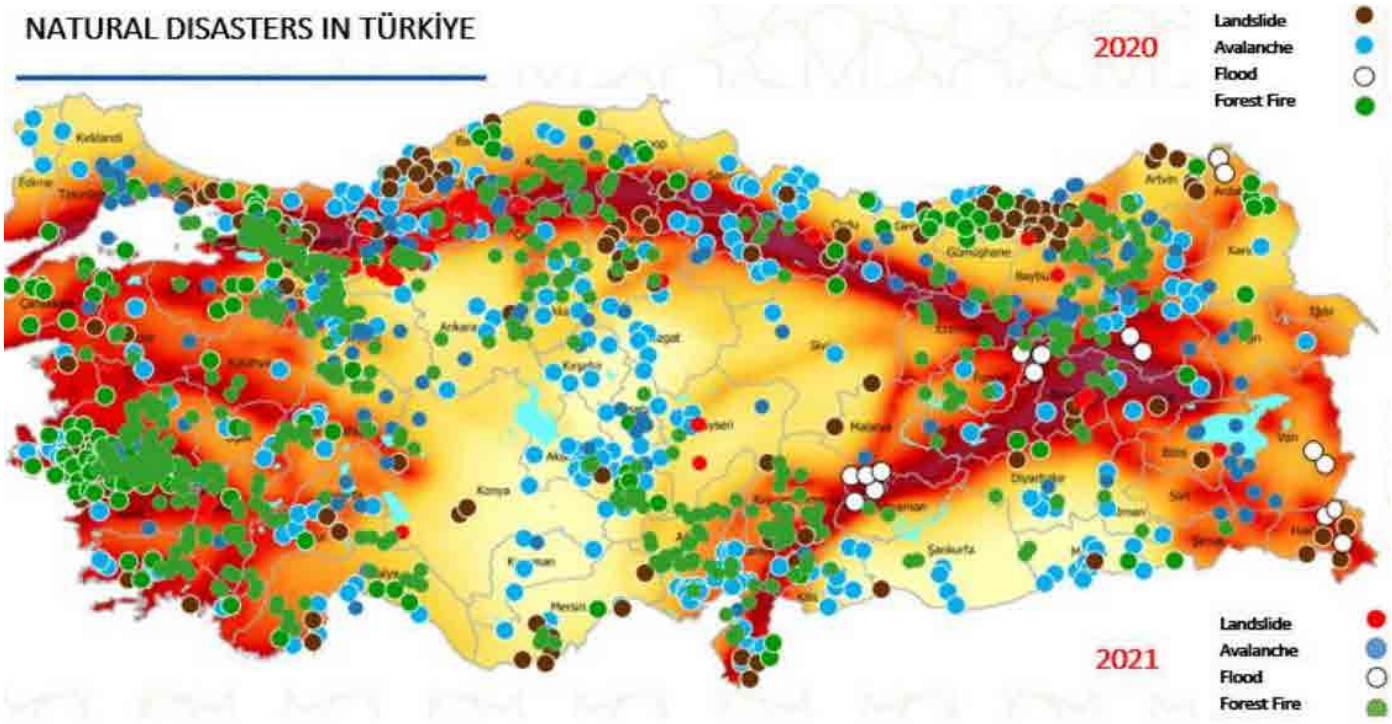


Figure 3. National Disasters in Turkiye in 2020 and 2021. (Source: AFAD, 2022)

Climate risk due to energy consumption and demand

Türkiye has experienced rapid urbanization, with the urban population growing from 29 million to 74.2 million between 1990 and 2020 (National Communication of Turkiye, 2023). Approximately 75% of Türkiye's building stock was built before 2000, and around 80% of the building stock comprises residential buildings (WRI Turkiye, 2023). Türkiye's transportation sector has likewise experienced significant growth, including the extension of road and railway networks, and the construction of new airports, seaports, tunnels, and bridges (National Communication of Turkiye, 2023).

The building and transportation sectors are among Türkiye's primary energy consumers. Türkiye's 9.5 million buildings routinely account for 31.1% (36.9 Mt) of total energy consumption (2053 Long term Climate Strategy of Turkiye, 2024 and National Communication of Turkiye, 2023). The transport sector accounts for 25% (27 Mt) of the country's final energy consumption. Road transport dominates at 94.44% of the sector's energy use, followed by air transport at 2.68% (National Communication of Turkiye, 2023).

Türkiye's total electricity demand has increased by 19% between 2016-2021, and the installed power capacity has increased more than threefold in the last two decades, reaching 115,975 MW by the end of 2024. Türkiye places significant emphasis on the development of renewable energy sources. In alignment with the National Energy Policy of 2017. Increasing the utilization of domestic and renewable energy resources remains a key priority. In the period 2016-2021, the installed power of renewable energy sources increased by 55%. As a result of these efforts, Türkiye ranks 5th in Europe and 12th globally in terms of installed renewable energy capacity. As of December 2024, the distribution of installed capacity by energy sources is shown in Figure 5 (Source: MoENR, 2025).

There therefore remain significant challenges in promoting a transition towards a low-carbon energy system. Türkiye's 2025 Investment Program allocates 1,444.4 billion TL (~40.4 billion USD) to 14,238 projects, with 16.7% of the funding directed to housing, 13.2% to transportation and communication, and %7.6 to the energy sector (SBB, 2025).

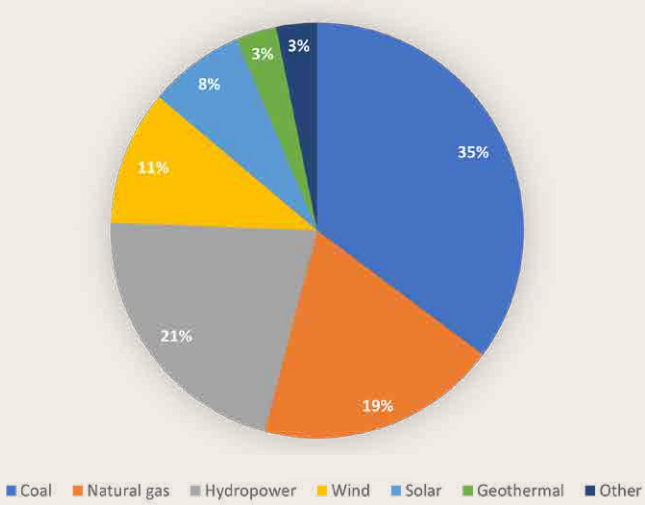


Figure 5. Electricity generation in 2024 in Turkiye (Source: MoENR, 2025)

Policy and regulatory context

Türkiye joined the United Nations Framework Convention on Climate Change (UNFCCC) in 2004 and the Kyoto Protocol in 2009. The adoption of the Paris Agreement on December 12, 2015 marked a pivotal step forward in addressing global climate action beyond the Kyoto Protocol.

In accordance with the Paris Agreement, member countries are required to submit updated Nationally Determined Contributions to UNFCCC every five years. On April 13, 2023, Türkiye submitted its Updated Eight Nationally Determined Contributions to the UNFCCC, committing to a 41% reduction in greenhouse gas emissions by 2030. This target translates to limiting emissions to 695 million tons of CO2 equivalent.

In recent years Türkiye has also undertaken significant policy inititiatives to mitigate climate change and reduce carbon emissions. Some of the most important legislative instruments are listed in Text Box 2. Such initiatives are undoubtedly hugely important in improving energy efficiency and thereby mitigating the impact of climate change. But it is necessary to look elsewhere for guidance on climate adaptation.

Türkiye's climate adaptation strategies

Türkiye has prioritized climate adaptation policies through initiatives such as vulnerability and risk assessments, information system development, and legal and policy instruments. Key legislative and strategic documents guiding these efforts are highlighted.

To enhance coordination and implementation, the Directorate of Climate Change was established on October 29, 2021, under the Ministry of Environment, Urbanization, and Climate Change. The Directorate is responsible for developing and executing national and international policies, strategies, and actions to address climate change adaptation and resilience. Furthermore, it facilitates institutional collaboration and oversees climate-related negotiations.

The National Climate Change Adaptation Strategy and Action Plan (2011-2023) addressed critical sectors, including water resource management, agriculture and food security, ecosystem services, biodiversity, forestry, disaster risk management, and public health. As the plan concluded in 2023, efforts to develop the Climate Change Adaptation Strategy and Action Plan (2024-2030) were initiated under the Enhancing Adaptation Action in Türkiye Project. This project is implemented by the Ministry of Environment, Urbanization, and Climate Change in collaboration with the United Nations Development Programme (UNDP), with co-financing from the European Union and the Republic of Türkiye.

Law on Energy Efficiency (Law No. 5627): Aims to enhance energy efficiency, reduce energy waste, and alleviate economic burdens while protecting the environment.

Regulation on Energy Performance of Buildings: Establishes principles for efficient energy use in buildings and waste prevention.

Regulation on Green Certificate for Buildings and Settlements: Introduces evaluation and certification systems to promote environmentally friendly buildings.

Regulation on Eco-design of Energy-Related Products (EuP): Sets eco-design requirements for products to improve energy efficiency and sustainability.

Law on Land Development Planning and Control (Law No. 3194): Ensures environmentally sound and scientifically planned urban development.

Presidential Circular No. 2023/15 on Energy Saving in Public Buildings: Increases the energy efficiency target in public buildings from 15% to 30% by 2030.

The scope of the 2024-2030 action plan has been expanded to include additional sectors, such as urban development, energy, tourism and cultural heritage, industry, transport and communication, and social development. In total, the updated strategy focuses on 12 sectors:

Agriculture and Food Security

Biodiversity and Ecosystem Services

Water Resources Management

Public Health

Energy

Disaster Risk Reduction

Urban Development

Social Development

Tourism and Cultural Heritage

Transport and Communication

Industry

Cross-Cutting Issues

Through these comprehensive strategies and coordinated actions, Türkiye is demonstrating its commitment to building resilience and addressing the impacts of climate change across various sectors.

While the new action plan for 2024-2030 has expanded its scope to include multiple sectors, the construction sector remains notably absent. This exclusion is significant as the construction sector plays a critical role in enabling adaptation strategies across other sectors. The built environment is closely connected with agriculture, energy, urban development, disaster risk reduction, transportation, and public health, among others.

Therefore, the construction sector is a fundamental part of the solution for achieving adaptation goals. Hence the development of a sectoral road map for the construction sector is of critical importance. It is also important that key stakeholders from within the construction sector are actively involved in production if it is to achieve cross-sectoral recognition.

Key legislative and strategic documents for climate adaptation in Turkiye include:

Environmental Law

Eleventh Development Plan (2019-2023)

Regulation on Strategic Environmental Assessment

National Climate Change Strategy (2010-2023) and Action Plan (2011-2023)

National Climate Change Adaptation Strategy and Action Plan (2011-2023)

Energy Efficiency Strategy and National Energy Efficiency Action Plan (2017-2023)

2053 National Transport and Logistics Master Plan

Türkiye's Green Deal Action Plan

Final Recommendations of the Climate Council

Türkiye's National Energy Plan

Medium-Term Programme (2024-2026)

Twelfth Development Plan (2024-2028)

2053 Long Term Climate Strategy

THE PARTICIPATORY WORKSHOP

The aim of the workshop was to create an interactive platform to raise awareness on climate adaptation and mitigation, explore sectoral perceptions, and co-produce a practical and forward-looking roadmap for resilience in the Turkish construction industry.

A participatory workshop format was deliberately chosen to ensure that diverse voices, experiences, and expertise from across the construction industry were actively engaged. Involving representatives from key stakeholder groups, including public institutions, private sector companies, professional associations, was essential to capture a comprehensive understanding of both systemic challenges, feasible solutions and high priority actions.

Stakeholders spanning different phases of the construction supply chain were brought together to encourage cross-sector dialogue, knowledge exchange, and collaborative problem-solving. This multi-stakeholder approach was grounded in the recognition that climate change is a complex challenge that cannot be effectively addressed in isolation and adaptation requires collective efforts of multiple stakeholders.

In this section, steps of the participatory workshop design will be explained. The Project team organized the workshop with support from the METU Research Coordination Office. The workshop was approved by the Human Research Ethics Committee of the Middle East Technical University, protocol number 0575 ODTUIAEK-2024.

The agenda for the workshop can be found in Appendix I.

The Design of the Workshop

The workshop was planned as a multi stakeholder workshop with 25-30 participants. Invitations were sent to selected companies, institutions, associations (such as Turkish Contractors Association and Association of Turkish Consulting Engineers and Architects), that would represent different stakeholders involved in the Turkish construction sector. 27 participated in the workshop held on November 19th, 2024 at METU Technopark (Etkim Building, Platin 2).

In the invitation letter sent by the ISPF project team, the scope and expectations from the participants were clarified as:

"Climate change, marked by rising temperatures and water scarcity, is a global threat impacting all aspects of life, including the construction industry.

As weather patterns become more unpredictable and the frequency of extreme weather events such as floods and hurricanes become more frequent, the construction industry should not only work to mitigate climate risks through emission reductions and sustainable practices but also prepare for an uncertain future.

Critical questions need to be addressed at company, industry, and national levels, including:

- How will climate change impact health and safety, project duration, and costs?
- Are current design methods, construction practices and existing infrastructure resilient for future climate scenarios, or will there be significant challenges and costs in adapting to these changes?
- How will climate-driven global market uncertainties reshape the industry's dynamics?"

The Workshop

Profile of the Participants

A wide range of participants representing stakeholders, including academics, professionals, and experts, came together for the Climate Risk and Resilience Workshop. A total of 27 participants came from various backgrounds, including public policy, academics, environmental consultancy, and construction. Appendix 2 depicts the stakeholders, their profession/background, and their experience in the sector. The distribution of the stakeholders was balanced among consultants, contractors, and government agencies, except three participants from NGOs (see Figure 6).

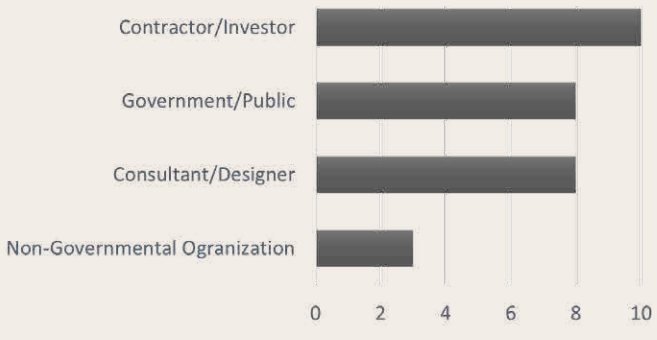


Figure 6. Stakeholders from different groups

The Sessions Conducted at the Workshop

The day started with setting the broader context of climate adaptation, followed by interactive sessions to identify key themes, cluster ideas, and develop adaptation pathways through group discussions and presentations. The workshop concluded with a wrap-up session to synthesize insights and outline the next steps for building sectoral resilience.

Session 1: Defining the context of the workshop

The workshop began with a focused session on defining the context of climate mitigation and adaptation (Figure 7). The session was started by delivering brief presentations about the critical importance of climate adaptation within the construction industry.

The first presentation provided clear definitions of essential terms, such as climate resilience and built environment to ensure a shared understanding among participants. Figures 8 and 9 illustrate key concepts discussed during this session.

A central focus of the session was to clarify the distinction between climate change mitigation and adaptation within the construction industry. Mitigation strategies were explained as proactive measures aimed at reducing greenhouse gas emissions and minimizing the construction sector's impact on global temperature rise.

Examples of these strategies include energy-efficient building designs, the adoption of renewable energy sources, and the use of low-carbon construction materials. In contrast, adaptation strategies were described as measures that enable the construction industry to prepare for and cope with the adverse effects of climate change, such as extreme weather events, rising

sea levels, and shifting climate patterns. These strategies may involve designing infrastructure to withstand floods or earthquakes and retrofitting buildings for greater durability. By emphasizing the distinctions and interrelated nature, the session laid a strong foundation for understanding the dual responsibilities of the construction industry in addressing climate change: reducing its environmental impact while simultaneously preparing for its inevitable consequences.

Figure 7. Presentations at the beginning of the event

Session 2: Let's talk about climate and climate adaptation

In the second session, participants engaged in collaborative brainstorming activities to identify key themes for the workshop. Under the supervision of the event organizers, the participants shared their insights and perspectives using their professional expertise and personal experiences related to climate risk and resilience.

During the brainstorming session, the attendees were requested to think about climate risks in the built environment, related to many aspects, including but not limited to hazards, exposure and vulnerability, and impact on processes, assets, companies, projects, finance, and technology. The experts discussed key topics that should be considered in the climate adaptation agenda of the Turkish construction industry.

Questions to the participants :

i. The challenges:
How will the construction industry be affected by risk of climate change ?

ii. The actions:
What should we be doing now to be resilient to climate risk ?

Each expert was requested to use three Post-its and write a maximum of five words on each. They were also provided with some examples to get some idea about the scope of this task. Some examples were thermal comfort in housing, flood resilience in cities, design standards for water systems, lack of data/information for risk assessment, and competitive dynamics in international markets.

Attendees wrote their topics of interest/topics need attention on post-its, which were then displayed on a shared board. Participants were asked to comment on their post-its as well as the ones raised by the other participants. These discussions were very useful in understanding the underlying assumptions, interrelations between the topics, and meaning behind terminology used by the participants.

The notes were then grouped into clusters according to their relevance. Figure 10 presents the brainstorming session and the clustered post-its. As shown in Figure 10, sixty-one post-its were collected and categorized into seven clusters based on their content: material and methods, impacts, finance, systemic challenges, regulations and standards, design, assessment and management methods, and awareness and coordination. The detailed content of each cluster is provided in Appendix 3.

It is important to note that these clusters are not mutually exclusive and could be organized differently. Due to the dynamic nature of the workshop, an initial clustering was performed to guide the moderators in designing the group activity in the next session of the workshop. A brief description of each cluster is provided below.

Figure 8. Climate mitigation and climate adaptation in the built environment

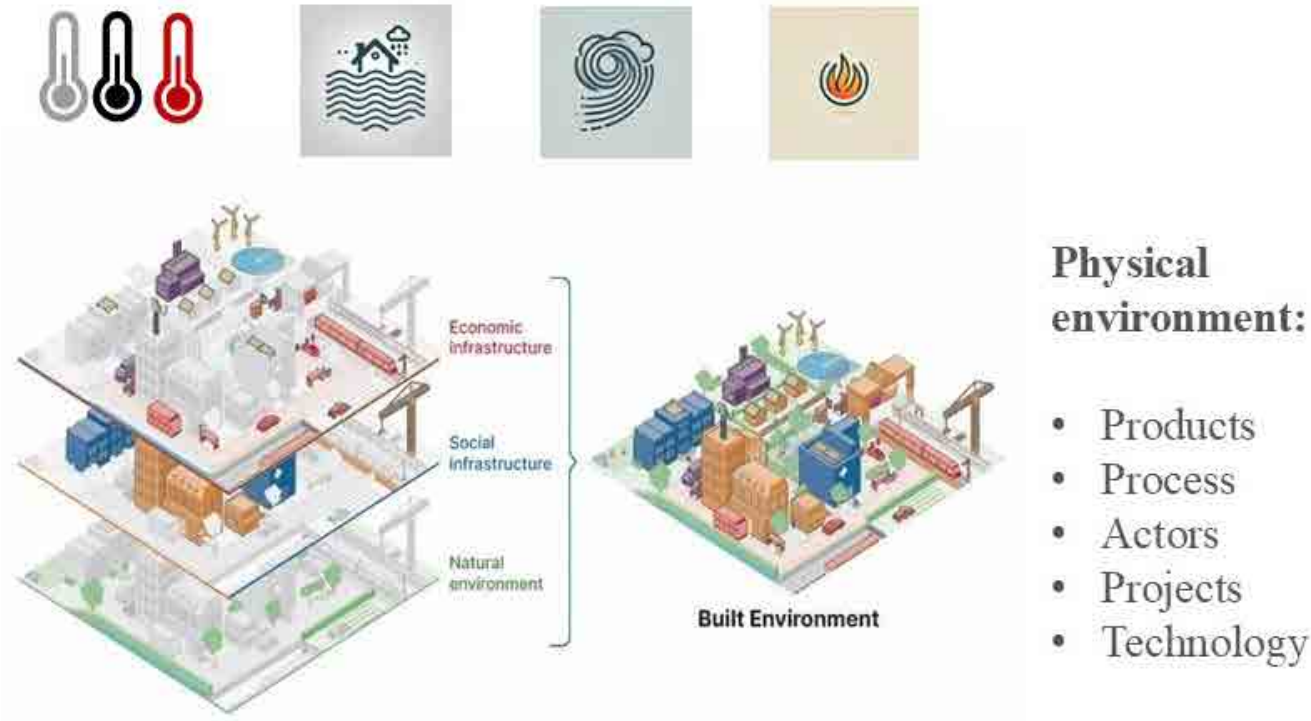


Figure 9. The impact of climate change on the built environment (Source: Cambride Centre for Smart Infrastructure and Construction)

Figure 10. Brainstorming session

THE INITIAL GROUPING OF CLUSTERS

Cluster 1– Material and methods

The first cluster focuses on the critical role of materials, technology and methods in improving climate resilience within the construction industry. Key points include prioritizing energy-efficient and durable materials, minimizing reliance on mechanical HVAC systems, and adopting nature-based solutions as well as technological methods. Additionally, the lack of resilient material standardization, using/finding durable material to extreme hot/cold weather conditions, reliable access to raw material, and adaptability to changing materials and methods in the construction process were highlighted within this cluster.

Cluster 2 – Impacts

The second cluster groups various impacts of climate change on the built environment and construction industry. It captures the increasing frequency of floods, durability against extreme weather conditions, and their effect on project timelines and existing infrastructures. Key concerns include water scarcity caused by high temperatures and evaporation, decreasing water levels in dams, and changes in dam construction. The cluster emphasizes the need to adapt or reconstruct existing structures to be aligned with changing climate conditions. Additionally, reliable renewable energy sources, vegetation management, and consideration of potential positive outcomes arising from climate risks were also discussed within this cluster.

Cluster 3 – Finance

The third cluster focuses on the financial challenges and opportunities associated with climate resilience and adaptation in the construction industry. Key issues include inadequate budget and resource allocation for climate adaptation projects, increased costs of projects due to climate change, and the need for better project evaluation at the feasibility stage. Additionally, the revision of materiality assessments of climate adaptation by financial institutions and regulatory bodies is emphasized. The cluster also highlights the importance of developing new financial tools and strategies to address resilience budgets and overcome funding constraints. The cost increases due to IFIs and DFIs were also discussed in this cluster.

Cluster 4 – Systemic challenges

The fourth cluster focuses on the systemic effects of climate change on Turkish construction industry. Key challenges include disruptions to global supply chains and manufacturing due to unforeseen disasters, affecting material delivery. The cluster highlights the need to adapt design standards to be ready for rising temperatures, floods, and changing precipitation frequencies. Issues such as weak infrastructure, insufficient design criteria, and inaccurate climate predictions are identified as contributing factors to city floods. Additionally, changes in domestic water supply, and the population were captured, and the changing patterns of demand were highlighted.

Cluster 5 – Regulations and standards

The fifth cluster captures the role of regulations and standards in improving climate resilience within the construction industry. It highlights the need for sharing the risks according to different regions and having flood-resilient design standards. A significant concern is the inadequate

or unclear legislation, which heavily affects the design and implementation stages. The cluster emphasizes the importance of integrating climate risk considerations into technical specifications and planning processes to improve the identification of potential impacts in the early stages. Challenges include the failure to implement proposed designs, the lack of new technologies by governmental institutions, and the risks due to rapidly changing regulations. Additionally, the need for better coordination among policymakers is captured.

Cluster 6 – Design, assessment, and management methods

The sixth cluster focuses on integrating climate considerations into design, assessment, and methodology in the construction industry. It emphasizes the importance of aligning architectural design with climate conditions and developing risk assessment frameworks to guide action plans and manage resources, such as time and money, effectively.

Key challenges include the lack of consideration or methodologies for the physical risks of climate change, limited project management tools incorporating resilience, and the absence of a global risk assessment methodology. The cluster highlights the need to consider potential damage scenarios, and data localization, and develop building management dynamics algorithms. Additionally, it highlights the difficulty of relying on past data to predict future risks.

Cluster 7 – Awareness and coordination

The seventh cluster highlights the importance of awareness and coordination in addressing climate resilience within the construction industry. It emphasizes the need to enhance awareness across all levels – from company actors and project personnel to clients and government authorities. Key challenges include a lack of standard terminology, limited knowledge about climate risks, and insufficient communication between institutions. The cluster also points to inadequacies in technical specifications and the problem of sharing data by the governments. It emphasizes the role of governments in conducting research, updating standards based on new information, and finding the finance to start construction.

In Session 2, it is observed that when addressing climate adaptation, considerable attention is given to the key terms of expected climate events and their effects. The most commonly highlighted climate event is the change in the temperatures, followed by disasters, including drought, flood, water scarcity, and finally change in demographics as a result of climate change. Participants highlighted both negative and positive dimensions of systemic effects. For instance, while rising temperatures and extreme weather events were identified as drivers of migration, they were also recognized as catalysts for exploring new settlements. These discussions reinforced the need for adaptive strategies that consider the cascading effects of climate events across sectors, communities, and ecosystems.

The participants mentioned the role of the construction industry in mitigating the climate risk and if mitigation actions are not taken today to minimize emissions and waste, then there will be higher costs to adapt to adverse climate scenarios.

P22, sector manager in a Multilateral Development Bank, stated:

"… the construction industry should now consider how to pay for its share of impact, it should internalize the cost….The materials and methodologies that are not climate friendly can be cheaper now, but they will not be in the future, because they cost more to the environment and society, than they should be taxed, and the cost to the construction companies would be higher. If mitigation efforts are not shown today, higher adaptation costs will be faced tomorrow"

Due to the interconnected nature of climate mitigation and adaptation, co-benefits and trade-offs between decarbonization and resilience actions, the participants mentioned about current mitigation actions such as renewable energy technologies and energy-efficient materials, and discussed whether an energy-efficient material will also be durable and reliable under high temperatures, emphasizing the importance of considering both objectives of sustainability and resilience in the construction industry while developing new technologies and materials.

Session 3. International and national priorities and actions

The workshop continued with a series of presentations on global challenges and adaptation pathways. This session prepared the foundation for the subsequent session in which the participants would re-think about the previously discussed topics after learning more about climate risk and national plans in Turkiye, as well as experiences of other countries, particularly the UK.

In the first part of these presentations (Figure 11), Prof. Dr. Stuart D. Green highlighted resilience as a wicked problem and gave several examples of the consequences of climate change. The necessity for setting resilience standards, and the importance of integrating actions that yield long-term interests over the short-term were discussed in detail. Finally, the presentation concluded with the tentative guideline principles for climate adaptation in the built environment.

Figure 11. Presentation by Prof. Dr. Stuart Green

In the second presentation (Figure 12), Prof. Dr. Irem Dikmen Toker discussed the climate adaptation agenda at three levels: national, business, and project. During this interactive session, attendees suggested adding a fourth level—individual—to the agenda, which was well received. The presentation also examined the UK's Climate Change Act (CCA), adaptation policy and regulations with particular emphasis on adaptation reporting power in the UK.

In the third presentation (Figure 13), Assoc. Prof. Dr. Güzide Atasoy Özcan elaborated on climate risk in different geographical regions of Türkiye, national policies and examples of climate adaptation initiatives, Türkiye's long-term climate strategy and current agenda, highlighting the need for a bottom-up approach for the integrated sectoral outlook towards climate footprint of the built environment.

In the final presentation (Figure 14), Assoc. Prof. Dr. Emre Caner Akçay highlighted critical impact of climate change on specific sectors and assets. He provided a detailed analysis of the impact of climate change on hydropower plants and electricity transmission and distribution infrastructure. The presentation highlighted that climate change will affect hydropower plants through decreased precipitation amounts, fewer rainy days, reduced snow cover, and extreme weather events. Electricity transmission and distribution infrastructure will be impacted by higher temperatures, frost and icing, and strong winds. Dr. Akcay also mentioned about the impact of climate change on the international contracting business by giving specific examples from markets that Turkish contractors are currently working in.

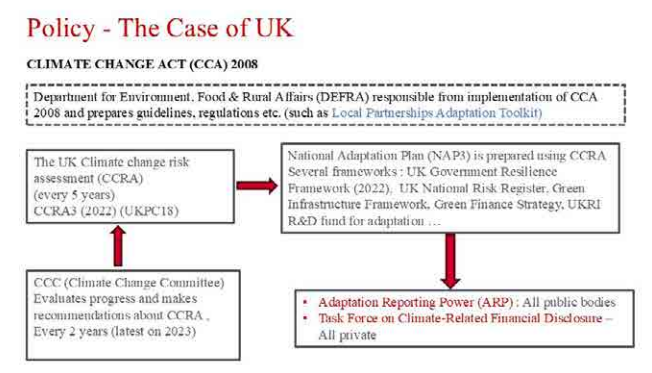


Figure 12. Presentation by Prof. Toker

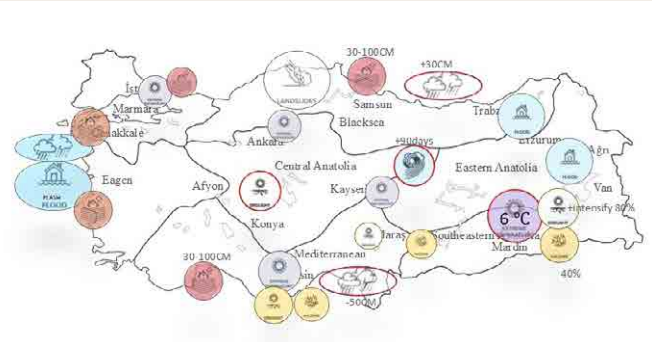


Figure 13. Presentation by Assoc. Prof. Dr. Güzide Atasoy Özcan

Figure 14. Presentation by Assoc. Prof. Dr. Emre Caner Akçay

Sessions 4, 5, and 6: Let's focus on key areas

After the presentations by the moderators, participants engaged in further discussions, under the moderators' supervision, to identify the key areas/priorities for further exploration of climate adaptation in the Turkish construction industry. Discussions during this session helped to reorganize the initial clusters so that participants work on "high priority" topics to formulate strategies for adaptation.

To determine the topics for group activity, the initial clusters were reorganized considering the interrelationship between the clusters and priorities highlighted by the participants during discussions. Participants were presented with five main topics related to climate adaptation and resilience: Business, Finance, Governance, Infrastructure, and Projects. However, the business topics, including international contracting and company management, were not given priority by the participants. The emergence of high priority themes is shown in Figure 15.

Accordingly, the participants were divided into four groups based on their interests and expertise also considering the issue of diversity (Table 1 and Figure 16).

Figure 16. Dividing the participants into four groups

Table 1. Participants representing different stakeholders in each group

WORKSHOP GROUPS	THEME	PARTICIPANTS	STAKEHOLDER REPRESENTATION
G1	Infrastructure	P3, P12, P14, P16, P25, P26	Government/Public (1) Contractor/Investor (2) Consultant/Designer (3)
G2	Finance	P8, P9, P11, P13, P20	Non-Governmental Organization (1) Government/Public (1) Contractor/Investor (3)
G3	Governance	P1, P2, P5, P7, P10, P18, P24	Government/Public (3) Consultant/Designer (4) Non-Governmental Organization (1)
G4	Projects	P17, P19, P21, P6, P23	Government/Public (3) Contractor/Investor (2) Non-Governmental Organization (1)

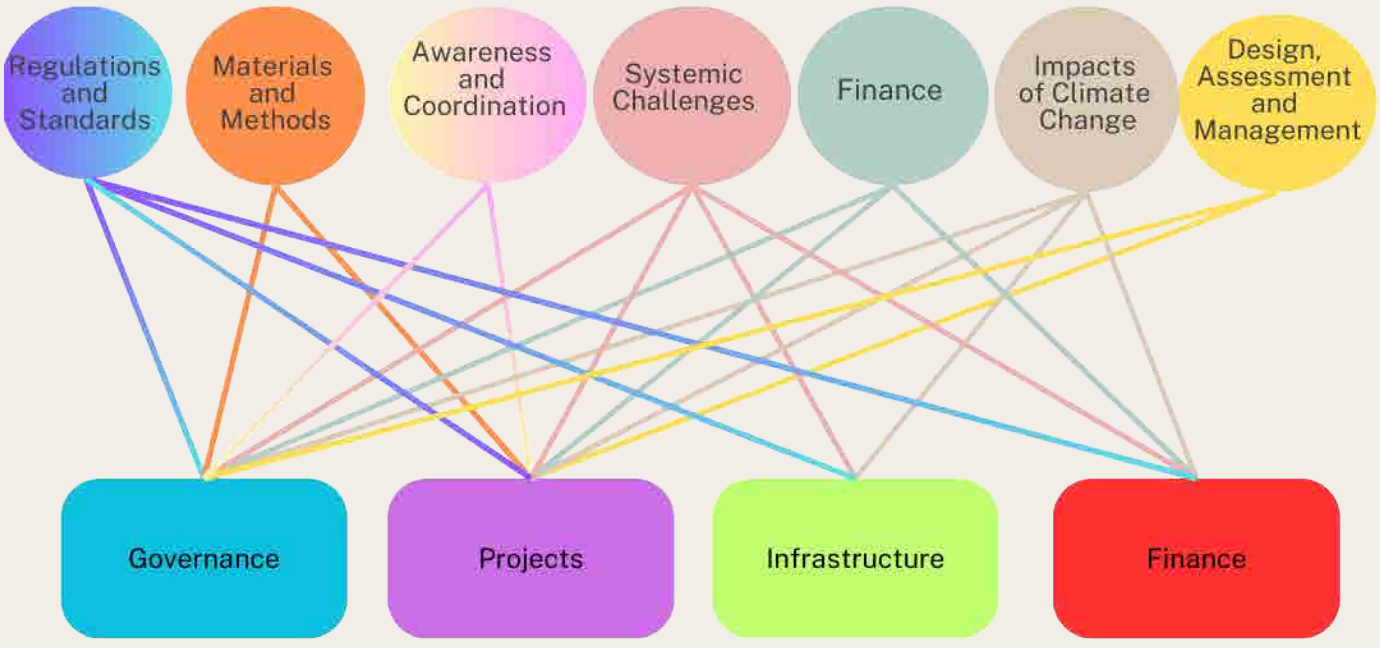


Figure. 15 The high priority themes that emerged during the workshop

The groups were given approximately one hour to discuss their thoughts within their groups and write down the key notes on the flip charts. In this part, the participants were requested to consider the stakeholders, roles, and responsibilities towards climate adaptation and discuss the actions that should be taken or the strategies that should be developed to enhance resilience. After the discussions, each group prepared a 10-15-minute presentation to summarize their insights and perspectives (Figures 17 - 20).

The group presentations provided valuable insights into climate adaptation in the construction industry, emphasizing both individual and organizational pathways. Key themes from the discussions included priority areas, balancing mitigation and adaptation, sustainability vs resilience, the cross-cutting role of data, and the critical influence of governance and finance. The discussions underscored that inaction is not an option—climate challenges will intensify, leading to more severe impacts from extreme events. Addressing these issues within a defined timeframe is imperative, as they represent one of the most pressing problems humanity faces.

The groups were asked to respond to the below questions:

Governance: How can the construction industry be more resilient to climate change?

Project management: How can the construction projects be made resilient to climate change?

Infrastructure: How can infrastructure be made resilient to climate change?

Figure 17.Presentation by the Governance group

Figure 18.Presentation by the Infrastructure group

Figure 19.Presentation by the Projects Group

Figure 20.Presentation by the Finance group

WORKSHOP FINDINGS

THE FINANCE GROUP

The Finance Group preferred to structure their recommended actions considering the "actors" and timeframe as "short-term" and "long-term." The short-term actions that need to be taken by the actors, which are government, local authorities, and private companies are discussed as well as a longer-term recommendation on establishing an independent climate change authority as a leading actor for climate actions.

The Group mentioned that the Government has a central role in funding climate resilience projects, including new infrastructure projects and climate-proofing the existing assets. It has been discussed that the government should have a strategic long-term investment plan to prioritize resilience projects. In the short term, the Government should:

- Prepare a plan considering alternative climate scenarios
- Identify priorities
- Develop financial mechanisms and incentives
- Find and allocate budget to resilience projects considering priorities

Critical role and urgent action by the Government was highlighted as

"*updating the standards considering climate change and preparing technical regulations to ensure climate resilience.*"

Without these standards and regulations, it would be challenging to design resilient infrastructure systems and conduct a realistic feasibility study that is needed to ensure cost-effectiveness and raise finance.

The Group proposed that:

1. The government issues climate resilience bonds and/or catastrophe bonds to fund investments for climate-proofing and resilience-building projects as in other countries such as Jamaica. The Group discussed that disaster funds can also be leveraged for climate adaptation projects.

2. The government funds projects through taxes such as carbon taxes from the private sector.

3. The government gives guarantees and incentives for the project life cycle to share climate risks in public-private partnership projects.

4. In the short term, private investors and local authorities such as municipalities should raise funding for urgent climate resilience projects. For example, municipalities can utilize international partnerships and International Financial Institutions such as Multilateral Development Banks and Regional Development Banks to initiate projects within this domain. The EU Climate ADAPT project and the Covenant of Mayors Initiative on Adaptation to Climate Change were given as an example.

The Group also proposed that a long-term strategy is needed to ensure that necessary investments can be made for climate resilience. Their proposal is to establish an independent body, which is a central authority, to develop policies and enforce regulations for climate mitigation and adaptation, and provide scientific, technical, and policy advice on climate action, which is similar to the UK's Climate Change Committee.

The Central Climate Change Authority (CCA) was defined as an independent regulatory body that represents all stakeholders such as the government, private sector, and NGOs. CCA will ensure transparency, credibility, and effectiveness

By providing long-term and evidence-based strategies, CCA can reduce uncertainty for investors. CCA proposed by the Finance Group can advocate for the issuance of climate resilience bonds and the introduction of incentives to attract more funds for climate projects. CCA as an independent body that is accountable and has transparent reporting on the use of funds and outcomes of climate projects can facilitate raising funds from investors, especially from international markets and global financing mechanisms such as the Adaptation Fund.

A visual representation of each group's recommendations as a part of climate adaptation pathways is given in Figures 21 to 24.

THE INFRASTRUCTURE GROUP

The Infrastructure Group concentrated its efforts on defining the actions for climate adaptation by considering the infrastructure systems of municipality services and railway/highway projects. For these two branches, the group discussed short-term and long-term actions to be taken and the responsible parties for the implementation of these actions.

Infrastructure systems of municipality services in the analysis of this group involved stormwater collection, wastewater treatment, drinking water provision services, and the networks used for these purposes.

To adapt these services to changing climate conditions, the group proposed that regional strategic (action) plans be devised by the joined efforts of municipalities, institutions such as State Hydraulics Works (DSI) and Ilbank, and the Ministry of Environment, Urbanization and Climate Change.

In addition, the following short-term actions were proposed, for which the aforementioned governmental bodies and institutions are pointed out as responsible parties:

- Decisions on climate adaptation efforts should be made together with the participation of relevant stakeholders,
- Current/installed capacities of the infrastructure systems should be determined,
- Current technologies should be explored to determine the needs for their potential implementation,
- Financing conditions for climate-resilient solutions in infrastructure systems should be investigated.

The group also put forward a set of long-term actions, some of which are preceded by the proposed short-term actions. Adaptation and implementation of new technologies for enhancing the capabilities of the infrastructure systems to tackle climate adaptation is one of the prominent suggestions by the group, and this long-term action encapsulates the other proposed long-term actions, namely:

- Digitalization of the infrastructure networks in use,
- Management of water losses especially in potable water networks,
- Implementation of more efficient storm water harvesting systems,
- Utilizing renewable energy sources to address increasing energy demands of infrastructure systems.

Discussions of the infrastructure group on the actions related to railway/highway projects were concentrated on using tunnel boring machines (TBMs) for subway and highway tunnels, and surface construction works of these projects.

Construction companies, the government, and employers (municipalities, ministries, Directorate-General of Infrastructure Investments, etc.) are listed by the group as responsible parties for the implementation of proposed short-term and long-term actions.

The short-term actions suggested by the group are as follows:

- Determination of possible design changes in railway/highway projects necessitated by changing climate conditions,
- Exploration of improvements to ventilation conditions in subway systems and tunnels,
- Research and development efforts on technologies which could decrease the use of natural resources in these projects,
- Assessing the effectiveness of culverts and bridges in changing climate conditions,
- Implementation of systems to monitor the construction and operation of railway/ highway projects,
- Collection of local data on expected rates of resource consumption in these projects,
- Planning of meetings with the stakeholders of these projects.

The proposed long-term actions, some of which are rooted in the aforementioned short-term actions, are as follows:

- Use of heat-resistant products on railways to mitigate increased temperatures
- Implementation of technologies that could eliminate water consumption,
- Changes to the requirements outlined in technical specifications,
- Selection of climate-resilient materials in railway/highway projects,
- Provision of financial resources for climate adaptation efforts in these projects,
- Initiation of necessary legislative changes.

The actions and responsibilities outlined by the infrastructure group can be mapped to the duties and responsibilities assigned to the Central Climate Change Authority (CCA), which is proposed by the Finance Group and thought of as an independent body to develop policies and regulations for climate adaptation, in order to facilitate the sharing of roles and responsibilities among the parties with a sound and thorough methodology. A visual representation of Group's recommendations as a part of climate adaptation pathways is given in Figure 22.

The lack of infrastructure registry and asset management data is a crucial barrier to assess current vulnerabilities and take action for climate adaptation.

Data governance and use of digital technologies is needed to assess and manage resilient infrastructure systems.

Since water scarcity is considered to be one of the most critical scenarios in the context of climate change, urgent actions are needed to set up monitoring systems, determine the leakage/water loss, and digitalize the network for smart water management.

THE GOVERNANCE GROUP

Approach of the Governance Group to the vulnerabilities of the construction industry in its efforts towards climate adaptation involved recommended actions under the categories of Data-Related Requirements, Regulations, Communication and Coordination, and Climate Adaptation Methods. Parties or stakeholders expected to undertake these actions are explicitly stated for a number of actions, and these parties include but not limited to governmental bodies, construction companies, and international financial institutions.

Actions and issues listed under the category of Data-Related Requirements are as follows:

- A mutual understanding of the data required for climate adaptation,
- Data collection techniques,
- Data sharing platforms,
- Organizational data needs,
- Data management awareness,
- Data security mechanisms,
- Creating and expanding the data network,
- Tools to validate data,
- Data coordination among different departments,
- Cost overrun, time delay, and quality data on the impacts of climate change on the construction companies (by considering project performances) can be collected by governmental bodies.

The category of Regulations discussed by the Governance Group included the following issues and actions:

- Local and global regulations are required to be developed for climate adaptation,
- Education and training efforts on technical standards,
- Revision of tender requirements based on new regulations,
- Defining new penalties and the execution of the related rules and regulations for these penalties,
- Educational courses on climate adaptation should be integrated into curricula at all levels of education, from elementary schools to universities,
- Defining local energy sources,
- Collaboration with Multilateral Development Banks (MDBs).

Actions and issues listed under the category of Communication and Coordination are as follows:

- Climate adaptation committees at the company level, which could be regulated by governmental bodies or financial institutions,
- Climate risk and resilience workshops for small and mid-size construction companies in order to expand their knowledge base on these risks,
- Lessons-learned and best practice studies on climate risk and resilience conducted by large construction companies to be shared with small construction companies,
- Roles and responsibilities among different departments within construction companies,
- Founding an advisory board by the relevant ministries with representatives from construction companies that could facilitate an exchange of experiences on the implementation of climate change adoption strategies,
- Awareness + knowledge base expansion campaigns to be launched in schools, company departments, committees, and public authorities, which are intended for conveying the necessity of climate adaptation strategies.

THE PROJECTS GROUP

The Project Management Group has developed comprehensive recommendations to enhance resilience across all phases of the project lifecycle. These strategies aim to address climate-related challenges and facilitate the integration of climate adaptation measures. Below is a detailed breakdown of these recommendations, categorized by project phase.

1. Feasibility Phase

- Assess Financial Impact of Climate-Related Hazards
  - Conduct detailed studies on geographical conditions to evaluate financial risks associated with climate-related events.
- Incorporate Nature-Based Solutions
  - Explore and integrate nature-based solutions during feasibility analyses.
- Address New Climate Conditions and Predictions
  - Perform Environmental Impact Assessments (EIA) and Strategic Environmental Assessments (SEA).
  - Compare design alternatives to optimize climate change adaptation and mitigation.
- Engage Stakeholders and Build Networks
  - Establish networks to address employer requirements, governmental concerns, and community demands.
- Enhance Human Resource Capacity
  - Employ experienced personnel and provide regular training on climate-resilient project management.

2. Design Phase

- Develop Climate-Responsive Designs
  - Customize designs for local climate conditions, using passive strategies to minimize mechanical dependencies.
- Utilize Advanced Construction Materials
  - Select materials that are circular and environmentally friendly to enhance sustainability.

- Adopt Modern Methods of Construction
  - Employ sustainable construction techniques that generate less waste compared to traditional methods.

3. Planning Phase

- Revise Health, Safety & Environmental (HSE) Planning
  - Update HSE procedures to incorporate climate considerations.
- Reconsider Manpower and Equipment Planning
  - Adapt plans for manpower and construction equipment to address climate-related needs (including night shifts).
- Integrate Climate Considerations into Cost Planning
  - Account for potential increases in indirect costs, such as insurance and financial requirements (e.g., All Risk policies, bonds).

4. Supply Chain Management

- Ensure Resilient Supply Chain Operations
  - Select material suppliers and subcontractors based on their capacity to address climate adaptation needs.
- Promote Resilient Manufacturing and Delivery
  - Focus on manufacturing and delivering project materials and equipment designed for resilience under climate impacts.

5. Construction Phase

- Provide Climate-Adapted Tools and Equipment
  - Equip sites with tools and machinery suitable for extreme weather conditions.
- Select Experienced Subcontractors
  - Engage subcontractors with proven ability to adapt to climate challenges.
- Safeguard Contractual Rights
  - Protect contractual rights related to claims and additional works arising from climate change impacts.

6. Monitoring and Evaluation

- Establish a Dedicated Monitoring Team
  - Form a team to periodically evaluate all project management processes with a focus on climate change resilience.
- Provide Feedback for Future Projects
  - Regularly report findings and recommendations to inform future projects.

7. Maintenance and Handover Processes

- Enhance Maintenance Team Training
  - Train maintenance teams to handle extreme weather events and evolving climate conditions.

8. Learning From Projects (Post-Project Appraisal)

- Document Institutional Knowledge
  - Maintain detailed records of actions and progress to build institutional capacity.
- Provide Recommendations for Future Projects
  - Compile lessons learned and actionable insights to improve resilience in upcoming initiatives.

The group emphasized the importance of adopting modern methods of construction (MMC) to enhance the resilience of projects as outlined in Text Box 6.

For example, in regions experiencing extremely hot weather conditions, such as Saudi Arabia, modular construction can offer significant advantages. This method not only reduces construction time but also minimizes the need for water, making it particularly suitable for arid climates.

A visual representation of the Project Management Group's recommendations as part of climate adaptation pathways is provided in Figure 24.

Another critical point raised by the group was the increasing importance of human resources in project management for climate-resilient projects. The complexity of climate-related challenges requires highly skilled and experienced professionals. The group recommended the employment of specialized personnel and the provision of periodic training programs to build the capacity needed for effective climate adaptation and mitigation.

Developing climate-responsive designs was also highlighted. Customizing designs for local climate conditions and using passive strategies to minimize reliance on mechanical systems can lead to more sustainable and adaptive infrastructure. These designs leverage local knowledge and environmental factors, reducing energy consumption and increasing overall project efficiency.

The group also underscored the financial implications of climate risks on future projects. As climate-related hazards intensify, project costs are expected to rise. This includes potential increases in indirect costs, such as insurance premiums and financial requirements, as well as direct costs related to the adaptation and mitigation measures. Developments in finance and contractual arrangements are critical for risk and cost sharing due to climate change.

Finally, the group identified supply chain management as a critical aspect of ensuring project resilience in the face of climate-related challenges. Ensuring resilient supply chain operations was emphasized as a priority. This involves selecting suppliers and subcontractors with the capability to address climate adaptation needs effectively. By partnering with stakeholders who demonstrate a commitment to resilience, projects can reduce vulnerabilities associated with delays, shortages, or compromised material quality due to climate impacts.

The methods proposed to address vulnerabilities related to climate adaptation in the construction industry were:

- Project management methods and tools should be developed to incorporate sustainability and climate adaptation in budgeting, planning and quality assurance activities in construction projects, and standards should be devised for the use of these methods and tools by governmental bodies,
- Generic risk breakdown structures and climate adaptation strategies to be used by construction companies can be formed by the Ministry of Environment, Urbanization and Climate Change,
- Methods for collecting and storing building energy efficiency data should be explored,
- Supply-demand methods for energy,
- Sustainable efficiency methods,
- Incorporating climate adaptation into project selection/bidding processes by introducing evaluation criteria for the climate adaptation level of bidding companies, which could be checked by examining financial data, technical background and project delivery performance,
- Methods for climate adaptation monitoring, control and compliance,
- Methods to employ artificial intelligence (AI) in climate adaptation.

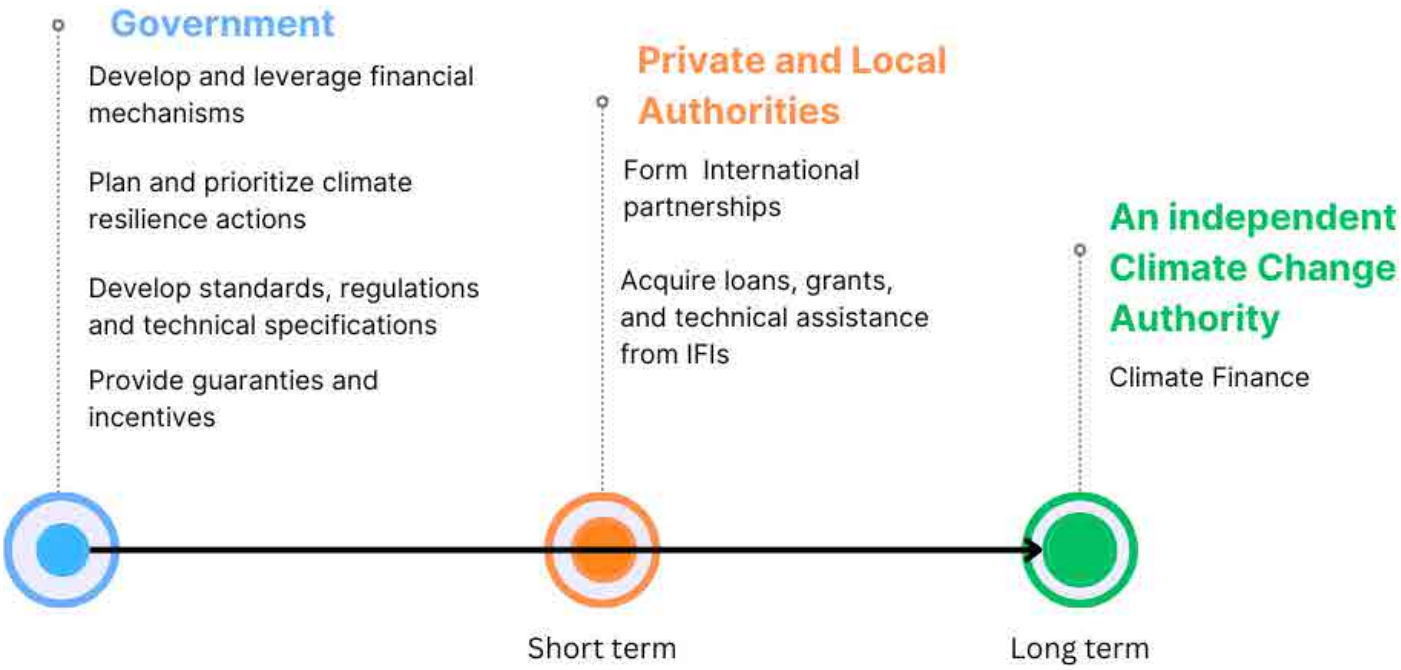


Figure 21. Finance Outlook

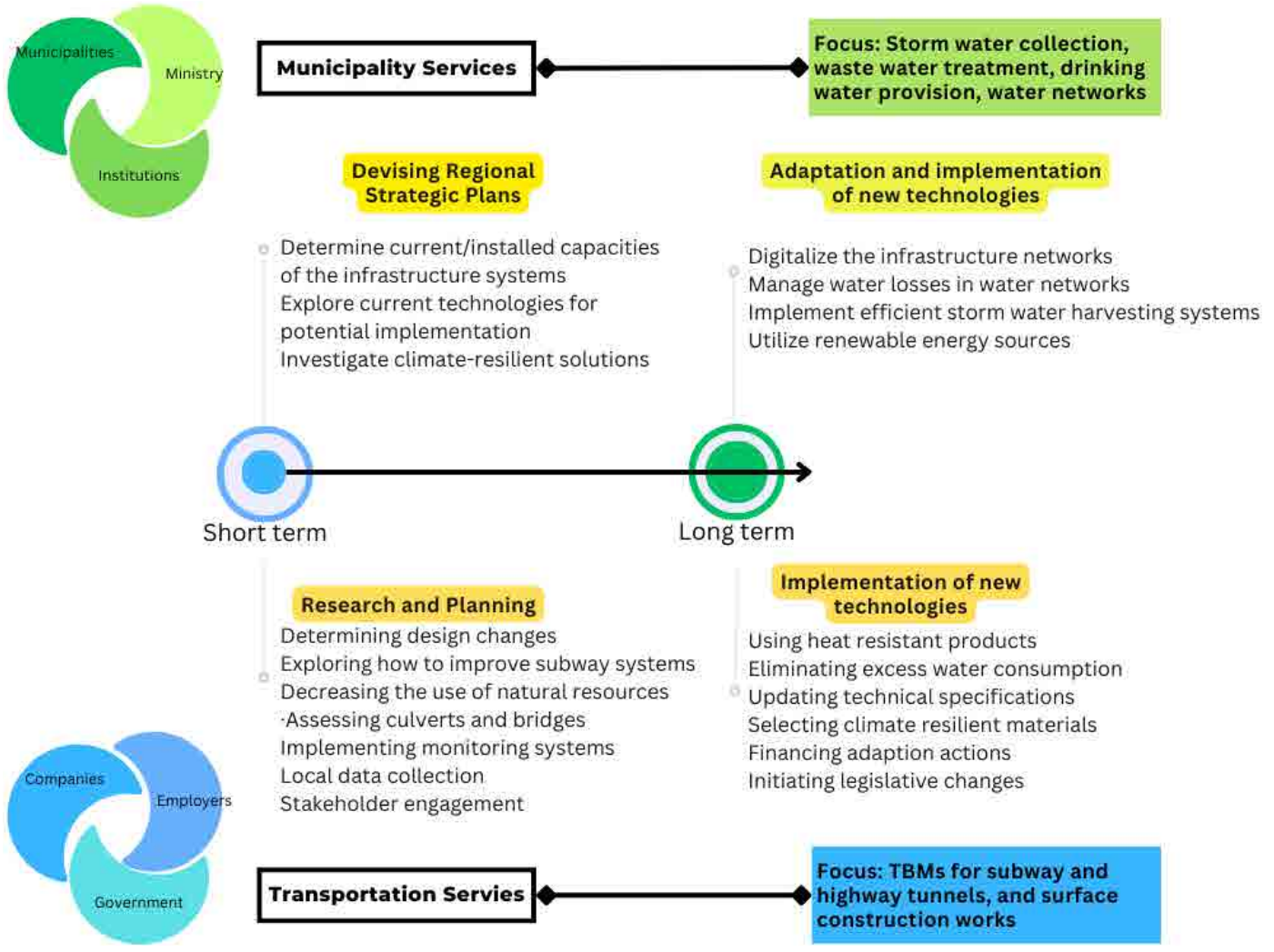


Figure 22. Infrastructure Outlook

Figure 23. Governance Outlook

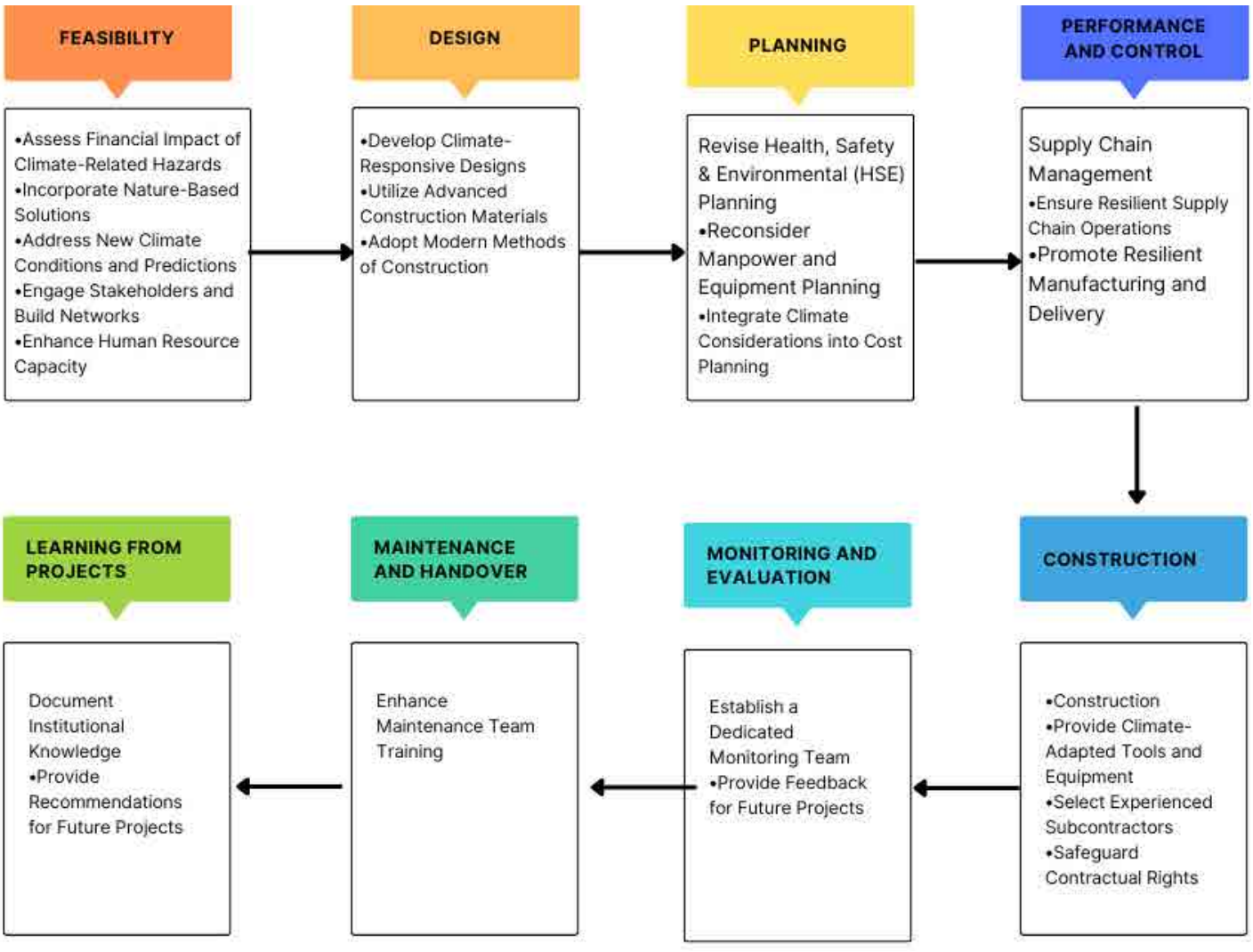


Figure 24. Project Management Outlook

DISCUSSION OF FINDINGS

The participatory workshop provided a valuable platform for stakeholders to engage in collaborative dialogue, exchange insights, and co-produce preliminary adaptation pathways for the Turkish construction industry.

Analysis of the clustered themes, group outputs, and visual summaries (Figures 21 to 24) reveal several overarching themes and common challenges, as well as critical actions needed to enhance climate resilience across the sector. Table 2 details adaptation pathways, divided into specific actions identified by the four groups. In Table 2, long-term action plans are shown in black; while the short term actions are shown in blue.

Findings demonstrate that climate adaptation for the Turkish construction industry requires an integrated, multi-level approach, and the initial and urgent need is strategic adaptation planning. All groups agreed that a strategic long-term investment plan should be prepared by the government to prioritize resilience projects and reduce uncertainty for investors and regional climate adaptation plans should be prepared. The common and prominent strategic actions identified in the workshop are summarized in Figure 1.

The significance of climate-resilient infrastructure systems requires physical adaptation because uncertainty over future climate conditions presents a significant investment risk, requiring credible long-term adaptation plans. Managerial and planning pathways highlight the lack of a central coordinating body tasked with overseeing climate adaptation efforts in the construction sector. Fragmented governance structures and limited cross-agency communication can hinder the sector's ability to plan and act strategically. In response, the establishment of a central Climate Change Authority (CCA) can facilitate the development of climate-related regulations, coordination, and communication among stakeholders. Developing climate-responsive design guidelines and incorporating climate risk criteria into procurement and tendering processes

criteria into procurement and tendering processes can ensure that climate adaptation actions are contractually binding, and risks are shared. Since one recipe does not work for all, regional and organizational adaptations should reflect local conditions, vulnerabilities, and community needs.

Across all groups, there was widespread agreement on the critical need for reliable, localized climate data to support risk assessments, feasibility studies, and climate-informed design and construction processes. Adaptation to climate change, through information pathways highlight the need for standard terminology, and localized and reliable data for effective communication and coordination between policymakers, institutions, and stakeholders. Financing Climate Adaptation requires diverse and innovative financial instruments to fund climate adaptation investments across the construction supply chain, including climate resilience bonds, carbon pricing mechanisms.

Setting up data and monitoring systems, conducting climate vulnerability audits of existing infrastructure and enhancing digital monitoring of infrastructure performance to detect climate-related stresses in real time is as significant as capacity building. Awareness campaigns, training, education system reforms are an integral requirement for setting the foundation towards climate adaptation. Finally, discussions across all groups highlighted the transformative potential of digital technologies in enabling climate adaptation.

Table 2. Summary of adaptation strategies proposed by the groups

	FINANCE GROUP	INFRASTRUCTURE
Physical Infrastructure: Physical Adaptation	Climate-proofing existing assets and new infrastructure	Resilient water and transportation syst materials and ventila Management of water storm water harvestin Using renewable and l
Capacity Building: Education and Training for Adaptation		
Management and Planning: Institutional adaptation	An independent Climate Change Authority (CCA) for scientific, technical and policy advice on climate action	
Financing: Economic adaptation	Climate resilience bonds Resilience projects funded through carbon taxes Climate risk sharing between government and private sector in PPP	Innovative finance for climate adaptatio
Policy: Regulatory adaptation	Updating the standards and regulations for climate resilience	Regional climate ada be prepared. Design standards upd highway design
Collaboration: Collaboration for adaptation	Municipalities establishing international partnerships to initiate resilience projects (EU funds)	Collaboration betwee government bodies (prepare regional acti Decision-making on relevant stakeholders
Information: Data for adaptation		Registry of assets Database of curr infrastructure system Data about resour projects Asset management d
Technology: Technology for adaptations		Digitalization of the in Technology to minim natural resource cons
Practice and Behavior: Project management adaptation		
Monitoring Systems: Monitoring and Control for Adaptation		Implementing monitor construction and oper

GROUP	GOVERNANCE GROUP	PROJECTS GROUP
ems (heat-resistant tion) losses, more efficient g systems. ocal energy sources.		Climate responsive and passive design. Construction sites and supply chains made resilient to climate change
	Education and training in companies on climate change and adaptation Climate change training integrated into curricula from elementary schools to universities	Regular training to professionals on climate-resilient project management.
	Climate adaptation committees at companies and advisory boards at ministries. New roles and responsibilities regarding climate change in construction	
mechanisms needed n		Increased cost of infrastructure due to climate change.
ptation plans should dated for railway and	Project management standards should be updated Climate change actions considered during tendering	Health, Safety & Environmental Planning regulations be updated
en municipalities and DSI, Ministries etc) to on plans climate action by all s	Collaboration with MDBs Collaboration and knowledge exchange between government bodies and industry	Community engagement
ent conditions of s ce consumption in ata	Define data required for climate adaptation Government can collect project data to assess impact of climate change Climate risk breakdown structure developed by the Ministry	Lessons learned databases in companies on climate risk mitigation in projects
frastructure networks ize waste, water and sumptions.	Technology to collect and store building energy efficiency data Use of AI for climate resilient projects	Advanced materials and technology for sustainability and resilience
	Learning from climate risk events in projects to develop resilience in future projects	Incorporate climate resilience into feasibility studies, design, resource planning, cost estimation, supply chain management and contracts. Utilise modern methods of construction to minimize the impact of weather events
ring systems for ations	Methods for climate adaptation monitoring, control and compliance	Dedicate teams to monitor climate change resilience

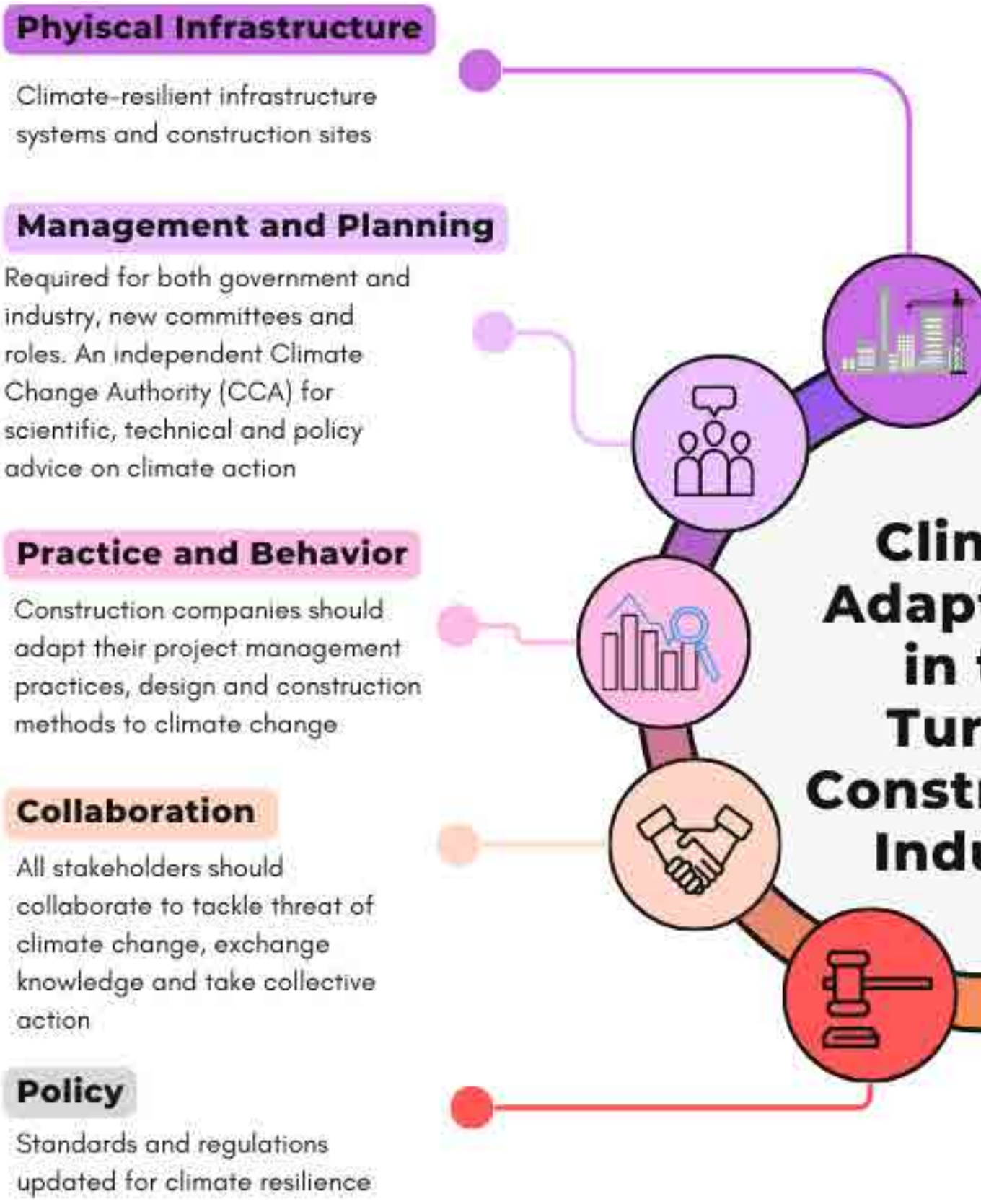


Figure 1. Adaptation strategies for the Turkish construction industry

Financing

Finance is urgently needed for climate-proofing of existing infrastructure and new infrastructure projects, new mechanisms are needed such as climate resilience bonds

Information

Institutional level data requirements be defined, digital asset registries, and climate risk checklists be developed

Monitoring System

Climate change, resilience, and adaptation related monitoring systems be developed

Capacity Building

Awareness raising and developing human resources necessary at all levels

Technology

Climate-resilient materials, digital technology and AI for climate resilience in infrastructure systems

CONCLUSIONS

The participatory workshop highlighted the urgent need for a coordinated and forward-looking approach to climate adaptation in the Turkish construction industry. As climate risks intensify, the sector must evolve from reactive responses to proactive planning, integrating climate adaptation considerations into project design, infrastructure planning, regulatory frameworks, financing mechanisms, and organizational practices. Failure to do so will increase the vulnerability of critical infrastructure, raise project costs, disrupt supply chains, and lead to social and economic losses.

The workshop's collaborative process reinforced the importance of multi-stakeholder engagement, bringing together government, industry, and academia to co-develop realistic and actionable adaptation pathways. Key takeaways include:

- Climate proofing of existing infrastructure and developing new climate resilient infrastructure systems is key to enable systemic climate resilience in the country.
- The need for clear, climate-informed design standards and technical regulations, reflecting updated risk assessments and future climate scenarios.
- The establishment of an independent Climate Change Authority to oversee data collection, facilitate cross-sectoral coordination, and ensure climate risks are systematically addressed in policy and practice.
- The development of dedicated climate resilience financing instruments, supported by transparent reporting and risk-sharing mechanisms, to mobilize public and private investment.
- Capacity building and training to enhance climate risk literacy across the sector, from senior executives to project managers and site teams.
- Developing data governance systems and embracing digital technologies to enhance resilience.
- Exploring new methods, technologies and principles of construction project management, project delivery systems and supply chain management needed to ensure that projects are resilient to climate change

Stakeholders of the Turkish construction industry envisions a climate-resilient construction sector that proactively adapts to evolving climate scenarios while supporting sustainable economic growth, environmental consciousness, and social well-being.

Through collaborative governance, innovative financing, and knowledge-driven practices in projects and infrastructure investments, the construction industry will play a leading role in building safe, adaptive, and sustainable future. By aligning sectoral adaptation pathways with national climate strategies and global sustainability goals, the Turkish construction sector can become an integral part of climate resilient development.

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LIST OF TABLES

LIST OF FIGURES

APPENDIX I

Workshop Agenda

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Adaptation to Climate Change: Turkish Construction Industry

Workshop

NOVEMBER
19,2024

Today's Agenda

9:30 - 9:45	Welcome
9:45 - 10:00	Session 1. Defining the context: Climate mitigation and adaptation
10:00 - 11:00	Session 2. Setting the agenda of the day: Brainstorming on workshop themes
11:00-12:00	Session 3. Presentations: Global challenges and adaptation pathways
12:00-12:45	Lunch break
12:45-13:15	Session 4. Clustering the themes
13:15-14:15	Session 5. Climate Adaptation Pathways (1): Groupwork
14:15-14:30	Coffee break
14:30-15:30	Session 6. Climate Adaptation Pathways (2): Group presentations
15:30-16:00	Session 7. Wrap-up: Towards the construction industry roadmap

APPENDIX II

Profile of the participants

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Part. ID	Stakeholder Type	Role/ Profession	Experience (years)
P1	Government/Public	Environmental Engineer	1-4
P2	Government/Public	Senior Civil Engineer/Overseas Operations Chief	5-9
P3	Government/Public	Planning Branch Manager	15-19
P4	Consultant/Designer	Enterprise Resource Planning (ERP) Coordinator	>20
P5	Consultant/Designer	Mechanical Installation Manager	>20
P6	Contractor/Investor	Business Control & Risk Management Director	>20
P7	Consultant/Designer	International Tenders & Business Development Manager	10-14
P8	Contractor/Investor	ESG (Environment, Social, Governance) Director	15-19
P9	Non-Governmental Organization (NGO)	Board Member	>20
P10	Consultant/Designer and Non-Governmental Organization (NGO)	Hydrologist	>20
P11	Contractor/Investor	Deputy General Manager	15-19
P12	Environmental Consultant	Environmental Engineer	10-14
P13	Contractor/Investor	Managing Director/Board Member	15-19
P14	Contractor/Investor	Deputy Corporate HSE (Health, Safety, and Environment) Manager	10-14
P15	Contractor/Investor	Civil Engineer	15-19
P16	Contractor/Investor	Environmental Manager	15-19
P17	Contractor/Investor, and Non-Governmental Organization (NGO)	Technical Office Chief	5-9
P18	Consultant/Designer	Founder & Consultant	10-14
P19	Government/Public	Grant Manager	15-19
P20	Government/Public	Grant Manager	15-19
P21	Government/Public	Civil Engineer	10-14
P22	Contractor/Investor	Project Management	>20
P23	Government/Public	Business Owner	>20
P24	Government/Public	Transportation Costs and Efficiency Branch Manager	>20
P25	Consultant/Designer	Coordinator	15-19
P26	Consultant	ESG expert	1-4
P27	Contractor/Material Supplier	Project Manager	>20

APPENDIX III

Clusters of Post-its

Table A1.1: Post-its, Cluster 1 – Material and methods

Cluster	Post-it	Content
Materials	M1	• Inefficient usage of materials, sources, equipment, etc. • Energy-efficient equipment materials shall be prioritized.
Materials	M2	Storage of construction materials on site (extreme weather conditions)
Materials	M3	Minimization of mechanical HVAC requirements
Materials	M4	Use nature-based solutions rather than technology and material
Materials	M5	Lack of resilient material standardization
Materials	M6	Use/find durable material for extreme hot/cold weather
Materials	M7	Reliable access to raw material
Materials	M8	Construction processes, materials, and methods are changing

Table A1.2: Post-its, Cluster 2 - Impacts

Cluster	Post-it	Content
Impact	I1	Flood frequency-changing
Impact	I2	Reliable renewable energy sources
Impact	I3	Durability against extreme weather conditions
Impact	I4	High-temperature High evaporation Decreasing of water levels in dams Changes in dam construction Water scarcity
Impact	I5	Asset – Existing structures and need for adaptation/re-construct
Impact	I6	Vegetation management
Impact	I7	Project delays due to extreme weather events
Impact	I8	Any positive impact of climate risk

Table A1.3: Post-its, Cluster 3 – Finance

Cluster	Post-it	Content
Finance	F1	Budgeting – Allocation of proper sources
Finance	F2	Lack of funding for climate adaptation projects

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Finance	F3	Evaluation of the projects at the feasibility stage
Finance	F4	Financial issues – (Adaptation to change in regulation, etc. needs funds)
Finance	F5	Lack of financial resources to allocate climate adaptation
Finance	F6	Revision of materiality assessment of climate adaptation by finance institutions and regulatory bodies
Finance	F7	Increased cost of projects due to cost of climate change
Finance	F8	Generating new types of financial tools to overcome resilience budgets
	F9	Cost increases due to IFIs/ DFIs

Table A1.4: Post-its, Cluster 4 – Systemic changes

Cluster	Post-it	Content
System effects	S1	• Supply chain will be affected • Due to unforeseen disasters manufacturing and specially delivery will be in trouble
System effects	S2	Resilience of global supply chains
System effects	S3	Construction of infrastructure projects Risks: Natural resource constraint Exp. Water usage for process Changing process and design Cost effect increasing recycling efficiency
System effects	S4	Increase of temperatures Flood Change in design standards for frequency of precipitation
System effects	S5	City floods: 1) Weak infrastructure 2) Not enough design criteria adaptation 3) Failure to predict of correctly specially climate change
System effects	S6	Domestic water supply changing
System effects	S7	Changing patterns of demand – Implications for Turkish contractors
System effects	S8	Population changing
System effects	S9	Location of where we build – system effects

Design and Methodology	DM8	Climate resilient design
Design and Methodology	DM9	Data does not repeat itself. Cannot use previous data to predict future
Design and Methodology	DM10	Localization data
Design and Methodology	DM11	Building management dynamics algorithms
Design and Methodology	DM12	Balance between mitigation and adaption

Table A1.7: Post-its, Cluster 7 – Awareness and coordination

Cluster	Post-it	Content
Awareness and Coordination	AC1	Actors – Awareness of the company
Awareness and Coordination	AC2	Lack of standard terminology knowledge and awareness
Awareness and Coordination	AC3	Government should conduct research – lack of information – change of standards due to latest information – finding the finance to start construction
Awareness and Coordination	AC4	• The problem of sharing data from the government • Lack of communication between institutions • Inadequacy of technical specifications and regulations
Awareness and Coordination	AC5	• Awareness of the project(s) personnel/client/ etc. • Stakeholders and clients have a lack of awareness in terms of climate risks
Awareness and Coordination	AC6	Increase the awareness of government authorities

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Table A1.5: Post-its, Cluster 5 – Regulations and standards

Cluster	Post-it	Content
Regulations	R1	Sharing of risks according to different regions (Regulations and Standards)
Regulations	R2	Flood resilient design standards
Regulations	R3	Unclear or less than adequate legislation – Legislation has huge effect on design and implementation stages – Legislation shall consider the climate risks
Regulations	R4	Should be included in technical specifications
Regulations	R5	Planning – Risks and potential impacts identified
Regulations	R6	1) Not implementation of proposed designs and projects 2) Lack of new technologies and methods in governmental institutions
Regulations	R7	Change of regulations and rapid adaptation will be a risk (This will also affect company's reputation and business opportunities)
Regulations	R9	Coordination of policy makers

Table A1.6: Post-its, Cluster 6 – Design, assessment and management methods

Cluster	Post-it	Content
Design and Methodology	DM1	Architectural design according to climate conditions
Design and Methodology	DM2	Defining risks Defining actions Reduction plan Money and time
Design and Methodology	DM3	Lack of consideration or methodology for physical risk of climate change
Design and Methodology	DM4	Finding out possible damage scenarios prior to a specific built environment
Design and Methodology	DM5	No global risk assessment methodology (Except EP4)
Design and Methodology	DM6	Lack of project management tools incorporating climate risk and resilience
Design and Methodology	DM7	Concentrate on proactive perceptions