EUROPE AND
CENTRAL ASIA

TÜRKIYE

World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT

JUNE 2022

Table of Contents

Acknowledgments

This Country Climate and Development Report (CCDR) is a collaborative effort of the World Bank, the International Finance Corporation (IFC), and the Multilateral Investment Guarantee Agency (MIGA), produced by a core team led by Stéphane Hallegatte (Senior Climate Change Advisor), Hans Anand Beck (Lead Country Economist and Program Leader), and Xiaodong Wang (Lead Energy Specialist). The core writing team includes Camilla Knudsen, Claire Honore Hollweg, Craig Meisner, Fernando Blanco, Lauren Claire Culver, Stavros Papageorgiou, and Thanh Phuong Ha.

Modeling and analytical results were provided by Andrew Losos, Carla Cristina Solis Uehara, Charl Jooste, Daniel Garrote Sanchez, Daniel James Besley, David Groves, Esther Naikal, Etkin Ozen, Florent John McIsaac, Hasan Dudu, Ira Irina Dorband, Javier Baez, Jia Li, Joanna Mclean Masic, Kathleen Laura Patroni, Luis Blancas, Mattia Makovec, Noe Nicolas Reidt, Penelope Ann Mealy, Sophie Anne de Vries Robbé, Thomas Nikolakakis, and Yusuf Serengil.

Contributions and comments were received from Aart Kraay, Abhas Jha, Adeel Abbas Syed, Ahmadou Moustapha Ndiaye, Alanna Simpson, Alisan Dogan, Almudena Mateos Merino, Andrea Fitri Woodhouse, Arnaud Dupoizat, Aurelien Kruse, Aysenur Acar, Baris Tuncsiper, Basak Odemis, Ben Joshua Dickens, Bernard Haven, Binyam Reja, Canan Yildiz, Carolyn Fischer, Catherine Signe Tovey, Cecilia Briceno-Garmendia, Charles Pierre Marie Hurpy, Christoph Push, Claudio Jeremias Rojas Guzmán, David Stephen Knight, Dhruv Sharma, Donna Barne, Elco Eduard Koks, Elisabeth Huybens, Ellysar Baroudy, Emmanuel Pouliquen, Erika Rhoades, Faruk Khan, Ferid Belhaj, Ferzina Vistasp Banaji, Georges Bianco Darido, Gianfilippo Carboni, Guillermo Eduardo Díaz-Fañas, Gunhild Berg, Hans Timmer, Harry Anthony Patrinos, Heba Elgazzar, Helen Deborah Gall, Helene Blanche Naegele, Hoon Sahib Soh, Humberto López, Illango Patchamuthu, Indermit Gill, Indira Chand, Isabelle Blouin, Joshua Gill, Jamie Lee Brown, Jas Singh, Jiyoun Christina Chang, Joanna Charlotte Moody, Joel Reyes, John Roome, Juergen Voegele, Jun Han, Kanta Kumari Rigaud, Karla González Carvajal, Khafi Weekes, Kseniya Lvovsky, Laurent Debroux, Lisa Lui, Luz Berania Díaz Rios, Mamta Murthi, Margaret Triyana, Markus Pohlmann, Marolla Haddad, Maryla Maliszewska, Merve Demirel, Miles Mckenna, Murad Gurmeric, Nadwa Rafeh, Nathan Engle, Niharika Sachdeva, Pablo Fajnzylber, Paulina Estela Schulz Antipa, Paul McClure, Raju Singh, Regassa Ensermu Namara, Samu Salo, Samuel John Fargher, Sandeep Mahajan, Sanyu Lutalo, Seda Aroymak, Selin Efsan Nas Ozen, Seynabou Sakho, Sofia Guerrero Gámez, Shabih Ali Mohib, Sheila Braka Musiime, Sumir Lal, Tarik Sahovic, Thomas Farole, Thomas Michael Kerr, Tunya Celasin Aydinalp, Umut Kilinc, Verena Schaidreiter, Victor Bundi Mosoti, Winston Yu, Yasemin Orucu, Yoon-Kyung Anne Kim, Zahraa Nazim Saiyed, Zeynep Lalik, Zhimin Mao and Zoubida Allaoua. The team is grateful for the support received from Eliana Jimenez Rico, Fisun Altinbas, Gozde Yilmazturk, and Ulker Karamullaoglu.

Detailed feedback, suggestions, and comments were received from internal peer reviewers Ani Balabanyan, Asli Demirgüç-Kunt, Camilla Holmemo, Carole Megevand, Christian Schoder, Ethel Sennhauser, Farah Imrana Hussain, Ghislain Martial Yanou, Martijn Gert Jan Regelink, Michael Stanley, Nicholas Menzies, Ommid Saberi, Raffaello Cervigni, Richard Damania, Richard Martin Humphreys, Sebastian Eckardt, Silvia Martinez Romero, Somik Lall, and Vivek Pathak. Invaluable comments were also received from external peer reviewers Amar Bhattacharya (Brookings), Azim Sadikov (International Monetary Fund), Carter Brandon (World Resources Institutes), Ebru Voyvoda (Middle East Technical University), Erinç Yeldan (Bilkent University), Leon Clarke (University of Maryland), and Nicholas Stern (Grantham Research Institute).

The CCDR benefitted from dialogue with the Government of Türkiye in the context of the ongoing Türkiye Green Growth Analytical and Advisory Program and the High-Level Türkiye-World Bank Climate Brainstorming held on December 14, 2021. The team received important contributions from private

sector stakeholders at an event organized with TÜSIAD, the largest Turkish private sector business association, on January 25, 2022. Finally, the team presented and discussed the draft CCDR at the multistakeholder Türkiye National Climate Council on February 22, 2022, in Konya, Türkiye, and hosted a virtual technical briefing meeting with several ministries and government agencies on April 26, 2022.

The CCDR was prepared under the guidance of Anna Bjerde (World Bank Regional Vice President), Hela Cheikhrouhou (IFC Regional Vice President), Ethiopis Tafara (MIGA Vice President and Chief Risk, Legal and Administrative Officer), Steven Schonberger (World Bank Regional Director for Sustainable Development), Wiebke Schloemer (IFC Regional Director), Merli Margaret Baroudi (Director of Economics and Sustainability at MIGA), Auguste Tano Kouame (Country Director), Charles Joseph Cormier (Regional Director for Infrastructure), Lalita Moorty (Regional Director for Equitable Growth, Finance, and Institutions), and Fadia Saadah (Regional Director for Human Development).

Lucy Southwood was the production editor. Brad Amburn was the designer.

Acronyms

BAU	business as usual
BRSA	Banking Regulation and Supervision Agency
CBAM	Carbon Border Adjustment Mechanism
CCACB	Climate Change and Adaptation Coordination Board
CCDR	Country Climate and Development Report
CCUS	carbon capture usage and storage
CGE	Computable General Equilibrium
CMB	Capital Market Board
CO2	carbon dioxide
CPSD	Country Private Sector Diagnostic
EPM	Electricity Planning Model
ETS	Emissions Trading System
EU	European Union
EV	electric vehicle
FDI	foreign direct investment
GCI	Green Complexity Index
GCP	Green Complexity Potential
GDP	gross domestic product
GHG	greenhouse gas
GVC	global value chain
INDC	intended nationally determined contribution
IPPU	industrial processes and product use
kg	kilogram
kt	kilotonne
LGT	least cost with current government targets
LULUCF	land use, land-use change and forestry
MFMod	the World Bank's Macro-Fiscal Model
MoEUCC	Ministry of Environment, Urbanization and Climate Change
MRV	monitoring, reporting and verification
MtCO2e	million tonnes of carbon dioxide equivalent
NCCAP	National Climate Change Action Plan
NDC	nationally determined contribution
NDP	National Development Plan
NGFS	Network for Greening the Financial System
NO2	nitrogen dioxide
NPL	non-performing loan
NPV	net present value
OECD	Organisation for Economic Co-operation and Development
PM2.5	particulate matter, less than 2.5 micrometers in diameter
PM10	particulate matter, less than 10 micrometers in diameter
PPI	producer price inflation
PPP	purchasing power parity
PV	photovoltaic
R&D	research and development
RE	renewable energy
RNZP	resilient and net zero pathway
SCT	Special Consumption Tax
SO2	sulphur dioxide
tCO2e	tonne of carbon dioxide equivalent
TFC	total final energy consumption
TL	Turkish lira
TWh	terawatt hour

All $ amounts are US dollars.

Executive summary

As a country that faces significant vulnerability to the impacts of climate change, Türkiye has made ambitious climate change commitments, ratifying the Paris Agreement in October 2021 and committing to net zero emissions by 2053. The country is establishing new institutional arrangements for climate change issues, including the recently formed Ministry of Environment, Urbanization and Climate Change (MoEUCC), and is updating its National Climate Change Action Plan. The intensification of climate-related events in recent years—including floods, forest fires, and sea pollution—and the potential implications of the European Union (EU) Green Deal for Türkiye's economy have contributed to the urgency of the country's climate change agenda. Most recently, the war in Ukraine and attendant energy supply disruptions and price increases highlight risks for countries like Türkiye that rely on fossil fuel imports, underscoring the urgency of climate action in support of energy security and affordability.

This Country Climate and Development Report (CCDR) explores opportunities and trade-offs for aligning Türkiye's development goals with its recent commitments on climate change. It explores how climate action—in line with the country's mitigation goal of achieving net zero emissions by 2053 as well as its adaptation and resilience needs—would affect Türkiye's growth and development. It looks at how climate action can help achieve the country's development objectives, capture opportunities offered by green technologies and sectors, protect the economy against longer-term risks, such as large-scale disasters or carbon lock-in as the world transitions toward reduced greenhouse gas emissions, and support a just and inclusive transition (figure S.1).

Figure S.1: Türkiye's development and climate objectives

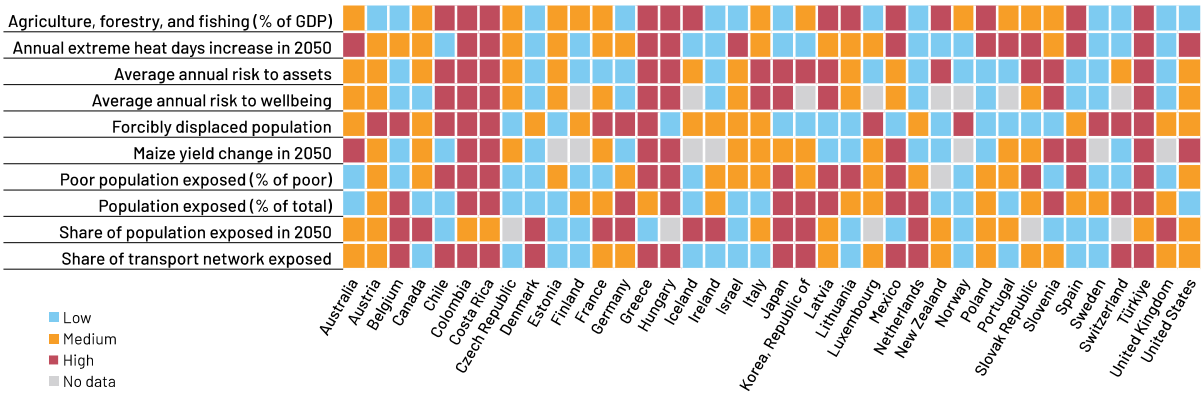
DEVELOPMENT PRIORITIES	NET ZERO EMISSIONS	ADAPTATION AND RESILIENCE
• 11th National Development Plan • March 2021 Economic Reform Program • Medium Term Programme (2022-24)	• Ratification of Paris Agreement • Announcement of commitment to achieve net zero emissions by 2053 • Green Deal Action Plan	• National Climate Change Adaptation Strategy and Action Plan

Türkiye has made considerable development progress since 1990, but macrofinancial volatility jeopardizes future progress. Rapid economic growth tripled income per capita to a peak of $12,000 in 2015, making Türkiye the world's 19th largest economy. However, since 2016, macroeconomic shocks and adverse geopolitical events have slowed the country's development progress. Unemployment has remained high—over 10 percent since 2015—and is compounded by low labor force participation, especially for women and youth. High labor informality persists, and, with a few exceptions, jobs are growing faster in low-productivity sectors. Foreign direct investment is estimated to have dropped from over 3 percent of gross domestic product (GDP) in 2008 to around 1 percent in 2019, with more than half going to real estate in the last two years. Low capital growth combined with low and declining total factor productivity growth have lowered potential growth to around 4 percent in 2021. In April 2022, consumer and producer price inflation reached a two-decade high of 70 and 122 percent year-over-year, respectively. While gross general government debt to GDP fell to a low of 28 percent in 2016, currency depreciation, COVID-19 outlays, and rising borrowing costs drove it to 42 percent in 2021, narrowing the government's fiscal space.

Although the increase in Türkiye's greenhouse gas (GHG) emissions has been slower than economic growth and its per capita emissions are lower than in the Organisation for Economic Co-operation (OECD) or EU countries, there is a strong case for a forceful mitigation agenda in Türkiye. The energy sector—which includes the power, transport, building, and industrial sectors—is the country's single largest contributor to GHG emissions, accounting for three-quarters of total emissions. Türkiye's power, transport, and agriculture sectors are less carbon-intensive than the EU average—partly due to the large penetration of renewable energy (RE) in Türkiye's power system and low motorization rates. However, coal dependency is high and set to increase further under current investment plans. And the building sector (residential and non-residential) is less energy-efficient than the EU average. Manufacturing is more carbon-intensive than the EU average, exposing Türkiye to risks if the EU introduces the Carbon Border Adjustment Mechanism (CBAM). Türkiye's forested landscapes act as carbon sinks, reducing the country's net carbon emissions.

Türkiye's geographic, climatic, and socioeconomic conditions make it highly vulnerable to the impacts of climate change and other environmental hazards, making adaptation and resilience high priorities. Türkiye has high vulnerability in 9 of 10 climate vulnerability dimensions, compared with a median of 2 of 10 in other OECD countries (figure S.2). Its transport system is more vulnerable than those of comparable countries, and the country is experiencing food security issues, increasing water stress, and unprecedented disaster events, such as the 2021 forest fire season. This vulnerability is due to a combination of climate factors, population exposure (for example, the share of the population exposed to floods and forest fires), and socioeconomic factors (such as the share of agriculture in the economy).

Figure S.2: Climate risk and vulnerability in Türkiye and other OECD countries



Notes: Countries are rated using a benchmark approach: those rated at high risk (red) are in the top third, medium risk (yellow) are in the middle third, and low risk (blue) are in the lowest third.

A resilient and net zero pathway can help Türkiye achieve its development and climate objectives but implies a significant departure from current trends and important policy changes

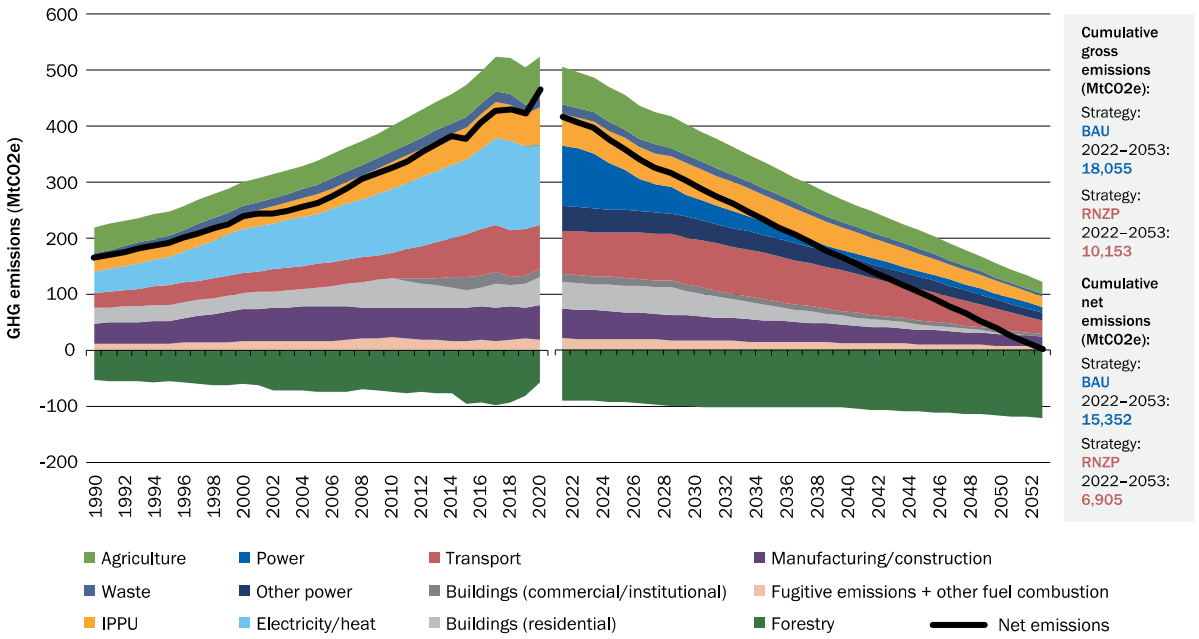
There are multiple possible paths for aligning Türkiye's development and climate objectives. To explore feasibility, costs, and benefits, we developed an illustrative resilient and net zero pathway (RNZP) that combines adaptation and resilience actions with the 2053 net zero pledge. The RNZP is based on two main principles:

- **Boosting resilience and adaptation requires a whole-of-economy strategy and a supportive socioeconomic environment.** The RNZP prioritizes supporting adaptation in the private sector by ensuring access to information, technology, and finance. It includes actions to enhance the resilience of critical public assets and services, agriculture systems and land use plans, water

resource management, and financial resilience (including insurance and adaptive social protection and the integration of climate and disaster risks in macroeconomic and fiscal policies).

- **Türkiye can achieve its 2053 net zero emissions target (figure S.3) but this will require major changes in many economic sectors.** The transformation includes deep decarbonization of the power sector; a combination of energy efficiency and electrification in buildings; modal shift, energy efficiency, and electrification in transport; a change in current practices to maximize carbon sequestration from forest landscapes; and emissions reduction efforts in the rest of the economy (including industries, agriculture, waste management, and water management).

Figure S.3: Historical emissions (left) and RNZP emissions (right)

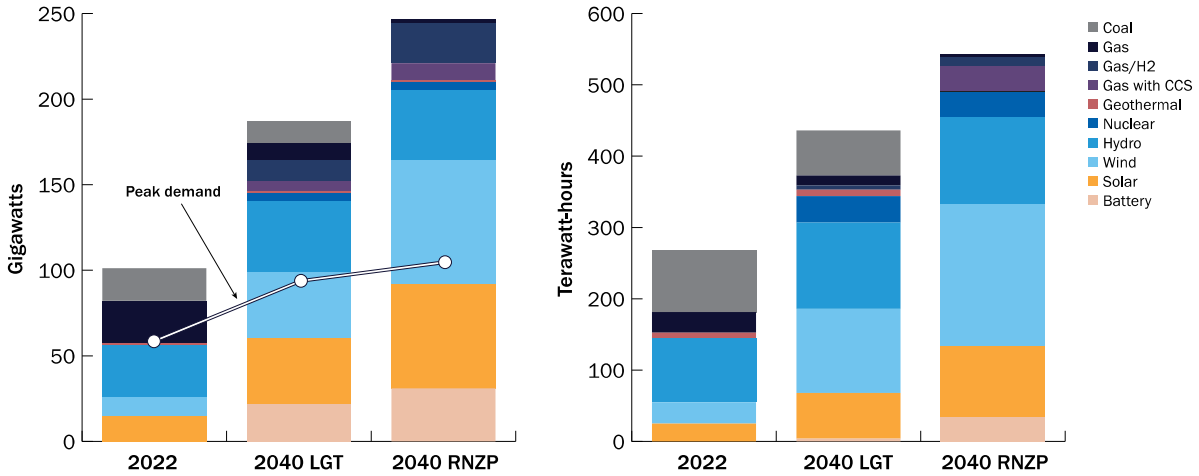


Notes: BAU = business as usual; RNZP = resilient and net zero pathway.

The RNZP emphasizes several priority areas for boosting economy-wide resilience and adaptation. These include the need to facilitate adaptation by firms and people, for example by expanding public provision of climate and disaster risk information; adapting land use plans and protecting critical public assets and services, including strengthening resilience to severe and growing water-related risks; and mainstreaming adaptation, resilience, and disaster risk finance in macrofiscal policies, including by assessing the economic costs of climate change and disasters, and reflecting contingent liabilities in fiscal policies, budget allocation, and public investment.

In the RNZP, emissions from the power sector are significantly reduced by 2040, despite an increase in demand from electrification of end-use sectors (figure S.4). Even without a carbon constraint, new coal power plants are neither needed nor the least-cost option to meet growing electricity demand. Instead, Türkiye can achieve energy security through an accelerated pace of least-cost investments in domestic solar and wind—building on its track record of tripling renewable energy capacity in the last decade—and investing in energy efficiency, battery and pumped storage, geothermal, and gas generation with carbon capture and storage (as well as completion of the nuclear plant under construction). This would enable the country to meet a doubling of energy demand by 2053 to fuel its growth ambitions, with the added benefit of lowering emissions and improving energy security by reducing reliance on imported coal, gas, and oil.

Figure S.4: Türkiye's power system capacity (left) and electricity generation mix (right) in 2022 and 2040



Note: LGT = least-cost option including plants under construction and the government's RE target but with no emissions constraint; RNZP = resilient and net zero pathway.

By enabling Türkiye to achieve net zero emissions with significant residual emissions in hard-to-abate sectors, negative emissions from forest landscapes play a key role in the RNZP, but they also create risks. Forest carbon storage is vulnerable to economic and climatic factors, such as forest fires. A robust strategy toward net zero must therefore consider how to do more in emitting sectors if negative emissions from forests prove impossible—for example, due to increasingly frequent forest fires.

Achieving Türkiye's climate commitments would yield net economic gains, but require large public and private investments

The RNZP illustrates the feasibility and overall benefits of aligning development with climate-related goals. As Türkiye imports 99 percent of its gas and 93 percent of its oil, energy efficiency and renewable energy could generate major benefits by reducing air pollution, energy imports and expenditure, and vulnerability to disruptions in global energy markets. When all costs and co-benefits are accounted for, the net economic impact of the RNZP is positive over 2022–30, and it increases when considering longer-term horizons: the RNZP leads to a net $15 billion gain over 2022–30 and a $146 billion gain over 2022–40, largely due to reduced fuel imports and health benefits from decreasing air pollution (table S.1).

Large investments would be required, but remain manageable, when compared with the size of the Turkish economy. Compared with the baseline scenario that does not include climate objectives, Türkiye would need to invest an additional $68 billion over 2022–30 (in present value terms) in the RNZP; that is 1.0 percent of discounted cumulative GDP over the period. Over 2022–40, this number grows to $165 billion, or 1.2 percent of discounted cumulative GDP. These investments add 21 percent to the existing $319 billion needed over 2022–30 in key sectors: power ($52 billion), residential ($243 billion), and transport ($24 billion), and 34 percent to the $482 billion needed over 2022–40.

We can expect about half of these investments to come from the private sector. The ability to mobilize private capital depends on the macroeconomic context, sectoral regulations, financial sector deepening, and access to long-term capital. While the World Bank Group's forthcoming Country Private Sector Diagnostic (CPSD) will investigate these opportunities in more detail, this CCDR uses assumptions based on current shares of private investments, the need for publicly funded incentives to redirect and trigger private investments (for example, the public sector would provide half of the

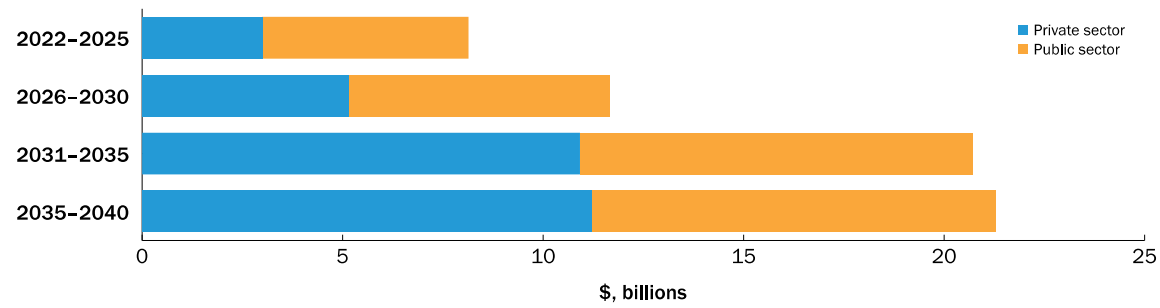
financing needed for residential buildings to attract the rest from private sources), and the needs for compensation and social expenditures, especially to manage the consequences of early closing of coal power plants and mines. With these assumptions—equivalent to a broadly 50-50 public-private investment split on average—the analysis finds that additional annual (undiscounted) public investment needs for the RNZP could be around $5 billion until 2025, and $6 billion by 2030 (figure S.5). These estimates can be compared with the 2020 public investment budget, which covers all sectors and totals 2.6 percent of GDP, or around $18 billion per year.

Table S.1: Investment needs and economic costs in the RNZP (additional compared with baseline)

	2022–30 ($, billions)	2022–40 ($, billions)
POWER		
Additional investment: new generation and storage capacity	+5	+33
Additional investment: transmission and distribution	+8	+14
Other economic costs: operational and fuel costs	-9	-23
Other economic costs: air pollution externality costs from coal	-9	-38
Other economic costs: decommissioning of coal plants and mines	< +1	+1.4
RESIDENTIAL		
Additional investment: energy efficiency, electrification, and resilience	+45	+100
Other economic costs: gas imports	-11	-46
Other economic costs: lives lost and injuries	-1	-3
TRANSPORT		
Additional investment: new resilient infrastructure	+8	+15
Other economic costs: fuel imports	-12	-36
Other economic costs: cost of disruptions	-3	-11
Other economic costs: air pollution, congestion, and road fatalities	-40	-171
FOREST LANDSCAPES		
Additional investment: restoration, reforestation, and fire management	+2	+3
Other economic costs: loss of harvest revenues	+1	+5
AGRICULTURE		
Other economic costs: on-farm emissions reductions	< +1	–
INDUSTRY AND MANUFACTURING		
Other economic costs: cement, iron, and steel	–	+11
TOTAL INVESTMENTS AND ECONOMIC COSTS		
Net economic costs	-15	-146
includes: additional investment	68	165

Notes: All amounts are discounted using a 6 percent discount rate. Decommissioning costs do not include the social expenditures to facilitate the transition of affected workers and communities. Numbers in red are net costs; numbers in green are net benefits.

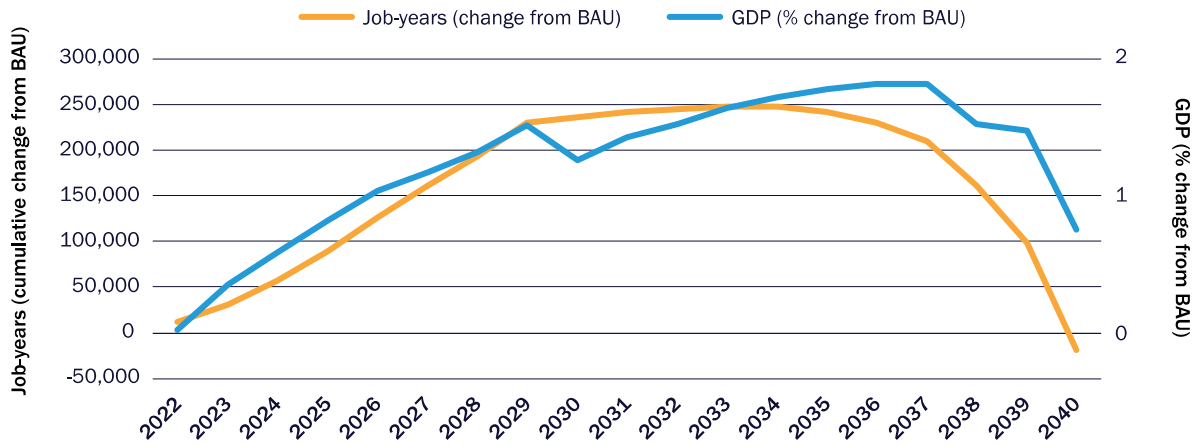
Figure S.5: Additional annual investment needs for the RNZP



Integrating development and climate objectives would lead to higher growth and employment, but could create significant transition challenges for exposed sectors and their workers

Even without considering benefits from avoided climate change impacts, we expect the RNZP to increase GDP growth and employment, thanks to large investments, energy efficiency, technological upgrading, and reduced fuel costs (figure S.6). Türkiye's GDP grows faster in the RNZP, in which sectoral roadmaps are combined with economy-wide interventions, including carbon taxes with appropriate recycling. However, this growth benefit would be lower if carbon tax revenues are not recycled in a way that supports private sector investment and if additional investments in the RNZP crowd out other investments. Growth benefits are also markedly lower after 2035, as decarbonization of the power system gradually leads to higher electricity prices. The net impact on jobs is small, with 230,000 more jobs in 2030 in the RNZP, but with the growth slowdown after 2035 erasing these gains.

Figure S.6: Impact of the RNZP transition on GDP (right axis) and cumulative jobs (left axis), 2022–40



Note: BAU = business as usual; GDP = gross domestic product.

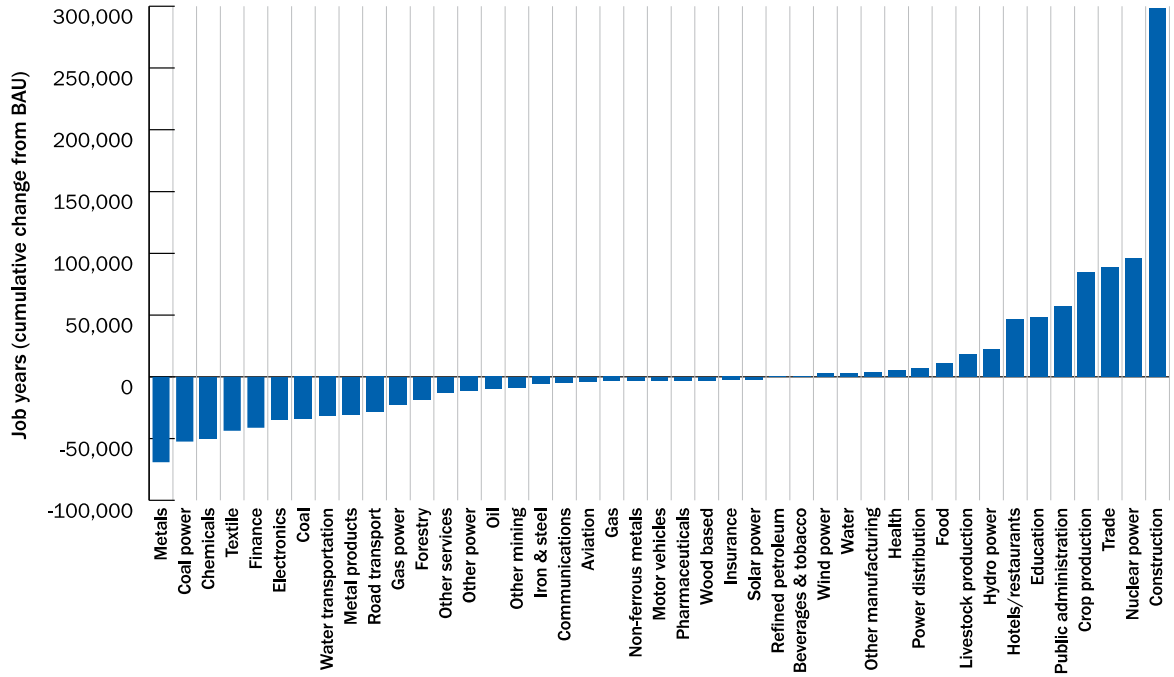
While the additional investments needed are significant, their overall impacts on the fiscal and external balances are relatively small. The analysis shows that additional investments raise capital and related imports, but savings in oil and gas imports offset these in the current account balance. Public debt levels in the RNZP rise by 1 to 3 percentage points of GDP compared with a baseline scenario, as government revenues from a carbon tax help offset borrowing for investment needs. This provides an indication of the fiscal space the government has should it choose to save less and instead take on a larger share of the total investment needed in capital and innovation to support the transition. Macroeconomic stability is essential to preserving this fiscal space and fostering private sector investments.

The impacts of decarbonization on consumption are positive. Policy makers need to pay careful attention to housing affordability, food security, electricity prices, mobility, and access to jobs and services. We expect the impact on inflation to be limited, with the effect on food and manufacturing prices under 1 percent in 2030 and below 2.5 percent in 2040. Additional carbon tax revenues can be used to compensate low-income households for adverse impacts, such as a rise in energy prices. With 13 percent of the carbon tax revenues recycled as cash transfers, all household income classes would benefit.

Decoupling emissions from growth involves economic restructuring and changes in labor demand, which poses challenges to a just and inclusive transition. Although Türkiye's green transition likely

will create new jobs in environmentally friendly production, it will also place other jobs at risk, particularly in sectors with fewer options for transitioning to more sustainable ways of production (figure S.7). And this transition will affect a country with already significant social challenges, including those linked to the recent rise in poverty (with over 10 million people now below the poverty line), the world's largest refugee population, and low female labor force participation (the lowest among OECD countries). Türkiye's lower share of green jobs and its higher share of jobs that require upskilling compared with its peers also make it a challenge to upgrade the skills of its workforce. Ensuring a just and inclusive transition will require careful management of economic and labor market adjustments, investments in human capital and education, strong and adaptive social protection systems, and targeted interventions for retraining and reskilling.

Figure S.7: Impact of the RNZP on labor demand by sector, 2022–30



Note: BAU = business as usual.

The advantages of pursuing the RNZP are greater if we account for global decarbonization trends and the benefits of retaining access to global markets and participating in global value chains. Climate action in other countries will affect Türkiye through changes in global demand, technologies in global value chains, and trade rules. The impacts of the EU's CBAM will be significant on a few emission-intensive industries that have high trade exposure to the EU market. Some of these industries will face lower output and employment, requiring action to facilitate structural adjustments both within and between sectors. But the aggregate macroeconomic impacts of an EU CBAM will be limited.

Türkiye's firms have a relatively high degree of sophistication, as reflected in their integration in global value chains and growing value-added from exports, and the country has large potential in green global value chains. The CBAM creates an opportunity for Türkiye to benefit in markets where competitors are more carbon-intensive, especially if the country makes increasing efforts on energy efficiency in industries and on the performance of the logistics system. Türkiye is already well integrated in electric mobility value chains and has significant opportunities to participate in the global solar and wind energy value chains, a topic that will be explored in the forthcoming CPSD.

This CCDR also looks at how natural risks may affect the economy, though it does not account for all threats. Analysis of floods and earthquakes[1] shows that, while there are large short-term welfare costs after big events, they are manageable in the long run, with total GDP losses in 2100 below 1.6 percent of GDP in 95 percent of the simulated scenarios. However, impacts on poor and vulnerable populations can be substantial, with the risk of a significant increase in transient poverty after large shocks. While floods and earthquake risks are widely distributed across the country's population, wildfire and food security risks mostly affect the poorest.

Climate change threatens agricultural productivity, rural incomes and employment, and food security, especially through its impact on water scarcity. The Global Food Security Index ranks Türkiye 47th for overall food security. Climate change patterns are expected to significantly impact yields, especially through increased water scarcity, and to pose challenges to the sustainability of Türkiye's fisheries and aquaculture. A 10 percent reduction in water supply could cost Türkiye 6 percent of GDP, about $50 billion. This would exacerbate food price pressures and overall food security concerns. Lower-income populations would be most affected, since the share of income they spend on food is three times larger than the richest households. Impacts on the tourism industry are also likely to affect incomes and growth. Assessment of these impacts, as well as adaptation priorities, is a priority for future work.

Short-term priorities include "no regret" options that contribute to growth and climate objectives, but also difficult changes in a few key sectors

Delaying some interventions could reduce short-term transition costs, allowing Türkiye to benefit from the decline in green technology costs and adjust its strategy as more information becomes available (table S.2). For example, while electrifying residential heat and other energy use is needed to achieve net zero emissions, doing so immediately magnifies the challenge of decarbonizing the power system. In contrast, the cost of electrifying existing buildings is manageable, so delaying this action until 2030 would allow Türkiye to benefit from cheaper technologies (heat pumps, induction cooking) and less carbon-intensive electricity. Similarly, completely decarbonizing Türkiye's carbon-intensive industry will require new technologies, such as hydrogen-based steel making and carbon capture and storage, but widespread implementation of these technologies is more realistic after 2030.

Table S.2: Illustrative list of policies, classified according to urgency and synergies with short-term growth

	More urgent	Less urgent
Growth policies	• Macroeconomic stability, human capital and social protection, institution strengthening	
Synergies	• Investing in energy storage and renewable energy (including transmission, distribution, and integration); removal of fossil fuel subsidies • Modal shift and efficiency gains in passenger transport and freight • Energy efficiency in industries, especially carbon- or energy-intensive ones • Improving decision making for more resilient infrastructure • Improving water management (efficiency, irrigation, drainage, diversification) • Improving waste management (for resilience and carbon emissions) • Shifting toward climate-smart agriculture (and fisheries) and repurposing support in the sector • Green finance and disaster risk financial protection	
Trade-offs	• Exit from coal and just transition • Energy efficiency and resilience in buildings • Sustainable forestry practices • Pilot projects for carbon capture and storage and low-carbon technologies in industries (e.g., hydrogen)	• Electrification of buildings • Low-carbon technologies to reduce industrial processes and product use

[1] While earthquakes are not a climate hazard, most policies and measures to manage risks—from construction standards to disaster risk finance instruments—have to consider the full range of threats in their design, especially in a country that is as exposed to earthquake risks as Türkiye.

Some changes are urgent, because current trends are creating lock-ins into carbon-intensive patterns that will increase costs and create financial risks, such as stranded assets. Particularly urgent is the need to realign current energy policies. This includes ending the costly support to domestic production and consumption of indigenous coal and stopping the construction of new coal power plants, which would be at high risk of becoming stranded assets before the end of their lifetimes.[2] It would also require significant upscaling of renewable energy with a diversified power mix—including wind, solar, hydropower, geothermal, gas generation with carbon capture and storage, and nuclear—as well as investments in energy storage, particularly battery energy storage, which the country has yet to start investing in. This clean energy transition is necessary to achieve the government's net zero target, and it would contribute to reducing dependency on imported energy without compromising energy security. It would also reduce exposure to geopolitical risks and energy price volatility on global and regional markets.

Other changes are urgent in sectors with long-lifetime assets, technological inertia, or declining natural capital. This includes action to improve energy efficiency in new residential buildings, which would reduce energy costs and retrofitting needs, be synergetic with increasing resilience to earthquakes and high temperatures, and facilitate the decarbonization of the power system. Similar interventions to support energy efficiency in carbon- or energy-intensive sectors would improve external competitiveness and productivity and help Türkiye's economy prepare for future climate-related trade policies implemented by its main trade partners. For technologies to decarbonize heavy industries to be available and cost-competitive by 2030, investments in research and development and in pilot projects—including identifying sequestration opportunities—should start immediately. Supporting a modal shift toward rail, public transit, and soft modes (such as cycling and walking) requires early action on transport infrastructure and supportive, risk-informed urban planning with transit-oriented development. Finally, growing climate and disaster risks make adaptation and resilience interventions equally urgent, such as improved water management and agriculture practices to preserve water resources and productive soils.

Table S.3. Summary of sample 2030 sectoral milestones for the illustrative RNZP

SECTOR	2030 MILESTONES
Power 27% of total gross emissions in 2020	• 75% share of RE in power generation *(42% in 2020)* • 37% share of variable RE in power generation *(12% in 2020)* • 9% share of coal in power generation *(32% in 2020)* • 10 GW battery storage capacity *(0 GW in 2020)*
Transport 15% of total gross emissions in 2020	• Share of rail in total freight transport: 8% *(4% in 2020)* • Public transit (buses and rail) modal share for surface transport: 49% *(47% in 2020)* • Electrification of cars and buses: 12% and 19%, respectively *(both 0% in 2020)* • New investments screened for risks; critical assets identified and strengthened
Buildings 12% of total gross emissions in 2020	• New and retrofitted buildings to achieve Class A energy rating *(Class C in 2021)* • From 2030, electrification of new and retrofitted residential buildings • Combined seismic and energy retrofit of 2.5 million residential buildings • 100% of urban plans updated to account for future climate risks
Forest landscapes Carbon sequestration offsetting 11% of gross emissions in 2020	• Harvest rate 24.3 million m^3 *(26.0 million m^3 in 2020)* • Zero deforestation after 2022 • Average burnt area per wildfire reduced to below 2 hectares *(6.2 in 2020)* • 102 $MtCO_2e$/year emissions removals *(57 $MtCO_2e$/year in 2020)*
Rest of economy 46% of gross emissions in 2020	• Agriculture: emissions reduced by 19% to 55 $MtCO_2e$ • Fugitive emissions reduced by 18% to 17 $MtCO_2e$ • Manufacturing/construction (except IPPU) reduced by 19% to 44 $MtCO_2e$ • Solid waste reduced by 19% to 14 $MtCO_2e$

Notes: GW = gigawatts; $MtCO_2e$ = million tonnes of carbon dioxide equivalent; IPPU = industrial processes and product use.

[2] Türkiye's planned investments in new coal-fired power generation are the world's 5th largest and Türkiye alone accounts for 73 percent of the OECD and EU pre-construction pipeline.

Türkiye can use the RNZP and its priorities to define intermediate milestones, which it can use more directly to design policies, identify investments, and inform its revised nationally determined contribution (NDC). Table S.3 presents the 2030 milestones for the RNZP, which the government can use as medium-term targets for its next NDC, as a basis for sectoral ministry and agency proposals and investment plans, or to allocate budgets, track progress, and report to Parliament and the population.

Six short-term priorities to trigger the transition

Some interventions that tackle underlying structural obstacles to Türkiye's growth and development can also help achieve the country's climate objectives. Those include measures to promote:

- **Macroeconomic stability:** Reducing macroeconomic volatility, stabilizing inflation, building external reserves, and maintaining a prudent level of public debt, all of which are essential to enable the required public and private investments.

- **Human capital and social protection:** Investing in people through health and education, ensuring higher labor force participation (especially for women), and building stronger and more comprehensive safety nets to reduce macroeconomic transition costs and minimize social costs.

- **Institutional strengthening:** Better integrated policy documents, improved economic decision-making and budgetary processes, and more efficient public spending through procurement and public investment management.

Making improvements in these three domains creates clear synergies: in addition to accelerating growth, they would make the economy better able to manage the transition toward climate resilience and net zero emissions. But these interventions also need to be complemented with a set of targeted sectoral approaches.

Priority 1. Realign energy policies to exit from coal and decarbonize the power sector: Make parallel efforts, through a new energy security compact, to commit a just and inclusive transition from coal, by (i) not building new coal plants; (ii) retiring most existing coal power plants and mines by 2040 and compensating for lost future revenues; (iii) supporting laid-off workers and affected communities; (iv) facilitating environmental remediation; (v) scaling up renewable energy; (vi) deploying grid integration measures, particularly battery and pumped storage, remunerating storage services, and expanding and digitalizing transmission networks; and (vii) ensuring well-designed power markets, with careful consideration of implications for reliability and electricity prices.

Priority 2. Maximize the economic benefits of the transition with a supportive macroeconomic and financial environment: Implement macro-stabilizing and structural interventions to raise economic productivity by (i) alleviating factor market rigidities; (ii) removing or repurposing fossil fuel and agricultural subsidies, and deploying de-risking instruments; (iii) enabling public investments and mobilizing private investments through a tax reform that combines subsidy reform with a carbon tax (or an equivalent emissions trading system) in all sectors except agriculture and landfills; (iv) mainstreaming climate objectives in macro-fiscal and monetary policy; and (v) reforming the financial sector to extend tenor and taxonomy, developing green and blue bonds, and improving transparency and disclosure of climate-related risks in the financial system. The latter will be further explored in the forthcoming Financial Sector Assessment Program.

Priority 3. Make the economy more energy efficient: Establish a more ambitious National Energy Efficiency Action Plan to 2030 for transport, buildings, urban industry, and waste sectors, with (i) more stringent and well-enforced building standards and codes; (ii) strategies and investments to support modal shifts in transport and transit-oriented urban development; (iii) a national program for

building renovations; (iv) national schemes to support energy efficiency in factories, including energy audits and efficiency reporting, and improved recycling programs for metals, e-waste, and other waste; and (v) a progressive and coordinated shift toward electrification in industries, as well as space and water heating, coupled with rooftop solar schemes to offset impacts on the grid.

Priority 4. Maximize negative emissions from forests and landscapes: Mainstream sustainable forest management to enhance carbon sinks and manage climate risks (especially wildfires), with investment in landscape restoration through reforestation, forest and grassland rehabilitation, cropland management, and wetland conservation.

Priority 5. Make growth more resilient and sustainable: Adopt an economy-wide approach that mainstreams (i) resilience and future climate change impacts in public and private sector decisions, by including climate risks in budgeting procedures; (ii) infrastructure and building construction standards; (iii) procurement and public investment management; (iv) urban and infrastructure planning; (v) water management plans and regulations, complemented by modernized irrigation and drainage and diversified freshwater resources; (vi) agriculture policies and support, including subsidy repurposing; and (vii) social protection systems.

Priority 6. Minimize social disruptions and ensure a just and inclusive transition: Build a strategy that (i) identifies at-risk sectors and workers; (ii) anticipates and prepares for retraining and reskilling needs; and (iii) strengthens social protection systems to make them more reactive, flexible, and better able to absorb expected and unexpected shocks. Repurposing retired coal power plants and closed coal mines can not only lead to economic and energy transition, but also mitigate the social impacts and disruption of these closures.

The way ahead

This CCDR explores important issues and opportunities created by climate change for Türkiye but does not provide definitive answers. There are two priorities for future analytical work:

- First, the government needs to design a long-term strategy that is integrated into its development and economic plans and policies and prepare a revision of its NDC that is consistent with Türkiye's long-term commitments and objectives.

- Second, broad policy recommendations need to be translated into much more detailed policy advice and investment plans. For example, detailed policy recommendations on the design of a just and inclusive transition from coal will be the focus of follow-up analytical products.

Türkiye's development and climate objectives are ambitious, and the policies and interventions that are needed to achieve them involve risks and uncertainty, making it important to follow an iterative approach. Careful monitoring and evaluation are needed to detect and manage expected and unexpected negative effects and to adjust policies over time. Türkiye does not need to set its strategy in stone for the next 30 years. Climate policy takes place in a context of incomplete knowledge and large uncertainties, which will only be resolved as countries implement climate policies, carefully monitor their impacts and results, and learn from their successes and failures. Contexts of deep uncertainty require flexible and regularly adjusted policies. This CCDR identifies a short-term strategy for 2022–30 that minimizes short-term trade-offs and maximizes synergies. It is important to consider the longer-term pathway over 2022–40 or even to 2053, keeping in mind that the strategy can and will be adjusted between now and 2030, based on what is learned in the meantime.

COUNTRY CLIMATE DEVELOPMENT REPORT:

TÜRKIYE

Introduction

As a country that faces significant vulnerability to the impacts of climate change, Türkiye has made ambitious climate change commitments, ratifying the Paris Agreement in October 2021 and committing to net zero emissions by 2053. The country is establishing new institutional arrangements for climate change issues, including the recently formed Ministry of Environment, Urbanization and Climate Change (MoEUCC), and is updating its National Climate Change Action Plan. The intensification of climate-related events in recent years—including floods, forest fires, and sea pollution—and the potential implications of the European Union (EU) Green Deal for Türkiye's economy have contributed to the urgency of the country's climate change agenda. Most recently, the war in Ukraine and attendant energy supply disruptions and price increases highlight risks for countries like Türkiye that rely on fossil fuel imports, underscoring the urgency of climate action in support of energy security and affordability.

This Country Climate and Development Report (CCDR) explores how to combine Türkiye's urgent economic and development priorities with its commitment to climate action (figure I.1). Based on a review of existing literature and a set of new analyses, the CCDR adopts a people-centered and whole-of-economy approach to identify policies and investments that provide both short-term results and longer-term climate benefits, while acknowledging transition and adjustment costs. The CCDR will be complemented by the forthcoming Country Private Sector Diagnostic (CPSD) and Financial Sector Assessment Program, as well as focused studies addressing some of the main challenges highlighted in the report.

Figure I.1: Türkiye's development and climate objectives

DEVELOPMENT PRIORITIES	NET ZERO EMISSIONS	ADAPTATION AND RESILIENCE
• 11th National Development Plan • March 2021 Economic Reform Program • Medium Term Programme (2022-24)	• Ratification of Paris Agreement • Announcement of commitment to achieve net zero emissions by 2053 • Green Deal Action Plan	• National Climate Change Adaptation Strategy and Action Plan

The report is structured as follows.

- In chapter 1, we provide a diagnosis of Türkiye's economic, social, and environmental situation, with a simple benchmarking of how the country fares compared with its peers. We then discuss potential threats from climate change and environmental issues.[3]

- In chapter 2, we present Türkiye's climate and institutional context through a review of its climate policies and commitments.

- In chapter 3, we present a resilient and net zero pathway (RNZP) that combines actions to boost climate adaptation and resilience—of human and natural systems—with policies to achieve the

[3] In the discussion on resilience and adaptation, we include geophysical risks, particularly earthquakes. While earthquakes are not a climate-related hazard, most policies and measures to manage risks—from construction norms to disaster risk finance instruments—have to consider the full range of threats. Ignoring geophysical risks would also obscure important synergies and risks.

country's commitment to reach net zero emissions by 2053. While this pathway is illustrative, and by no means Türkiye's only possible development path, we use it to discuss economic and financial costs and investment needs, as well as the opportunities and co-benefits from climate action.

- In chapter 4, we analyze the implications of the proposed RNZP interventions for various macroeconomic aggregates, exploring obstacles, constraints, and challenges for human capital and competitiveness. These include broad economic reforms—such as tax reforms or financial system regulations—as well as institutional, social protection, and human capital policies to support vulnerable populations through a just transition.

- In chapter 5, we conclude with concrete opportunities for climate action that create synergies with Türkiye's development objectives, moving from long-term development options, through medium-term milestones for 2030, to short-term policy priorities.

1. Climate-related risks and opportunities for development

MAIN MESSAGES

Türkiye has made considerable development progress in recent decades but macrofinancial volatility and uncertainty around the future course of macroeconomic policies jeopardizes future progress.

Türkiye's development path is threatened by significant climate and disaster risks—including water scarcity, earthquakes, floods, and wildfires—but also from global decarbonization trends, especially the European Green Deal, and their impacts on global value chains, global demand, and trade policies.

Türkiye has the capacity to benefit from climate action over the short term through both adaptation (to make the economy more resilient to the above-mentioned risks) and mitigation, with benefits associated with the growth in global demand for green products, green technological upgrading, increased energy security due to lower energy imports, cleaner air and water, and more livable and productive cities.

This first chapter reviews Türkiye's socioeconomic context and its profile in terms of climate change risks, carbon emissions, and other environmental challenges.

1.1. Considerable development progress but macroeconomic and structural hurdles

Türkiye has made considerable development progress but structural challenges and repeated macroeconomic shocks[4] can impede growth and the green transition. Rapid economic growth tripled income per capita to a high of $12,000 in 2015, making Türkiye the world's 19th largest economy (figure 1.1a). The share of people living on less than $5.50 a day fell by three-quarters to 8.5 percent between 2002 and 2018. However, since 2016, a series of macroeconomic shocks and adverse geopolitical events have contributed to slowing down the country's development progress. Unemployment has remained high—over 10 percent since 2015, reaching 12 percent in 2021—and is compounded by low labor force participation, especially for women and youth. High labor informality persists, and, with a few exceptions, jobs are growing faster in low-productivity sectors. Foreign direct investment (FDI), deterred by macroeconomic instability, is estimated to have dropped from over 3 percent of gross domestic product (GDP) in 2008 to around 1 percent in 2019, with more than half going to real estate in the last two years. Low capital growth combined with low and declining total factor productivity growth have lowered potential growth to around 4 percent in 2021. In April 2022, consumer and producer price inflation reached a two-decade high of 70 and 122 percent year-over-year, respectively. While gross general government debt to GDP fell to a low of 28 percent in 2016, currency depreciation, COVID-19 outlays and rising borrowing costs drove it to 42 percent in 2021, narrowing essential fiscal space (figure 1.1b).

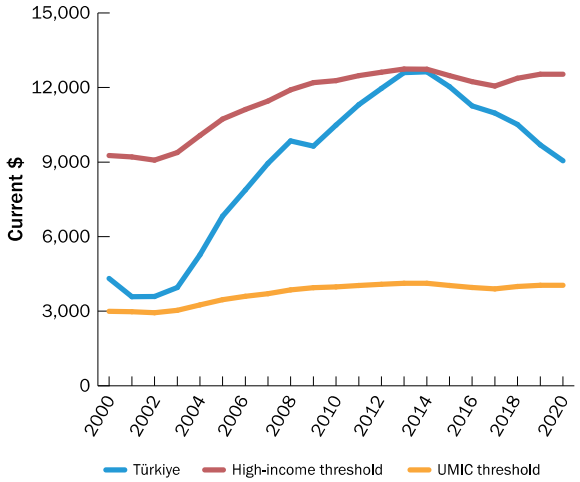
Spatial disparities, in terms of climate and natural risks, average climate and environmental conditions, and socioeconomic situations, also affect growth. Development and environmental challenges, access to infrastructure services, economic structure, and poverty levels differ in both

[4] For fuller treatment of the impact of the recent developments in macrofinancial conditions on investment (including foreign direct investment and financial intermediation) in capital and innovation, fiscal space, productivity, and competitiveness, see the Türkiye Economic Monitor (https://www.worldbank.org/en/country/turkey/publication/economic-monitor) and the Country Economic Memorandum http:/hdl.handle.net/10986/31931.

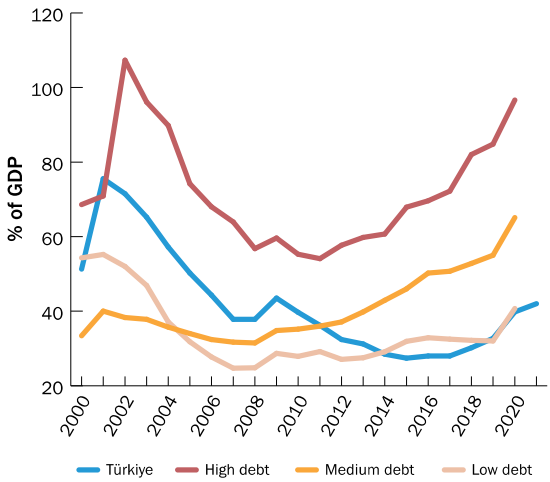
magnitude and nature across and between urban and rural areas. Flood and earthquake risks differ across and within regions and neighborhoods, while energy needs for heating and exposure of buildings to extreme high temperature are also heterogenous. Such disparities lead to different levels of environmental pressure and unequal development and growth.

Figure 1.1: Rapid income growth and declining debt levels

a) Per capita gross national income, 2001–20



b) General government gross debt, 2001–20



Source: World Bank staff calculations, based on World Development Indicators;[5] Kose et al. 2017; and IMF World Economic Outlook[6]
Notes: Panel a uses the Atlas method; UMIC = upper-middle-income country.

1.2. Notable (but uneven) successes in tackling environmental challenges

Türkiye has made progress in reducing air pollution, but health costs remain high relative to higher-income countries. Although the growth in nitrogen dioxide (NO2) and particulate matter less than 10 micrometers in diameter (PM10), has been stable or declining relative to Türkiye's economic growth, sulphur dioxide (SO2) and particulate matter less than 2.5 micrometers in diameter (PM2.5) emissions have increased, but at a slower rate than economic growth (table 1.1). Given its link to human health, the growth in PM2.5 is concerning, and its economic cost is equivalent to more than 5 percent of GDP.

Resource efficiency and recycling need to grow as part of a transition to a circular economy. Although Türkiye's municipal waste generation was lower than the OECD average (424 kilograms per capita in 2018 versus 525 in the OECD) and has been declining since 2001, the bulk of municipal waste is sent to landfills or dumpsites. Most domestic material consumption is in sectors related to non-metallic mineral extraction used in construction and buildings—including cement, stone and ceramic products, glass and glass products, stone, sand, and clay—and biomass used by rural households for domestic heating purposes.

Despite successful reforestation efforts, climatic and human-induced factors put pressure on land, soil, forests, and water resources. The combination of geographical, topographic, climatic, and soil characteristics, combined with unsuitable farming practices, makes Türkiye prone to erosion, with a recent study estimating that 32 percent of the country's territory is at high risk of land degradation and desertification (Dengizb and Uzunera 2020). Climate change is expected to exacerbate land degradation through soil erosion, fertility loss, and nutrient depletion, with negative impacts on agriculture and livestock productivity and the soil's capacity to serve as carbon sink. Increasing water

[5] https://databank.worldbank.org/source/world-development-indicators.
[6] https://www.imf.org/en/Publications/WEO.

scarcity and water pollution are also threatening the health of Türkiye's river basins. Of the country's 25 river basins, 15 face water availability constraints. Pollution from agriculture, industrial and domestic effluents, runoff, and sedimentation means that many are considered contaminated.

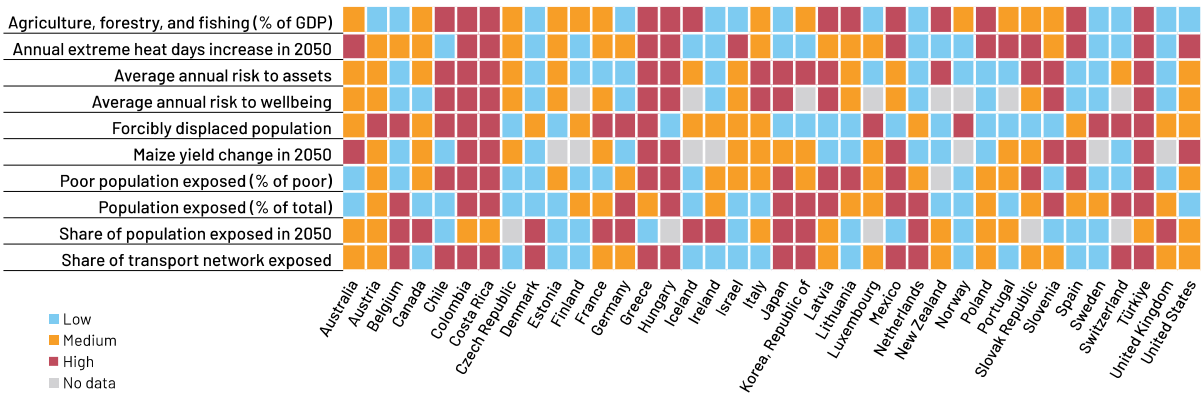
1.3. Significant climate-related challenges

The energy sector—which includes the power, transport, building, and industrial sectors—is the country's single largest contributor to greenhouse gas (GHG) emissions, accounting for three-quarters of total emissions (figure 3.1). Türkiye imports 99 percent of its gas and 93 percent of its oil, making it heavily exposed to supply disruptions and price volatility in global and regional energy markets, and to the consequences of global crises, such as the war in Ukraine. Boosting energy efficiency and renewable energy could generate major benefits by reducing energy imports, expenditures, and air pollution.

Table 1.1 shows that the increase in Türkiye's GHG and carbon dioxide (CO_2) emissions has been slower than economic growth and that its per capita emissions are lower than OECD or EU countries. Its power, transport, and agriculture sectors are less carbon-intensive than the EU average, partly due to the large penetration of renewable energy (RE) in Türkiye's power system and low motorization rate. Its residential and non-residential building sector, on the other hand, is less energy efficient than the EU average, offering an opportunity for important gains. Manufacturing is also more carbon-intensive than the EU average, exposing the country to risks if the EU introduces a Carbon Border Adjustment Mechanism (CBAM).

Türkiye's geographic, climatic, and socioeconomic conditions make it highly vulnerable to the impacts of climate change and other environmental hazards. Türkiye has a high vulnerability rating in 9 of 10 climate vulnerability dimensions, compared with a median of 2 of 10 in other OECD countries (figure 1.2). This vulnerability is due to a combination of climate factors, including an expected increase in extreme heat days and exposure of the population to climate impacts (for example, the share of the population exposed to floods), as well as socioeconomic factors, such as the share of agriculture in the economy.

Figure 1.2: Climate risk and vulnerability in Türkiye and other OECD countries



Sources: World Bank staff calculations, based on data from Climate Impact Explorer;[7] Kulp and Strauss 2019; Rentschler and Salhab 2020; UNISDR 2015; World Development Indicators;[8] and the World Bank Climate Change Knowledge Portal[9]
Notes: The presented indicators are a selection of drivers of risk in OECD countries. Countries are rated using a benchmark approach: those rated at high risk (red) are in the top third, medium risk (yellow) are in the middle third, and low risk (blue) are in the lowest third.

[7] https://climate-impact-explorer.climateanalytics.org/.
[8] https://databank.worldbank.org/source/world-development-indicators.
[9] https://climateknowledgeportal.worldbank.org/.

Table 1.1: Summary of environmental and sustainability trends and benchmarking

Indicator	Decoupling Trend	Key sources/main issues	Benchmark	
			Türkiye	Comparator
SO2 emissions (*kg per capita*)	RD	• Power, industrial combustion	29.4	OECD: 7.2
NO2 emissions (*kg per capita*)	AD	• Transport, power, industrial combustion	9.3	OECD: 13.1
PM10 emissions (*kg per capita*)	AD	• Industrial combustion and processes, other combustion	3.0	OECD: 3.4
PM2.5 emissions (*kg per capita*)	RD	• Industrial combustion, agriculture	2.4	OECD: 2.2
CO2 emissions (*kg per capita*), excluding the Land Use, Land-Use Change and Forestry (LULUCF) sector	RD	• Power, manufacturing, transport, buildings	5,090	OECD: 9,000
GHG emissions (*kg per capita*), excluding LULUCF	RD	• Energy, industrial processes, agriculture, waste	6,070	OECD: 7,740
Power (*% renewable energy in generation*)		• 3.8kg CO2/$ of value added • Reliance on indigenous lignite is increasing	42	EU: 38
Transport (*kg CO2/$ of value added*)		• 29% of total final energy consumption (TFC) • Road transport is the fastest-growing emissions source	0.5	EU: 0.7
Manufacturing (*kg CO2/$ of value added*)		• 33% of TFC is from non-metallic minerals, iron and steel, chemicals, textiles, food, and tobacco	0.2	EU: 0.1
Agriculture (*kg CO2/$ of value added*)		• Agriculture is responsible for 62.4% (1,500 kt) of total methane emissions	0.8	EU: 1.7
Buildings (*average kWh/m²/y*)		• Residential energy consumption: 21% of TFC in 2018 • Commercial and public buildings: 13% of TFC in 2018	SF: 220 MF: 175 NR: 270	EU (SF & MF): 180 EU: 250
Welfare cost of premature deaths from PM2.5 (*% GDP equivalent*)	RD	• Ambient concentrations are high in urban centers	5.3	OECD: 2.4
Municipal waste (2018, *kg/capita/year*)	RD	• 87% of all waste goes to landfill or dumpsites and only 12% is recycled	424	OECD: 525
Material consumption (*1,000 kg/capita/year*)	RD	• Türkiye imported 50% of all ferrous metal waste from EU in 2019	12.1	OECD: 13.6
Land degradation, desertification, and forests (*2010–20, annual net gain in forest area, %*)		• 642 million tonnes of soil transported per year; 43% of forests classified as degraded and in need of rehabilitation; the production value of wood and non-wood products is below potential	0.5	EU: 0.2
Water scarcity and quality (2017, *Water Exploitation Index plus*)		• 15 of 25 river basins are water-stressed; a third of lakes and up to half of rivers are contaminated by phosphorus and nitrogen	23.3	OECD: 8.4
Environmental protection expenditures (% GDP)	ND	• Mostly waste (45%) and wastewater management (40%)	0.9	EU: 1.9
Natural hazards and disasters (*average annual asset losses in % GDP*)		• 935 extreme events in 2019, with heavy rain/floods (36%), windstorms (27%), hail (18%), and significant earthquake risks to lives and infrastructure	0.20	OECD: 0.09

Sources: World Bank staff calculations, based on data from Turkstat, Eurostat, OECD Stat, various years[10]
Notes: Decoupling trend is based on comparison with GDP for the latest year of data. AD (blue) = absolute decoupling, where the growth of air pollutants is stable or declines relative to economic growth; RD (pink) = relative decoupling, where emissions increase at a slower rate than economic growth. Although rated as negative decoupling (ND) under environmental protection expenditures, it is also rated as positive (blue) because expenditures are growing faster than GDP growth. Under Benchmarks, the indicators are rated blue when Türkiye's indicator is better than the comparator (OECD or EU) and red when it is worse. The Water Exploitation Index plus (WEI+) is a measure of total freshwater use as a percentage of renewable freshwater resources (groundwater and surface water) at a given time and place. It quantifies how much water is abstracted and how much is returned after use to the environment. SF = single family, MF = multi-family, NR = non-residential; kg = kilogram; kt = kilotonne.

[10] https://www.tuik.gov.tr/; https://ec.europa.eu/eurostat/data/database; https://stats.oecd.org/.

2. Climate commitments, policies, and capacities

MAIN MESSAGES

Türkiye has moved swiftly on climate change in the last months, ratifying the Paris Agreement, committing to net zero emissions by 2053, and strengthening institutional arrangements for climate change issues by drafting and updating important policy documents, such as the National Climate Change Action Plan (NCCAP), and adding 'climate change' to the attributions of the MoEUCC. While the role of the MoEUCC has been determined by Presidential Decree No 85, its coordination with other ministries and agencies, will need to be refined and adjusted over time to ensure clear allocation of responsibilities.

To achieve its objectives, Türkiye needs to update its intended nationally determined contribution (INDC) to a strong and ambitious NDC and reflect climate objectives in major policy documents and government processes, especially regarding budgeting and investment cycles.

While the private sector has adopted multiple measures to address their environmental impacts, most firms—especially small ones—do not have organization-level strategic climate change objectives and dedicated managerial functions to enable them to cope with climate change impacts and manage and benefit from domestic and international decarbonization.

To achieve net zero by 2053 and its ambitious adaptation and resilience goals, Türkiye must make concerted efforts to increase the capabilities of all actors across the public and private sectors, the financial system, and civil society.

Türkiye has ratified the Paris Agreement and strengthened a set of domestic commitments on climate change. At the April 2021 Leaders' Summit on Climate, Türkiye announced a broad set of commitments and priorities related to climate change, with a strong emphasis on resilience and adaptation, and proposed actions around energy-efficient, climate-sensitive residential areas, agriculture, the Zero Waste Project, and renewable energy. This chapter provides a brief review of the country's commitments, their institutional implementation, and their integration in other policy documents. It also uses the World Bank's Enterprise Survey (World Bank 2019) to assess the private sector's preparedness for implementing the country's commitments.

2.1. A growing set of climate documents

A signatory since April 2016, Türkiye ratified the Paris Agreement in October 2021. Ahead of the Glasgow COP26 Summit, it also announced its net zero target of 2053. Next, it is expected to submit an updated NDC with a more ambitious emissions reduction target that is in line with its long-term commitment.

Türkiye has several climate policy documents. Climate change-related issues are regulated through the articles of various laws, including the Agricultural Insurance Law, Catastrophe Insurance Law, Nature and Biological Diversity Protection Law, Energy Efficiency Law, Building Energy Performance By-Law, and the By-Law for Preparation of Spatial Plans. The main climate policy documents are:

- National Climate Change Strategy (2010–23),[11] with short-, medium- and long-term objectives on adaptation and mitigation
- NCCAP (2011–23),[12] covering key areas, including energy, buildings, industry, transport, waste, agriculture, land use and forestry, and adaptation

[11] https://webdosya.csb.gov.tr/db/iklim/editordosya/iklim_degisikligi_stratejisi_EN(2).pdf.
[12] https://webdosya.csb.gov.tr/db/iklim/editordosya/file/eylem%20planlari/iklim_degisikligi_eylem_plani_EN_2014.pdf.

- NCCAP Monitoring System[13]
- National Climate Change Adaptation Strategy and Action Plan (2011–23).[14]

The country's 11th National Development Plan[15] (NDP) also proposes policies and measures[16] to tackle climate change under the environmental protection subsection of its Livable Cities and Sustainable Environment pillar, such as developing regional climate change action plans for its seven regions. In July 2021, the government released its Green Deal Action Plan[17] to help Türkiye transition to a sustainable and resource-efficient economy and in response to the comprehensive changes envisaged by the European Green Deal. To support the transition, the Scientific and Technological Research Council of Türkiye (TÜBİTAK) has developed guidance on priority research and development (R&D) and innovation themes and prioritizes these in their support programs.

Some cities and municipalities have introduced local climate change action plans, policies, and measures to strengthen resilience to climate change, while some sectoral policies and plans incorporate aspects or elements of climate change. Twenty-seven Turkish cities and municipalities have joined the Global Covenant of Mayors for Climate and Energy, the largest global alliance for city climate leadership with over 10,000 city and local government members. Of these, 16 have committed to a climate change mitigation target, but much remains to be done: 10 are still working on their emissions inventories and mitigation plans; none has an adaptation plan;[18] and only one (Izmir) has a climate change action plan and Green Cities Action Plan.

Although Türkiye has the capacity to formulate climate policy, some of its major documents could better reflect climate change issues. To this end, the country is currently drafting a Climate Change Framework Law, in which policies need to be harmonized. Associated regulations with clearly assigned roles, responsibilities, and coordination mechanisms are also needed to strengthen the country's climate agenda and align its policies with Paris Agreement goals.

2.2. Public sector preparedness: improved but with serious gaps

Türkiye has taken steps to strengthen its institutional arrangements for climate change issues by establishing a National Climate Council—an interministerial coordination mechanism—and a new Presidency of Climate Change under the MoEUCC. The MoEUCC is the national focal point for the climate change agenda and is responsible for: monitoring, coordinating, and evaluating local and international climate actions; emissions monitoring and reporting; preparing legislation; sharing information and raising awareness; and acting as secretariat for the Climate Change and Air Management Coordination Board—a horizontal governmental structure for coordinating climate change activities. The Board was restructured in October 2021 and renamed the Climate Change and Adaptation Coordination Board (CCACB).

There are no legal or regulatory requirements for mainstreaming climate change policy objectives into public financial management instruments, but there has been some progress on adaptation and resilience. To overcome the limitations of the traditional budget system, Türkiye introduced a central government-level program budgeting approach in 2021 with 67 programs.[19] Only 1 of the 67 programs covers climate change directly but the volume of indirect green spending to combat climate

[13] https://iklim.csb.gov.tr/e-iklim-sistemi-i-100.

[14] https://webdosya.csb.gov.tr/db/iklim/editordosya/file/eylem%20planlari/uyum_stratejisi_eylem_plani_EN_Final.pdf.

[15] https://www.sbb.gov.tr/wp-content/uploads/2021/12/Eleventh_Development_Plan_2019-2023.pdf.

[16] These include tackling climate change in sectors causing GHG emissions, making the economy and society more resilient to climate risks, improving capacities for adaptation to climate change, controlling emissions in the building, energy, industry, transport, waste, agriculture, and forestry sectors, and increasing capacities to adapt to the impacts of climate change.

[17] https://ticaret.gov.tr/data/60f1200013b876eb28421b23/MUTABAKAT%20YE%C5%9E%C4%B0L.pdf.

[18] www.globalcovenantofmayors.org/our-cities/.

[19] Annex 2 of the 2021 Budget Law No. 7258 published in the Official Gazette dated 31 December 2020 No. 31351.

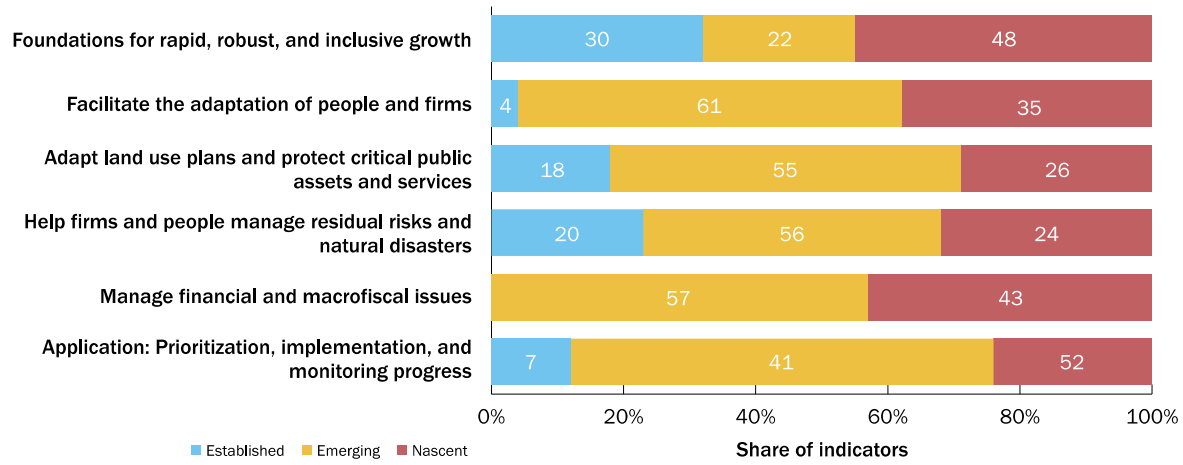
change and its effects is most certainly larger. The volume may become clearer as green budget tagging improves.

Nor are there any legal or regulatory requirements for addressing climate change policy objectives in the investment cycle and overall infrastructure governance. As a result, climate change policy objectives have not been mainstreamed across core infrastructure governance processes, regulations, strategies, and planning. The Strategy and Budget Office's 2022–24 Investment Program Preparation Guideline includes some climate screening requirements, such as the preparation of environmental impact assessments, and suggests that the environmental impact of proposed projects be factored into economic analyses.

Boosting adaptation and resilience are clear priorities for climate action. A systematic assessment of Türkiye's adaptation readiness prepared for this report identifies gaps in capacity and priority areas for policy development and interventions for climate adaptation and resilience.[20] Using *The Adaptation Principles* framework, the paper selected approximately 135 indicators to evaluate enabling factors for adaptation and resilience in Türkiye, paying special attention to the five key areas identified in its National Climate Change Adaptation Strategy and Action Plan: water resource management; agriculture and food security; ecosystems, biodiversity and forestry; disaster risk management; and public health.

Türkiye has started to lay a solid foundation for building adaptation and resilience through planning and policy development at various levels of government and in various sectors. There has also been progress in mainstreaming climate change adaptation and disaster risk reduction into national development processes, but more needs to be done to establish and fund priority actions and develop strategies and capacity to build resilience and strengthen preparedness (figure 2.1).

Figure 2.1: Adaptation and resilience readiness in Türkiye



Source: World Bank 2022 (forthcoming)

2.3. Private sector preparedness: progressing but uneven

Firms' preparedness for climate change and rapid decarbonization is uneven in Türkiye. Even though firms have a relatively high degree of sophistication, as reflected in strong export competitiveness and integration in global value chains, less than 10 percent of respondents to the World Bank's Enterprise

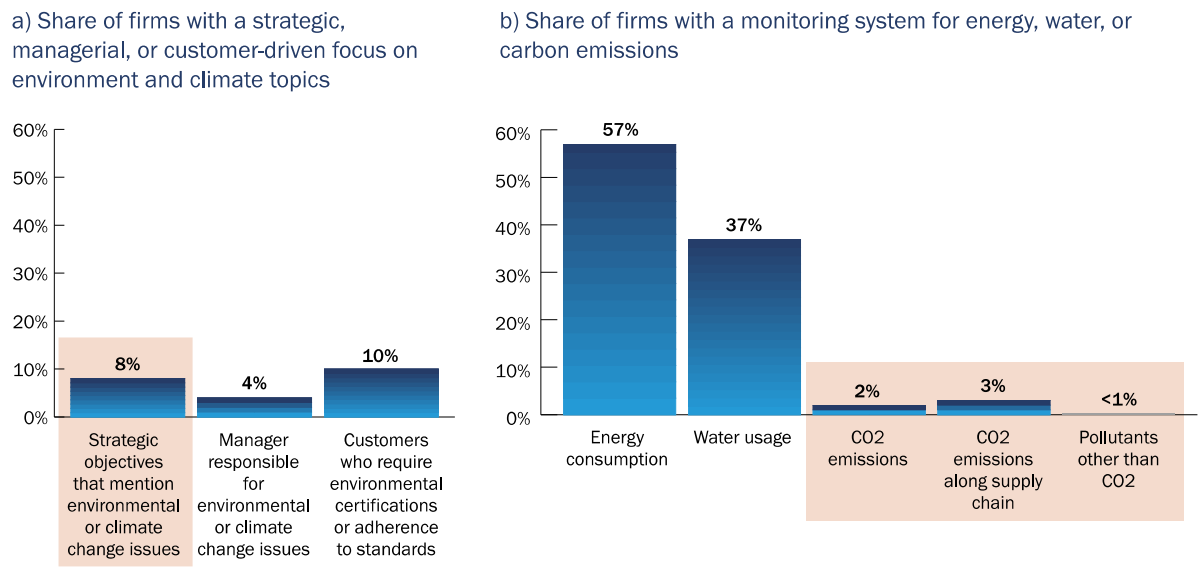
[20] World Bank 2022 (forthcoming) presents a systematic assessment of Türkiye's policies, plans and programs related to adaptation, risk management and resilience, to identify priority areas and interventions to strengthen the country's adaptation and resilience capacity to climate change and disasters. It uses a traffic light approach to help focus and prioritize actions, identify gaps, facilitate target setting, and monitor progress across sectors and aspects of resilience. Each resilience element is measured against three criteria: nascent, emerging, and established.

Survey for Türkiye have organization-level strategic climate change objectives and less than five percent have a dedicated managerial role with overview of environment or sustainability issues (World Bank 2019; figure 2.2). And while most firms monitor their energy consumption, only 37 percent monitor water consumption, and 2 percent CO2 emissions.[21]

Disaggregating by firm size shows that larger firms are relatively more likely to incorporate climate into their strategic objectives and have sustainability officers responsible for environment-related concerns. Climate focus was also more prevalent among export-oriented firms than domestic-focused businesses, possibly because they have to adhere to sustainability standards required by export destinations, particularly the EU market. Unsurprisingly, the less innovative firms in terms of R&D and/or product or process innovation are less likely to have climate-related strategic objectives.

Manufacturing firms have adopted multiple ancillary measures to address their environmental impacts in the last three years. More than a third of firms (35 percent) upgraded machinery, equipment, and other assets, while one-fifth of all firms surveyed made improvements to heating, cooling, and lighting systems, and 13 percent leveraged circular economy practices such as waste reduction, recycling, and management.

Figure 2.2: Turkish firms that focus on environment and climate topics and monitor emissions



[21] See chapter 4 for a discussion on the vulnerability of and opportunities for the financial sector and financial firms.

3. Pathways toward resilience and decarbonization

MAIN MESSAGES

The first prerequisite for reducing vulnerability to climate change is rapid, robust, and inclusive growth. Targeted priorities include: supporting adaptation in the private sector by ensuring access to information, technology, and finance; actions to enhance the resilience of critical public assets and services, urban and land use plans, and agriculture, water, and land resource management; and financial resilience built through insurance and adaptive social protection, and including climate and disaster risks in macroeconomic and fiscal policies, and disaster-related contingent liabilities in budgetary processes.

To achieve net zero by 2053, this CCDR suggests an RNZP that entails: near-decarbonization of the power sector by 2040; energy efficiency and electrification for zero carbon transport and buildings; industrial energy efficiency and technological innovation to mitigate hard-to-abate emissions; emissions reductions in agriculture and waste sectors; and maximizing the carbon sequestration potential of forest and agricultural landscapes.

Benefits of the RNZP exceed the costs. Sectoral roadmaps of the power, residential, transport, and forest landscapes sectors, with simplified analyses for industries and agriculture, suggest that the proposed RNZP offers economic gains ($15 billion for 2022–30 and $146 billion for 2022–40), through significant avoided energy imports, health gains, and other co-benefits. However, additional investment needs are large, reaching $68 billion for 2022–30 (1 percent of discounted cumulative GDP) and $165 billion for 2022–40 (1.2 percent of discounted cumulative GDP).

Building on Türkiye's socioeconomic and development context (chapter 1) and its ambitious commitments and policy objectives (chapter 2), this chapter aims to identify development pathways to enable the country to achieve its goals in terms of development, resilience (section 3.1), and GHG emissions (section 3.2), by developing an RNZP that successfully combines these multiple objectives (section 3.3). Chapters 3 and 4 both compare this RNZP with a baseline scenario that assumes the continuation of current trends and policies.

3.1. Priorities to boost economy-wide resilience and adaptation

The first prerequisite for reducing vulnerability and impacts of climate change is rapid, robust, and inclusive growth. Targeted adaptation and resilience policies can only deliver with a supportive socioeconomic environment. For example, although macroeconomic stability, financial inclusion, and social protection coverage are not adaptation policies, they strengthen households' and firms' ability to prepare for, cope with, and recover from external shocks, and enable the introduction and financing of more targeted resilience actions.

There are also opportunities for more targeted adaptation action to manage natural hazards and long-term climate change. These actions can reduce losses from natural hazards, but also slower changes in climate conditions that will affect human settlements, agriculture, or water availability. This CCDR also includes geophysical risks in its assessment: while earthquakes are not a climate hazard, most policies and measures to manage risks—from construction standards to disaster risk finance instruments—have to consider the full range of threats in their design, and considering all risks together creates significant opportunities, especially in a country as exposed to earthquake risks as Türkiye.

3.1.1. Facilitate the adaptation of firms and people

Strengthening the enabling environment will allow the private sector to internalize climate change risks in investment decisions, and transition to more resilient and competitive business models and economic activities. The private sector is highly exposed to natural disaster and climate change risks:

a 2013 market study of Türkiye's private sector (Baglee et al. 2013) identifies the sectors and industries that are most vulnerable to physical climate risks, including many of the 11th NDP's priority areas: electricity production, transmission, and distribution; water collection, treatment, and supply; sewerage; chemicals and chemical products; tourism; and construction.

The government can expand public provision of climate and disaster risk information at national, regional, and local levels. Türkiye has made good progress in assessing climate and disaster risks, including at regional and water basin levels, with the Turkish State Meteorological Service and State Hydraulic Works' robust hydromet database and new modeling capability. Areas for improvement include facilitating public access to climate and disaster information, supporting the generation of more granular climate scenarios and exposure and risk information (such as local-scale hazard maps), setting residual risk target levels, and identifying and assessing the risks to most vulnerable populations and communities.

But a large range of other market failures may require government attention. To ensure that households and firms are making the right decisions to manage climate change and natural disasters, the government needs to clearly establish responsibilities and liabilities in law and communicate these to all actors. This includes ensuring credible, transparent, and independent regulatory bodies for improving the predictability of the policy framework. In the building and residential sector, well-designed standards and regulations are essential to ensure new investments can cope with the most common hazards. It may be necessary to complement these with financial tools to help households manage the higher upfront costs of increasing resilience (box 3.1).

Box 3.1: More resilient cities and buildings, with energy efficiency co-benefits

To cope with the large seismic risks and to achieve significant energy efficiency co-benefits, the vast majority of pre-2001 Turkish buildings will need retrofitting or reconstructing, and improved enforcement of building codes is vital for new construction.[a] The almost 8 million buildings constructed before 2001 (of which 6.7 million are residential) are generally considered to be at high risk of serious damage or collapse. If Türkiye does not retrofit or reconstruct its existing building stock, more than 6,000 people could lose their lives prematurely by 2050.[b] Seismically retrofitting or demolishing and rebuilding all pre-2001 stock can save a significant number of lives. Figure B3.1.1 shows lives saved and cumulative seismic retrofit investments needed by 2050 for different retrofit paces.[c]

The government can drive private sector participation through its flagship Urban Renewal and Development Initiative. The initiative aims to renew 7.5 million units in risky areas by 2030 but with a $400 million budget, the government will need to mobilize further private sector support to meet the costs (figure B3.1.1). One way to do this is to promote combined efforts to bolster structural integrity with energy efficiency. This includes green certificates, for which there is a big appetite, especially among large developers.[d]

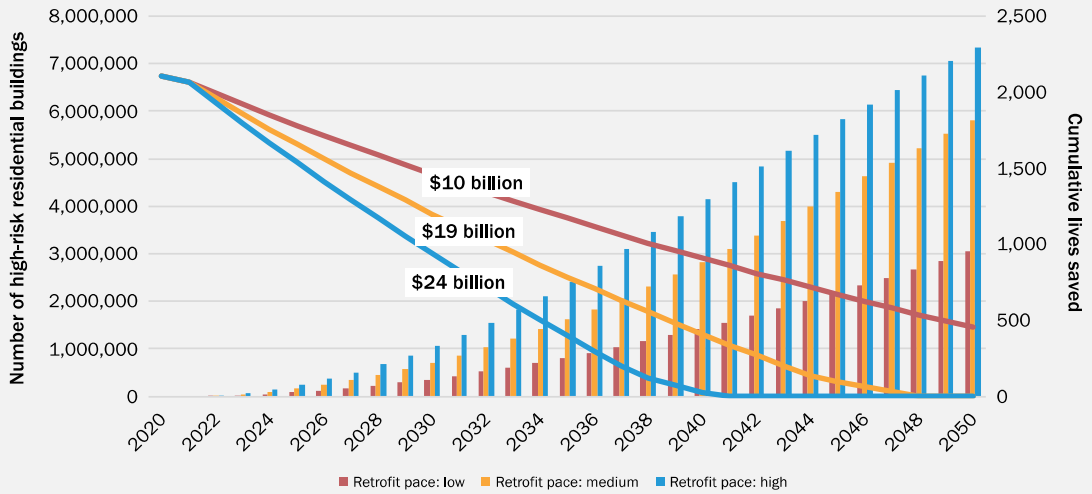
To achieve energy efficiency at scale and to preserve the integrity of cultural heritage, a vast majority of Turkish buildings need structural strengthening. Energy efficiency measures can only be implemented in buildings that comply with the 2019 building code—including the seismic design regulations—which means a large share of existing and historical buildings in Türkiye require seismic upgrading prior to, or in combination with, efforts to improve energy efficiency.

As well as helping Türkiye achieve climate change adaptation and mitigation outcomes, integrated seismic and energy retrofit of buildings can provide other benefits. Combining the two creates savings in labor costs and scaffolding expenses while minimizing disruption to building

occupants. Assuming a 25 percent reduction in retrofitting costs, total savings could amount to $20 billion ($13 billion, discounted) in a scenario where 300,000 buildings are retrofitted each year. Annual energy savings are projected to surpass investment needs in 2037 (figure B3.1.2). With the entire pre-2001 stock retrofitted by 2041, cumulative energy savings should exceed retrofit investment costs by 2045. But if seismic and energy retrofitting are carried out separately, energy savings will not exceed investment needs until 2050.

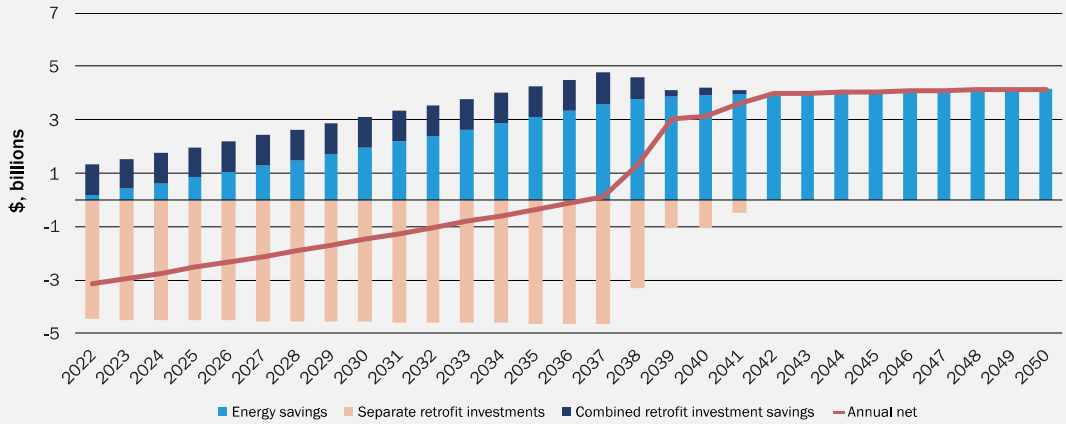
Retrofitting buildings also offer an opportunity to improve thermal comfort and help people cope with extreme high temperatures. Urban areas are particularly likely to experience extreme heat due to the urban heat island effect, caused by artificial materials absorbing heat, a lack of vegetation, buildings trapping heat and blocking breezes, and factories, cars, and air conditioners releasing heat. Under a global 2°C warming scenario, the area around Izmir would experience more than 16 days above 40°C each year, while Gaziantep would experience 31 days. The urban heat island effect would magnify the impact: data for 2003–18 show a summer daytime urban heat island effect of more than 3°C in Istanbul, and close to 2°C in Bursa.[e] Heatwaves are associated with a range of health conditions, increased mortality, lower productivity, poorer educational outcomes, and increased crime, domestic violence, and suicide rates. With less vegetation, low-income neighborhoods tend to get hotter than wealthy ones.

Figure B3.1.1: Retrofitting Türkiye's high-risk buildings: investment needs and cumulative lives saved by 2050



Source: World Bank staff calculations, based on data from the Global Earthquake Model

Figure B3.1.2: Integrated retrofitting: annual investments and energy savings (undiscounted), 2022–50



Source: World Bank staff calculations, based on data from the Global Earthquake Model
Note: Energy use is reduced to 60 kWh/m²/year and 50 kWh/m²/year for single- and multi-family homes, respectively.

[a] See Background Note 1.

[b] Note that this estimate, based on probabilistic seismic risk analysis by the Global Earthquake Model, is about five times lower than found in other studies, so the potential to save lives is likely much higher than presented here. See, for example, https://openknowledge.worldbank.org/handle/10986/25858.

[c] The analytical work is described in detail in Background Note 2.

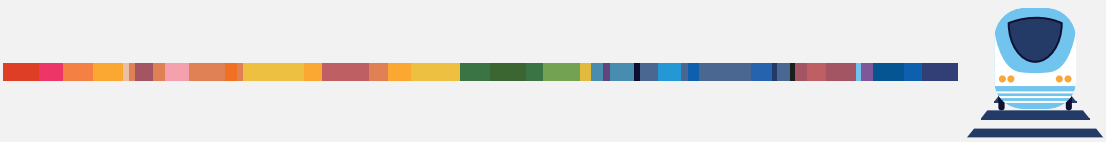
[d] Türkiye's market for green buildings is relatively mature. In 2019, it had the 7th most LEED-certified buildings in the world (Green Business Certification Inc, https://gbci.org/us-green-building-council-releases-2019-top-10-countries-and-regions-leed).

[e] Data from the Global UHI Surface Explorer (https://yceo.yale.edu/research/global-surface-uhi-explorer); Chakraborty and Lee 2019.

3.1.2. Adapt land use plans and protect critical public assets and services

Strengthening institutional capacity to manage and protect public assets will lead to more resilient growth. Necessary actions to future-proof Türkiye's critical assets and services include systematically considering climate and disaster risks in land use and urban planning; updating and enforcing building codes and design standards; and investing in resilient infrastructure. Ensuring resilience of critical buildings, such as hospitals and schools, is important for strengthening public health and community resilience, and the government has already done a lot in this area, such as introducing differentiated seismic design codes based on building use category. But further efforts are needed. The World Bank's *Lifelines* report finds that unreliable power and water supply and transport disruptions cost the Turkish economy 2.2 percent of GDP every year. Without action to adapt infrastructure systems, these costs are bound to rise.

A detailed assessment of Türkiye's transport system concludes that it has higher-than-average vulnerability and increasing its resilience will be expensive (box 3.2). Considering the worsening water scarcity, a follow-up study on the water sector is a priority (box 3.3), while assessing the exposure and vulnerability of all energy assets, particularly hydropower,[22] would help identify opportunities to boost the energy system's resilience, thus improving productivity and production efficiency. With its health system security in the bottom tercile of OECD countries, training medical personnel and enhancing emergency planning could expand surge demand capacity and prepare the country for future disasters. And while Türkiye is on the right path for increasing the resilience of its education system, only half of the population has access to remote learning resources, compared with the OECD average at 80 percent. Increasing households' access to electricity, internet, devices, television, and other enabling resources would strengthen it further. Digitalization also offers opportunity for resilience, but the country is constrained by low access to broadband internet and lack of digital skills.



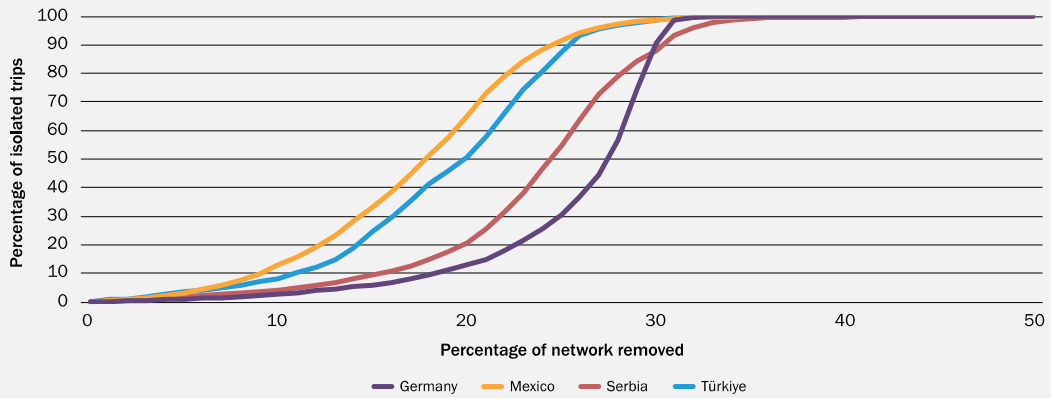
Box 3.2: A more resilient transport system

We conducted simulation modeling and analysis on multi-hazard risks to Türkiye's road and railway infrastructure, including a criticality analysis of the national transport network. Considering the entire national road and rail networks' exposure to current climate conditions, we also estimated damage from exposure of key linear and nodal transport infrastructure—including 16 seaports and 10 airports—to landslide, flooding, and wildfire.

[22] Türkiye's hydropower-generating assets, which contribute greatly to its RE potential, are highly exposed to droughts and earthquakes.

Türkiye's road network is less resilient to disruption than Germany's and Serbia's, but more resilient than Mexico's. Comparing network resilience modeling results with three countries, (figure B3.2.1), we find that Germany and Serbia, an upper-middle income peer country in the same geographical region, experience fewer isolated trips for a given level of network damage. With 20 percent of the network rendered inaccessible, 51 percent of trips in Türkiye cannot take place, compared with 13 percent in Germany and 21 percent in Serbia. In Mexico, a comparable upper-middle income country with a similar mix of industries, the transport system appears less resilient.

Figure B3.2.1: Disruption of the road network: isolated trips in Türkiye, Mexico, Serbia, and Germany



Source: World Bank staff calculations

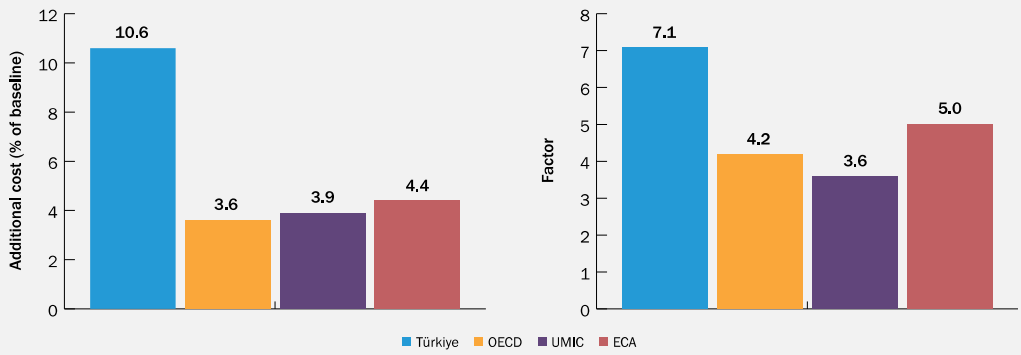
Subnational results show that road networks in Turkish regions have measurably different levels of resilience. Severe damage to 20 percent of the network in Ankara Region isolates only 8 percent of trips, compared with 22 percent in Istanbul, 28 percent in Adana, 34 percent in Izmir, and 69 percent in the Black Sea Region. Two of Türkiye's main seaports (Iskenderun and Trabzon) and two of its main airports (Trabzon and Gaziantep) are exposed to flooding from rainfall, riverine flooding, or both. Those same ports are also exposed to minor landslide hazards (less than 2 percent annual probability in all cases), and four seaports and three airports are exposed to wildfire.

Türkiye's infrastructure resilience investment needs are higher than other OECD countries, but gains are also higher. Because most of the transport system is exposed to various hazards, ensuring all new transport infrastructure assets are built to higher resilience standards would increase investment needs in the sector by almost 11 percent, but it could also reduce average annual repair costs by a factor of 7 (figure B3.2.2).

Figure B3.2.2: Investment needs for and cost-efficiency of resilient transport infrastructure

a) Annual investments needed to make transport infrastructure resilient by 2030

b) Resilient transport infrastructure would reduce annual repair costs by a factor



Source: Hallegatte, Rentschler and Rozenberg 2019
Note: UMIC = Upper Middle-Income Countries, ECA = Europe and Central Asia.

Box 3.3: Better water resource management and regulations

Climate change poses significant risks to Türkiye's water security. Over two-thirds of the country's 25 river basins face severe water scarcity, including those hosting the largest cities and economic hubs such as Istanbul, Ankara, Izmir, and Antalya, as well as important agricultural areas, such as the Konya plains.[a] By 2023, Türkiye's total water consumption will be 112 billion cubic meters, comprising 72 billion for irrigation, 18 billion for domestic use, and 22 billion for industry. Between 1990 and 2019, water demand for irrigation increased from 72 to 76.7 percent of total consumption. Increasing drought severity has exacerbated groundwater depletion, with water levels dropping by more than two meters in river basins such as Konya, threatening the long-term sustainability of agriculture and contributing to the occurrence of massive sinkholes. The 2020/21 drought left several reservoirs around major cities with their lowest water storage levels in 15 years: Istanbul's reservoir levels fell to less than 20 percent of capacity in early 2021, putting water supply services at high risk for the city's 16 million customers and other users, including industry. Climate change-related warming of the Marmara Sea, combined with widespread pollution from the discharge of untreated industrial and domestic wastewater, fertilizers and pesticides has also contributed to the mucilage crisis that threatens aquatic life, tourism, and fisheries.

A World Bank assessment on water scarcity estimates that a 10 percent reduction of water supply from climate change would cost Türkiye 6 percent of GDP and about $50 billion (Taheripour et al. 2020). Although the study only considers climate change impacts on the agriculture sector, the economic impacts of growing water scarcity are significant and will deepen. Negative impacts are also likely in other key sectors, such as energy—as water is needed for cooling and hydropower production—and industry. Of course, variability and extreme events more broadly have negative impacts on the economy. In the event of a 100-year flood, more than 3 percent of GDP (or $20 billion) and 3 million people could be affected.

To strengthen resilience to growing water-related risks and achieve its long-term net zero vision, Türkiye needs to complete land consolidation works and continue to invest in the following priority areas:

- Integrated water resource planning at basin level, including climate and other uncertainties
- Policy and regulatory instruments to encourage demand-side management at all levels in water supply and irrigation, and establish effective incentive-based coordination mechanisms for key stakeholders
- Multipurpose water storage, including the use of nature-based solutions and coupling with other renewable energy sources, such as floating solar
- Ongoing modernization of irrigation and drainage services—such as high-efficiency drip, remote sensing approaches, and automation—complemented by water-saving agriculture interventions, and more efficient water supply and sanitation services to reduce water losses and increase energy efficiency
- Diversifying freshwater resources by developing alternative water sources, including circularity through greater reuse of treated wastewater and conjunctive use of aquifers—for example, artificial recharge—and reducing water loss through more efficient irrigation and a drinking water conveyance system
- A circular economy through resource recovery—such as reduced energy use or methane capture—to help reduce GHG emissions.

Source: Background Note 3

[a] Absolute water scarcity is defined as providing less than 500 m^3/capita/year; water scarcity is less than 1,000 m^3/capita/year; water stress is less than 1,700 m^3/capita/year.

3.1.3. Help firms and people manage residual risks and climate change impacts

Türkiye can build on its good progress with early warning and disaster preparedness programs by strengthening resilience to and preparedness for extreme weather and disaster risks. There are opportunities to enhance early warning systems, emergency response capacity (including healthcare system preparedness), community engagement and training, and disaster response and coordination. Business continuity plans are an efficient way to accelerate and improve recovery and can be mandated for firms of a certain size or in certain sectors.

Financial instruments for risk reduction should be made available to all, particularly the poorest and most vulnerable people, to help them cope with and recover from shocks. Introducing systems—including financial tools, such as access to borrowing, insurance, and social protection (box 3.4)—can minimize the unavoidable impacts of climate change and natural disasters. Developing new solutions to incentivize the roll-out of such insurance products to banks, such as capital relief instruments, would be desirable to achieve scale.

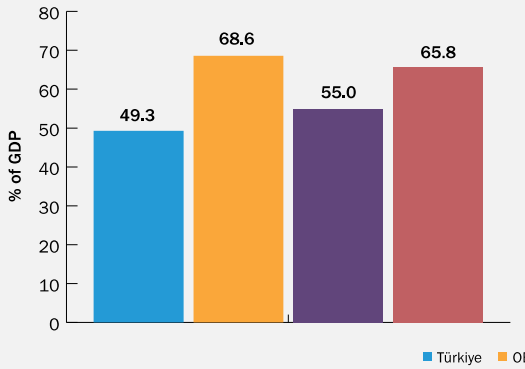
Box 3.4: Financial tools for resilience: combining insurance and social protection

Social protection coverage, social benefits, and insurance penetration are low in Türkiye compared with other OECD and upper-middle income countries, particularly for poor and vulnerable populations. Access to financial risk instruments—such as insurance, social protection, cash transfers, emergency borrowing, and postdisaster support—is essential for mitigating disaster impacts and reducing postdisaster poverty.

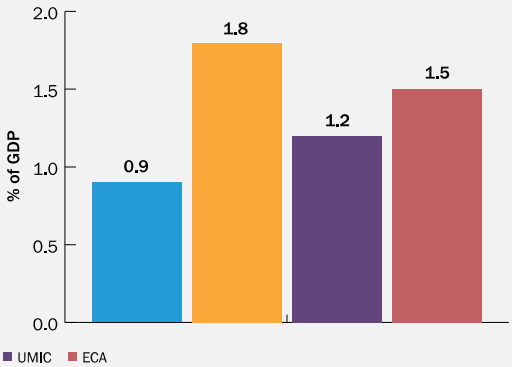
Low uptake of insurance for climate-related disasters in the private sector increases macrofiscal risks. Between 1980 and 2019, only around 14 percent of Türkiye's climate-related total economic losses were insured. This is lower than most European countries. This lack of insurance coverage highlights the potential exposure of public finances, especially if the government is expected to cover these losses. Any measures to promote insurance uptake would need to balance disaster risk management against costs to households and businesses, ensuring products are affordable. But even with higher insurance uptake, the government would continue to be exposed to a residual risk and could seek to transfer some of the domestic risk internationally, as they did with the mandatory Turkish Catastrophe Insurance Pool, established after the 1999 Marmara earthquake. Studies on the design of a disaster insurance product that covers a broader range of natural disasters have been initiated and are planned to be completed by 2023.

Figure B3.4.1: Disaster preparedness and risk management instruments in Türkiye

a) Social protection coverage, 2019



b) Non-life insurance penetration, 2008–17 average



Source: World Development Indicators[a] and IMF Climate Change Dashboard[b]
Note: UMIC = Upper Middle-Income Countries, ECA = Europe and Central Asia

[a] https://databank.worldbank.org/source/world-development-indicators.
[b] https://climatedata.imf.org/.

Climate change threats go beyond natural disasters to include long-term effects on agricultural productivity, rural incomes, employment, and food security. The Global Food Security Index ranks Türkiye 47th among 113 countries for overall food security.[23] This is due to high levels of drought stress and variability in its renewable water supply, which have important impacts on agricultural production, as the sector with the highest water use. In the mid-long term, climate change patterns are expected to significantly impact yields and crop viability in specific regions (Jägermeyr et al. 2021). A recent analysis found that a 10 percent reduction in water supply could cost Türkiye 6 percent of GDP, about $50 billion, especially through the effect on agriculture (Taheripour et al. 2020). Preventing such impacts would require improving value chain efficiency (including through food waste reduction), climate-smart practices with higher productivity (including sustainable practice and soil conservation), and market access for farmers. Recalibrating support to farmers to reduce distortions and incentivize more productive and sustainable practices would favor these changes (see also section 4.1.3).

Climate change also poses new challenges to the sustainability of Türkiye's fisheries and aquaculture systems.[24] In Turkish waters, the anchovy population has diminished as a result of sea water warming in the much cooler northern Black Sea regions (Tekinay and Güroy 2007). Future projections suggest that fish stocks will decrease in all the Black Sea regions except for sprat (Salihoglu et al. 2017). Climate-driven changes are also expected to have long and short-term impacts in aquaculture, one of Türkiye's fastest-growing industries where production is projected to reach 600,000 tonnes in 2023, with a value of around $2 billion (Çoban, Demircan and Tosun 2020).

The vulnerability of agriculture and fisheries to climate change can exacerbate food price pressures and overall food security concerns in Türkiye. Food and beverages accounted for more than one-third of the rise in inflation in the second half of 2021. Lower-income people would be most affected: recent analysis shows that food and non-alcoholic beverages account for 41 percent of total expenditure for the poorest households, three times the share for the richest households, who spend 14 percent (Baez, Inan and Nebiler 2021). High food prices or inflation—particularly of fruit and vegetables, which are highly affected by climate events—can lead to poor food choices, contributing to important health challenges.[25]

3.1.4. Mainstream adaptation, resilience, and disaster risk finance in macrofiscal policies

Türkiye's National Adaptation Strategy and Action Plan (2011) identifies the need to integrate climate adaptation considerations in macrofiscal policies. It can advance this goal and manage climate and disaster risks by assessing the economic costs of climate change and disasters, and by reflecting contingent liabilities in fiscal policies, budget allocation, and public investment. Facilitating and accelerating reconstruction does not reduce direct asset losses from disasters; instead, it minimizes their effect on welfare. For instance, disaster contingent planning, alongside financial instruments, could increase the speed of reconstruction and reduce the impact of a major disaster on consumption by almost 50 percent (box 3.5). Opportunities to mainstream climate and other natural risks in public finance include widening and making the tax base more robust, and using reserve funds, contingent finance, regional risk pools, insurance schemes and other risk financing instruments.[26] These actions need to be connected with the financial reforms discussed in section 4.2, to expand access to market disaster insurance for the population while guaranteeing the viability

[23] The index is a function of affordability, availability, quality and safety, and natural resources and resilience. Türkiye scores particularly poorly for affordability, natural resources, and resilience.
[24] For more details on coastal impacts and fisheries, see Background Note 3.
[25] For example, despite Türkiye's significant achievements in nutritional outcomes, obesity is increasing, estimated at 39.2 percent of adult (aged 18+) women and 24.4 percent of adult men (regional averages are 8.7 percent for women and 6 percent for men). This translates into increasing diet-related non-communicable diseases.
[26] See a review of these instruments in Hallegatte, Rentschler and Rozenberg (2020).

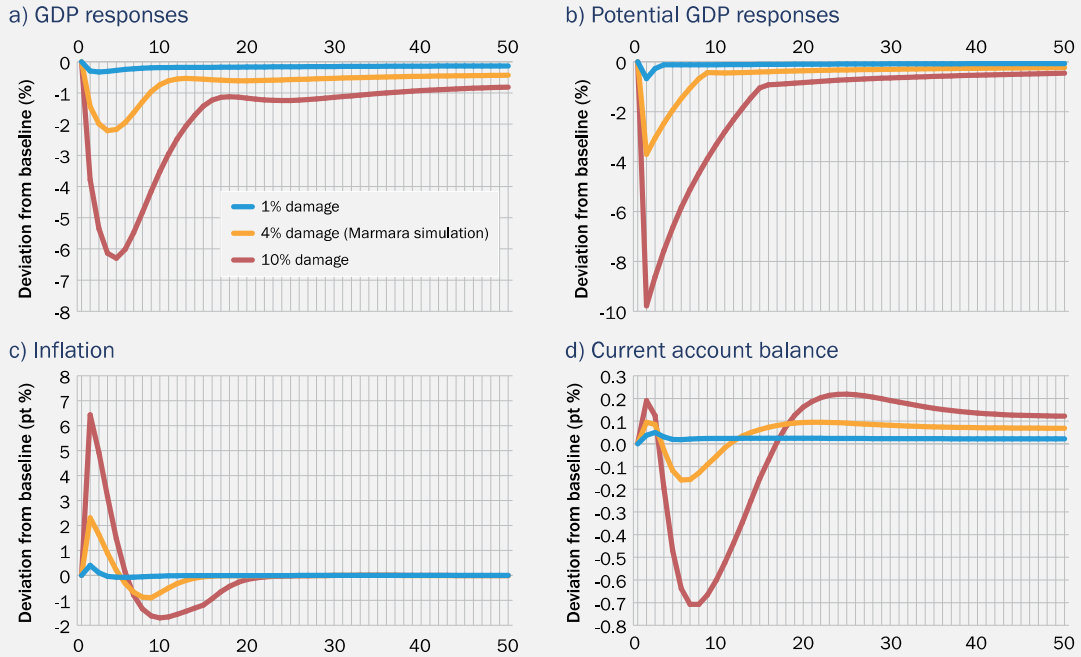
of domestic insurers—for example, by incentivizing foreign capital in the sector—and the stability of the financial system.

Box 3.5: The macroeconomic impact of natural disasters

For this CCDR, we analyzed the macroeconomic impacts of floods and earthquakes,[a] and considered how Türkiye could use macrofiscal and monetary policies to mitigate their cost. Using Global Earthquake Model data for asset exposure and vulnerability to earthquake[b] and using United Nations Office for Disaster Risk Reduction (UNISDR) flood data, we estimated asset losses for different return periods.[c] Linking the distributional asset losses to the World Bank's Macrostructural Model (MFMod) allows for modeling the direct and indirect channels of impact of both natural disasters and policy responses on the economy.

To explore the resilience of the economy, we compared the impacts of three natural disasters of increasing magnitudes: one with direct asset losses equal to 1 percent of GDP, one equivalent to the 1999 Marmara earthquake (with the higher range of available estimates at 4 percent of GDP), and one with asset losses at 10 percent of GDP (figure B3.5.1). Estimates for reconstruction range from less than a year to around 15 years for the largest disaster. Actual GDP responses are smoother than the responses of potential GDP, showing how the economy can absorb the immediate shock and reduce its impact. However, the GDP impact is longer than the reconstruction period, and large disasters have a significant impact on inflation (up to 6 percentage points for the largest shock) and the current account balance.

Figure B3.5.1: Impacts of a major disaster on GDP, inflation, and current account



Source: Hallegatte et al. 2022
Note: Horizontal axis is in years with the shock occurring in year 3.

The Turkish economy can absorb the impact of even relatively large shocks: thanks to resource reallocation, imports, and sustainable borrowing, total consumption loss remains similar to direct physical damages.[d] Beyond a threshold in asset losses, however, the economy's absorptive capacity is exceeded and total consumption losses rise above asset losses. It is possible to increase this ability to manage shocks within a stable macroeconomic environment with appropriate macrofiscal

and monetary policies, and preparedness and contingency plans. To mitigate impacts on consumption and welfare, two things are particularly important: planning ahead so large resources can be devoted to reconstruction to accelerate recovery, and implementing an appropriate monetary policy that responds to permanent changes and second-round effects, rather than transient supply shocks.

Earthquakes and increasingly frequent and intense climate-related floods are expected to reduce GDP and fiscal revenues, but the magnitude of the impact remains manageable in most scenarios. As they depend on random shocks, future losses from disasters are uncertain. But in the 95th percentile scenario, earthquakes reduce GDP by 0.9 percent and floods by 0.7 percent by 2100. Except in worst-case scenarios, the long-term average macroeconomic impact remains manageable (even though short-term pain can be large after large-scale events).

Source: Hallegatte et al. 2022

[a] It was not possible to include other important disasters affected the country, such as wildfires and heat waves, at this stage.

[b] See Background Note 1

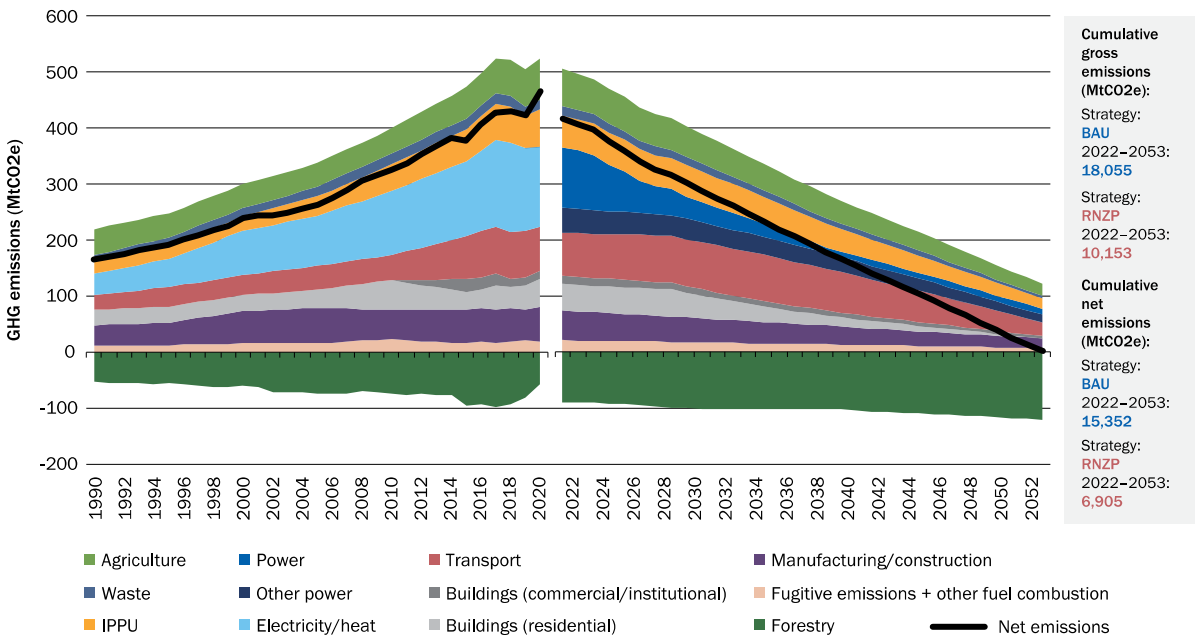
[c] A return period is the average time between events reaching a certain intensity. The lower the return period, the higher the frequency or annual probability of occurrence. A 100-year event has an 18 percent chance of occurring in a 20-year period, and 40 percent chance of occurring over a 50-year period. A 1,000-year event may sound negligible, but it has a 5 percent chance of occurring over a 50-year window, the lifetime of most buildings or infrastructure assets.

[d] Following Hallegatte and Vogt-Schilb (2016), we use the net present value (NPV) of consumption losses as the preferred metric for the welfare impact of disasters, and these can deviate significantly from the reconstruction cost.

3.2. An illustrative pathway toward the 2053 net zero objective

This section uses an illustrative net zero pathway, the RNZP, to explore feasibility, costs, and benefits of reaching the 2053 net zero target.[27] This is not the only path consistent with Türkiye's long-term target, and more analysis and work is needed to settle on the best possible path, distribution of action across sectors, and preferred policies and investments. However, analyzing this RNZP is useful for exploring challenges, policy options, costs, and benefits.

Figure 3.1: Historical emissions (left) and RNZP emissions, consistent with the 2053 target (right)



Source: World Bank staff calculations, based on Government of Türkiye 2022
Notes: BAU = business as usual; RNZP = resilient net zero pathway; IPPU emissions are assumed unchanged until 2030; emissions in sectors other than power, transport, residential buildings, and forestry are assumed to reduce between 68 and 69 percent by 2053.

[27] Türkiye's commitment to achieve net zero emissions by 2053 does not clarify whether the target covers all GHG emissions or CO2 emissions only. The RNZP provides an illustrative pathway to achieve net zero GHG emissions.

The RNZP scenario (figure 3.1) assumes: deep decarbonization of the power sector by 2040; energy efficiency (from 2022) and electrification (from 2030) in residential buildings; modal shift and electrification in passenger and freight transport; changes in land use and practices to maximize negative emissions from forest landscapes; and emissions reduction efforts in the rest of the economy (industry, agriculture, waste management, and water management).

Negative emissions make it possible to achieve net zero emissions at country level with significant residual emissions, but they also create risks. The flexibility they offer reduces aggregate costs by rendering unnecessary (or delaying) some of the most expensive emissions reductions in transport, agriculture, or industry. However, negative emissions from forest landscapes are vulnerable to economic and climatic factors, and a robust strategy toward net zero would need to consider how to do more in emitting sectors, should negative emissions from forests be impossible. The large drop in negative emissions in 2020, resulting in increased net emissions, emhasizes the importance and urgency of action in the forestry sector.

3.2.1. Power: zero carbon electricity as the foundation for decarbonization

Electricity is the largest contributor to emissions today, and a clean electricity grid is needed to drive emissions reductions through electrification of buildings, transport, and industry. Deep decarbonization of the power sector requires a sustained transition from coal, scale-up and integration of renewable energy, aggressive energy efficiency, and preparation for electrification. Box 3.7 outlines policy options to facilitate the energy transition.

To inform the discussion on clean energy transition pathways, we performed an exploratory analysis to identify policy and investment priorities to deeply decarbonize Türkiye's power system. We used the World Bank's Electricity Planning Model—a power system planning model that includes capacity expansion and unit dispatch—to understand the implications of different levels of emissions reduction on the capacity and generation mix, given assumptions about demand growth and available technologies.[28] The work should not be interpreted as a forecast, but as a projection of the scale and speed of necessary interventions. Here, we explore two scenarios:

1. **The least-cost with current government targets scenario (LGT), used as the baseline,** assumes Türkiye's current renewable energy targets, the completion of the 4.8-gigawatt Akkuyu nuclear power station, and utility forecasts of demand growth.

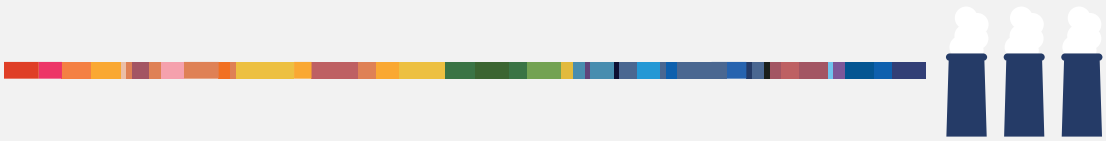
2. **The RNZP** assumes a 45 percent emissions reduction in the power sector in 2030 and a 90 percent reduction by 2040 relative to LGT, in line with achieving the economy-wide net zero target of 2053. In addition to the LGT assumptions, RNZP assumes that carbon capture with sequestration for gas and coal-fired power plants is available after 2035 and includes additional demand from electrifying residential buildings and transport, consistent with the scenarios in sections 3.2.2 and 3.2.3.

Transitioning away from coal-fired power is essential to achieve the government's net zero target and makes economic sense without compromising energy security. To achieve deep decarbonization in the power sector, Türkiye will have to retire most of its coal power plants by 2040, build no new coal plants, and replace the energy with cleaner, affordable, and reliable alternatives. The modeling suggests that 6 gigawatts of coal-fired generation can be retired because of age or economics as soon as renewable energy or zero carbon alternatives can be operationalized to replace the retired energy. An additional 13 gigawatts of coal plants must be retired by 2040 to achieve deep decarbonization in the power sector. As more than 65 percent of Türkiye's coal fleet is less than 20 years old, we estimate the

[28] A more detailed analysis of the power sector, with a description of the methodology used and additional scenario analysis, is available in Background Note 4.

economic value of stranded costs arising from early retirement to approximately $4 billion.[29] The government should start developing a compensation strategy and evaluating opportunities to repurpose coal plants or salvage assets to reduce overall compensation costs.

The coal transition requires removal of subsidies to coal (section 4.1.3) and early planning for a coal phase-down that ensures a just and sustainable transition. More than half of the power plants should be closed this decade, sequenced with investments in renewable energy, battery storage and gas-fired generation to replace the energy that would have been generated from coal. Planning for a just transition for affected workers and communities should begin well in advance of power plant retirements, which could begin as early as 2025. Prioritizing the least efficient plants means that domestic lignite consumption will be disproportionately impacted in the next few years. For example, a just transition out of coal would require actions to develop an institutional framework and financing mechanism for closing coal mines and retiring power plants; mitigate impacts on jobs and communities (section 4.3); and mitigate environmental impacts in terms of land reclamation. Repurposing retired coal power plants into renewable energy production and repurposing closed coal mine areas into alternative economic activities can turn liabilities into assets, generate revenues, and create the needed economic and energy transition.



Box 3.6: Economic and financial cost of the coal exit

The power sector model used in this CCDR estimates the *economic* cost of reducing carbon emissions from the power sector, including the cost of early retirement of coal power plants and the need to build alternative generation capacity to meet electricity demand. However, a just transition would also require transfers to asset owners and workers, which imply additional *financial* costs for the government. The economic and financial cost categories include:

1. **Compensation for early retirement of coal power plants:** Compensating private coal power plant owners will directly affect public finances and transfer the economic cost from coal power plant owners to the government. This is particularly important in Türkiye, given the young age of its coal power fleet. The modeled **$4 billion stranded costs** are estimated foregone profits perceived by generators, though different jurisdictions may use different methods to calculate compensation if they are applied.
2. **Decommissioning costs, including environmental clean-up costs:** A review (Raimi 2017) suggests a cost of around $100 million per gigawatt. In the RNZP scenario, retirement of 19 gigawatts of coal power capacity would therefore incur total costs of $1.9 billion (undiscounted) or $1.3 billion (undiscounted) in incremental costs for early retirement of 13 gigawatts.
3. **Replacing retired plants with alternative energy:** The RNZP includes investments in renewable energy, battery storage, and gas to replace the coal power plants that are retired early and provides an estimate for the additional investment costs. These are expected to be largely borne by private investors, as the assets will have a strong revenue stream and substantial benefits. The cost for transmission and distribution and RE integration will likely need to be funded by the public sector. These costs are already included in the RNZP estimates and in table 3.4.

[29] To calculate the economic value of stranded costs, we used the marginal price value delivered by thermal plants to the system. We did not include the value of early retirement benefits—such as improved air quality and health outcomes—or other costs of just transition, such as support to workers and affected communities or plant or mine decommissioning (box 3.6).

4. **Environmental remediation costs of coal mine closures:** Coal and lignite mining in Türkiye is largely in open mines, with a total estimated area of 213 square kilometers or 53,000 acres (Maus et al. 2020). Remediation costs for surface mines vary from site to site but per square kilometer costs have been estimated at $1.9 million in West Virginia, United States; $7.6 million in Appalachia, United States; and $11 million in Lusatian Lignite Basin, Germany. Assuming closure of all coal and lignite mines, and acknowledging that the uncertainty is extremely large, we can expect the total cost to be around $1 billion.
5. **Social costs for coal power plant workers:** Social expenditures depend on political choices. To provide an estimate, we assume 500 workers per gigawatt, and double this number to account for wider impacts on communities. Assuming that compensation is equal to two years of income for affected workers (around $10,000 per year), these costs reach $20 million per gigawatt, or an incremental cost of $260 million (undiscounted). If we include compensation of workers at end-of-life coal power plants, total reach $380 billion (undiscounted). This cost component is a transfer and will be entirely borne by the government.
6. **Social costs of coal mine closures:** According to the Labor Force Survey, there are around 43,000 coal miners in Türkiye but 430,000 people can be assumed directly or indirectly affected by the coal mine closures. Social expenditures will depend on political choices but assuming that compensation is equal to two years of income (around $10,000 per year), the social cost of coal mine closures in Türkiye reaches a total of $8.6 billion (undiscounted) or $10 billion if rounded. This can be considered an upper bound.
7. **Foregone subsidies:** Coal subsidies to coal-fired power plants and state-owned Turkish Hard Coal Enterprises amounted to $475 million in 2020 and $200 million in 2018, respectively, and around $90 million worth of coal was provided to poor households in 2019. In the RNZP, removal of these subsidies would generate an annual fiscal benefit of $765 million in foregone subsidies over 2022–40 or $15 billion (undiscounted). However, $2 billion (undiscounted) is assumed repurposed into alternative support to poor households.

These estimates increase the economic cost of the RNZP by $1.4 billion (discounted), mostly due to remediation for closed coal mines. From the public finance perspective, the impact is larger, with a net $4 billion (discounted) increase over 2022–40. Transfers to coal power plant owners, workers, and miners ($12 billion, discounted) are partly offset by foregone subsidies ($8 billion, discounted). While these costs are real, the coal power plants and mines would be expected to close in any scenario due to technical and economic trends (and local externalities from using coal and lignite) though probably later in the 21st century in a scenario without climate objectives.

Deep decarbonization in the power sector results in 60 percent of power generated by solar and wind, underscoring the importance of grid integration and storage (figure 3.2). New solar and wind investments are the cheapest way to meet new demand for energy and could meet most future power demand without compromising energy security.[30] In this context, battery energy storage investments and policies to remunerate grid services are essential.[31] Around 2030, Türkiye will need battery or pumped hydro storage to manage the increasing penetration of solar and wind and provide sufficient system reserve. After 2030, some of these services will be provided by low-emission, flexible thermal generators which could run on natural gas or hydrogen, depending on the evolution of technology and the need for emissions reductions. In the RNZP, hydropower, geothermal, nuclear, and gas generation

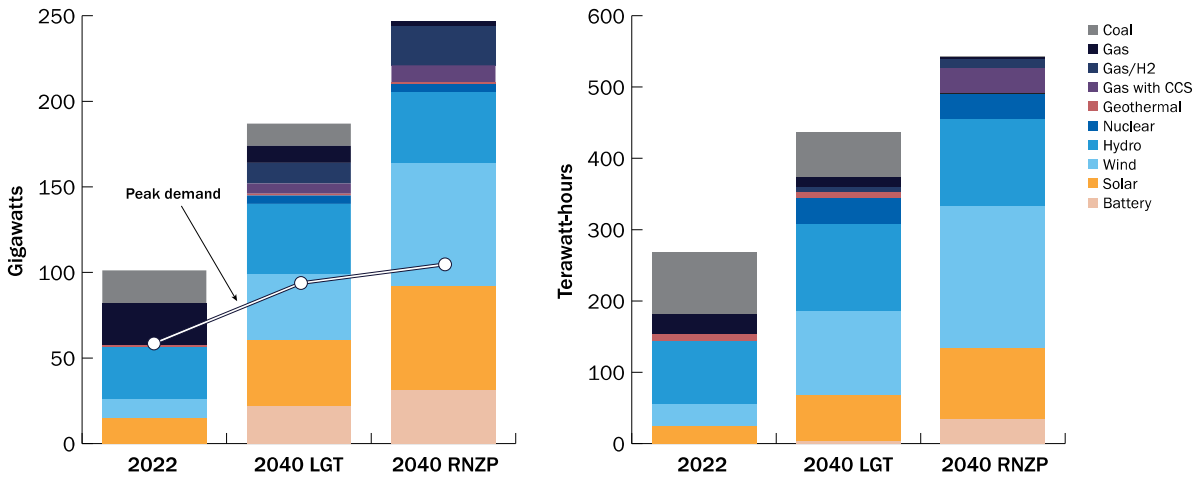
[30] Under the RNZP, gas demand will gradually decline, but will pick up again after the mid-2030s. This will provide system flexibility to accommodate a high share of variable renewable energy with a very low capacity factor, but it could be replaced by green hydrogen with cost reduction. Therefore, RNZP reduces dependency on gas imports compared with business as usual.

[31] The distribution sector is fully privatized, and while it has been successful in reducing losses and ensuring RE integration, on the back of the need for greater RE supply, continued investments in distribution are key.

with carbon capture provide the stability of the power system. The relative role of various technologies implemented after 2030, such as battery storage and carbon capture, will have to be revised over time, as the evolution and cost of these technologies remain uncertain.

While the power sector can be mostly decarbonized by existing technologies, Türkiye is likely to need to pilot innovative technologies such as hydrogen and carbon capture and storage in the next decade to reduce emissions in industry and achieve zero emissions in the power sector. The government will have a key role to play in creating the enabling environment and policy frameworks for these technologies and the facilitation of private sector investments. As the RNZP sees 9.6 gigawatts of battery storage installed by 2030, the right regulations and systems would need to be put in place over the next few years, particularly remuneration policies to compensate system flexibility and battery storage such as ancillary service market and time-of-use tariffs. Concessional financing may be needed at the initial stage to bring costs down.[32]

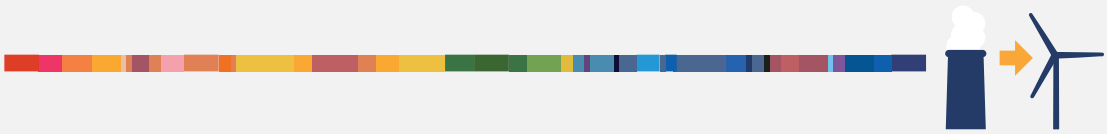
Figure 3.2: Türkiye's power system capacity and electricity generation mix, 2022 and 2040



Source: World Bank staff estimates
Notes: Gas/H2 = hydrogen gas; CCS = carbon capture and storage.

Deep decarbonization in the power sector would increase the present value of investment in power generation and battery storage by 50 percent ($33 billion) between 2022 and 2040, compared with the LGT scenario.[33] Fuel and variable cost savings keep the increase in the present value of the system cost to 6 percent. Deep decarbonization is responsible for raising the average cost of generation by 17 percent in 2040, relative to LGT. Achieving net zero emissions will require increased investment in transmission and distribution. Present value estimates of the network investment costs are an estimated $8 billion in the LGT scenario, rising to $14 billion for RNZP. A well-designed procurement program to improve the enabling environment for clean electricity investments and the necessary infrastructure should be a high priority.

[32] Adding 9.6 GW battery storage capacity by 2030—only slightly less than the entire global market of 12 GW in 2021—is going to be challenging but the RNZP is in line with global net zero scenarios, which expect accelerated growth with 150 GW installed globally by 2025 and 600 GW by 2030 (https://www.iea.org/reports/energy-storage). As many countries shift from a baseload-based system (in which the cheapest generation is dispatchable) to a system with a large share of renewables (in which the cheapest generation is nondispatchable and variable), Türkiye is expected to benefit from both other countries' experience and technological developments.
[33] The LGT scenario is a least-cost scenario in the absence of climate constraint and differs markedly from current investment pipelines (which include coal power plants that are not least cost).



Box 3.7: A roadmap to facilitate the energy transition

Türkiye would benefit from developing and implementing a long-term energy transition roadmap, strategy, and action plan to shift from fossil fuels to clean energy, with clear incentives for private sector participation. Laying out clear targets, pathways, and policies to ensure a sustainable, secure, and competitive energy future and achieve net zero emissions by 2053, this roadmap should also consider uncertainty in future objectives, and availability and cost of upgraded technologies.

Transparent competitive auctions can further reduce RE costs. While Türkiye has done well on renewable energy, it has not fully benefited from the global wave of dramatically decreased RE costs and innovation. International experience has demonstrated that competitive auction schemes have been quite effective in bringing down RE tariffs. In many countries, renewable energy has reached grid parity with coal power plants. Türkiye's recently launched RE auction system is an encouraging step in the right direction and could eventually replace feed-in tariffs, even though further incentives are needed to improve attractiveness for private investors.

The high share of variable renewable energy requires RE—and particularly battery storage—to be integrated into the grid. Improving its grid integration would require: proactive and integrated power system planning; expansion and digitalization of transmission networks; well-designed grid codes and power markets; remuneration for energy storage services to scale up battery storage investments; more flexible generation; increased inter-regional trading (which is today less than 3 percent of consumption); appropriate enabling policies and regulations; demand-side management; and technical solutions for accurate weather forecasting, frequency control, voltage control, and synchronous control.

Distributed renewable energy is a global trend that provides decentralized clean energy supply and reduces grid demand (section 3.2.2). To capture this opportunity, it is important to allow third-party private developers to provide rooftop solar photovoltaic (PV) and distributed RE services directly to customers, the prevalent business model globally.

In the RNZP scenario, electric vehicles (EVs) add 10 gigawatts of peak power demand by 2040 but coordinated charging could reduce total system costs. This additional load requires investing in 23 gigawatts of new power, mainly in the form of wind and battery storage. The power system for transport electrification could cost as much as $20 billion but coordinated charging can reduce total system costs by $3 billion. The government can influence people's charging behaviors with policies and incentives, such as time of use pricing, public charging stations, and workplace charging infrastructure.

3.2.2. Energy use in buildings: new standards and retrofits

As well as being necessary for decarbonization, energy-efficient buildings and sustainable heating and cooling systems provide higher thermal performance, better health, and lower energy costs. Most of the energy consumed in residential, commercial, and public buildings is for heating and cooling, which represents up to 70 percent of residential energy consumption (IICEC 2020). In 2018, more than half of the energy used in commercial and public buildings was electric; just over a quarter was from natural gas, while coal and oil provided 16 and 6 percent respectively. Residential buildings, on the other hand, mostly used natural gas (51 percent of total consumption), followed by electricity (23 percent), bioenergy and coal (8 percent each), geothermal (6 percent), solar (3 percent), and oil (1 percent) (IEA 2021).

Without further energy efficiency and heating improvements, energy demand from buildings will likely more than double by mid-century due to expected population and economic growth. Türkiye's

building stock is projected to grow from 9.9 million buildings in 2020 to 17 million by 2050 (an average annual growth rate of about 1.8 percent) while floor area is projected to double from 3.6 to 7.2 billion square meters in the same time (2.3 percent average annual growth rate); of these, 6.3 billion are residential.[34] However, the recent economic crisis and the COVID-19 pandemic have caused the domestic construction sector and investments in internationally recognized green buildings to stagnate.

Achieving Türkiye's 2053 net zero target will require complete electrification of energy-intensive heating alongside parallel efforts on energy efficiency, while maintaining housing affordability. Over time, electrification of heating should be introduced as the norm in new buildings, and technologies that use fossil fuels, such as gas furnaces, should be replaced by electric ones, such as heat pumps, in existing buildings. It is, however, important that electrification is accompanied by efforts in energy efficiency as without major improvements in energy efficiency, electrification will put significant pressure on the power system and could more than double investment needs for electricity generation.

Immediately improving energy efficiency in buildings generates benefits and facilitates decarbonization of the whole economy, while delaying electrification of heating until 2030 reduces overall costs. Here, we explore an RNZP scenario where all residential buildings are seismically retrofitted or demolished and rebuilt by 2040, and energy efficiency measures are introduced in new and existing buildings from 2022 (to achieve Class A, which indicates the most efficient energy performance level). Additional investment needs and implications for demand for gas and electricity are in table 3.1. To facilitate the decarbonization of the power sector, the analysis done for this CCDR suggests it is better to start electrifying heating in buildings only after 2030. As well as improving energy efficiency, broader green building interventions—including water and materials efficiency—are important opportunities for reducing emissions, conserving natural resources, and lowering utility bills. The analytical work is described in detail in the Background Note 2, which also analyzes other scenarios.[35]

Table 3.1: Emissions, investment needs, electricity demand growth, and gas import savings in the RNZP scenario for residential buildings

Targets: 50 kWh /m^2/year in 2053; 0% fossil fuels by 2053; 100% seismically resistant buildings by 2040	
Cumulative emissions 2022–53	788 MtCO2e
Total investments 2022–53 (discounted, 6%)	$126 billion
Electricity demand growth from 2021 to 2030	19 percent
Gas import savings 2022–53 (discounted, 6%)	$87 billion

Notes: Investments are additional to a business-as-usual scenario. MtCO2e = million tonnes of carbon dioxide equivalent.

3.2.3. Energy use in transport: Avoid-Shift-Improve

Different combinations of public policy, infrastructure interventions, and end-user and service provider behavioral dynamics offer several possible trajectories for Türkiye's long-term transport decarbonization pathways. To assess this quantitatively, we developed a transport demand-supply, energy consumption, and GHG emissions model to calculate key economic and climate outcomes associated with policy-relevant scenarios, or well-defined policy trajectories through 2060.[36] Here, we explore an RNZP scenario where the transport sector achieves carbon neutrality by 2060 through full adoption of electric cars, trucks, and trains, low-carbon aviation, maritime, and pipeline transport, and multidimensional support of public transport and rail (figure 3.3). The business-as-usual (BAU) scenario we compare with assumes that passenger car use evolves in a similar way as it has in high-

[34] Estimates produced by the Global Earthquake Model for the World Bank.

[35] The scenario analysis covers residential buildings only (responsible for 75 percent of Türkiye's buildings emissions), but action will also be needed in the non-residential sector, including commercial and public buildings.

[36] The model is described in detail in Background Note 2 which also includes detailed results and additional scenario analysis.

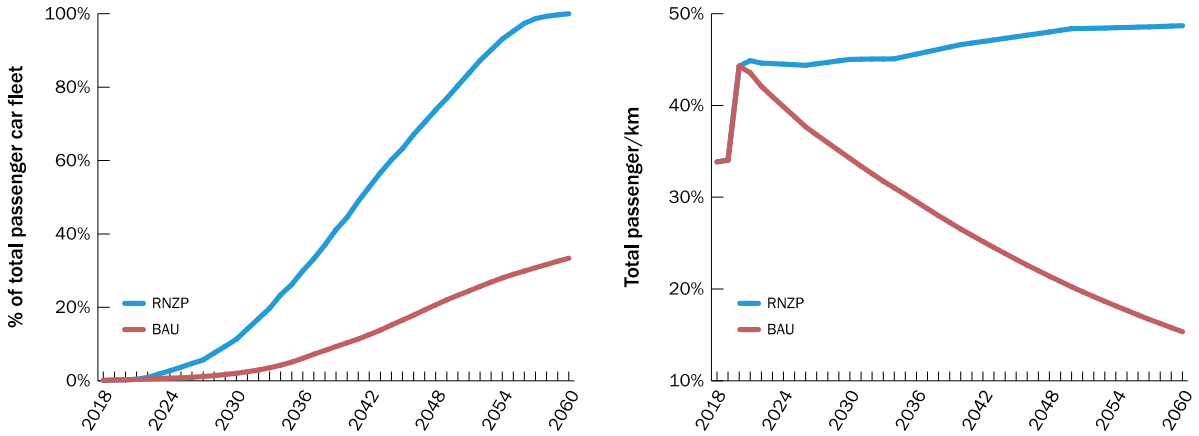
income EU countries, there is little to no changeover time in the national modal split for passenger and freight transport, and EV adoption rates reach 33 percent penetration by 2060.

The analysis confirms that attaining significant cuts in emissions from transport will require the kind of integrated package of interventions envisaged in the RNZP scenario. This includes some—but not enough—support towards electrification (box 3.8). The package will also need to expand access to quality public transport across the board (from mass transit to micro and shared mobility, and non-motorized transport), and promote gains in freight transport multimodalism and operational efficiency. Over the long term, the expected drop in fuel tax revenue will create challenges for financing infrastructure construction and maintenance and new sources may need to be mobilized, including general taxes or new options such as distance-based charges (see also chapter 4).

Figure 3.3: EV adoption and modal share under RNZP and BAU scenarios, 2018–60

a) EV adoption for passenger cars

b) Modal share, public transit (buses and rail)



Source: World Bank staff estimates

Public policy support would be critical for EV production and adoption. A mandate to increase the percentage of zero and low-emission vehicles, for example, would foster greater EV market penetration by creating incentives for charging infrastructure development and investments in EV and battery manufacturing. Tax reduction and incentives would also help increase EV uptake, ideally as part of a broader policy package. Research shows that public investment in charging stations is several times more effective than offering consumer subsidies for promoting EV sales per unit of public expenditure (Li et al. 2020).[37] Municipal-level commitments to and planning for electrifying and upgrading the bus fleets would also encourage domestic e-bus manufacturers, help develop the market, and facilitate Türkiye's inclusion in the e-mobility global value chain, as domestic demand can influence the localization of factories (box 3.9).

Deep decarbonization of transport of the kind anticipated under the RNZP scenario is not significantly more expensive over the 2022–60 timeframe compared with BAU in terms of infrastructure investments and is associated with sizable savings in the outyears through reduced oil consumption and the economic value of avoided carbon emissions. Table 3.2 shows the estimated cost of the RNZP scenario compared with the BAU road and rail infrastructure scenario—including direct current fast-charging stations along Türkiye's motorway network—fossil fuel consumption, GHG emissions, and road transport externalities. The RNZP scenario results in estimated savings of $114 billion in avoided fossil fuel consumption, without counting the benefits from energy security and reduced exposure to global oil

[37] In April 2022, the Ministry of Industry and Technology launched a grant program with a budget of TL 300 million for the establishment of high-speed charging stations in Türkiye.

price volatility, and $639 billion in avoided road transport externalities, all in present value terms cumulative through 2060.

Table 3.2: Cumulative road and rail infrastructure investment costs by scenario, 2022–60

	BAU	RNZP
Discounted investments, 6% discount rate ($, billions)		
Motorways	31.8	25.7
State and provincial roads	3.1	3.3
Highway charging stations	0.3	1.1
New electrified rail tracks	7.8	27.5
Converted electrified rail tracks	1.7	7.5
Replacement and extension of locomotive fleet	0.9	1.8
Total	**46**	**67**
Crude oil equivalent consumption cost at 2021 prices ($, billions)	349	235
Cumulative tank-to-wheel CO2 emissions (MtCO2e)	4,626	2,218
Cost of road transport externalities ($, billions)		
Air pollution	163	138
Road fatalities	689	397
Congestion	580	258
Total	**1432**	**793**
Cumulative electricity consumption, EVs and rail (TWh)	**621**	**2332**
2060 electricity consumption (TWh)	**49**	**174**

Notes: Cost of transport road externalities includes passenger cars, motorcycles, urban and intercity buses, and light and heavy-duty trucks with gasoline or diesel engines. TWh = terawatt hour. MtCO2e = million tonnes of carbon dioxide equivalent.

Box 3.8: Can we decarbonize transport with electrification only?

To assess the extent to which electrification alone can be a viable strategy to decarbonize Türkiye's transport sector, we explored a scenario with transport electrification, but no modal shift. Assuming the same policy trajectory as BAU in terms of car use, public transport adoption, and multimodalism in freight, this scenario has the same EV adoption level for passenger cars, buses, motorcycles, and trucks as the RNZP scenario. While EV replacement results in significant emissions reductions compared with the baseline, it falls short of what is needed to achieve the 2053 target. This confirms that, without complementary measures, an electrification strategy is unlikely to put Türkiye on a trajectory commensurate with its decarbonization aspirations and is therefore too risky.

International experience shows that, as well as falling short on decarbonization impacts, an electrification-only strategy is likely to lock in other undesirable socioeconomic outcomes, such as road congestion, road accidents and fatalities, higher local pollutant levels, and less livable cities. While expected vehicle automation improvements may mitigate some of these impacts, particularly around congestion and poor road safety improvements, such mitigation will only be partial. It is also likely to be of lower magnitude than increased public transit use with greater adoption of transit-oriented development, deeper integration between land use planning and transport planning to facilitate micro- and active mobility in denser urban spaces, and greater levels of freight consolidation, multimodality, truck-to-rail modal shift, and logistics digitalization.

Box 3.9: Boosting productivity and competitiveness with resilient, zero-carbon freight

Türkiye's freight logistics transition goes hand-in-glove with its decarbonization pathway because low-carbon logistics are, on the whole, more efficient and competitive. This should create incentives and synergies to accelerate the modernization of Türkiye's logistics sector over the medium and long terms. In 2019, only 4 percent of freight is transported by rail, coincidentally the same as for passenger transport. This is less than a quarter of the EU's share (17 percent), signaling significant room for multimodalism and greater adoption of rail freight operations.

Türkiye's commodity mix—intense in bulk and breakbulk goods like iron ore, steel products, and cement, as well as bulky products like passenger cars—and the relatively long distances per freight trip are compatible with greater use of bulk and intermodal rail (containers and trailers on rail). Surveys of Türkiye-based shippers show that a primary reason for the low adoption of rail freight is a generalized lack of last-mile rail connectivity to/from organized industrial zones, major manufacturing facilities, maritime ports, logistics centers, and other cargo-related logistics clusters. Targeted infrastructure investment, alongside railway service delivery improvements—including from private providers under Türkiye's reformed railway market, consistent with the EU acquis—can greatly increase rail freight modal share, reducing logistics costs, highway congestion and road infrastructure wear and tear, while also freeing up capital for firms to invest in productivity-inducing projects. This would help the government meet its NDP objective of more than doubling the modal share of rail freight to achieve a 10 percent market share by 2023.

Even if rail freight gained significant modal share in the coming years, trucking would likely remain the dominant mode of freight transport, as it is in most upper-middle income and high-income countries. So, measures to decarbonize and increase the efficiency of trucking operations deserve policy priority. At current levels of battery technology, electrifying trucking—particularly heavy-duty trucks used for long-haul shipments—is challenging, while other promising technologies, such as hydrogen, are still under development. Complementary measures, such as wider cargo consolidation, equipment sharing and standardization, digitalizing corridors through technologies like intelligent highways and smart railway signaling systems, and more seamless intermodal truck-rail transitions for containerized freight, will therefore be needed to increase the efficiency of trucking and logistics.

Decarbonizing aviation and maritime transport will also be part of Türkiye's transition. The zero carbon fuels required for decarbonizing aviation and maritime transport are not yet commercially available, but Türkiye can take steps towards enhancing readiness to enable this transition.

3.2.4. Waste management: a significant potential for more sustainable cities

Solid waste management is an important component in addressing climate change in Türkiye's cities (Kaza et al. 2018). For example, 10 percent of Istanbul's emissions are from the solid waste sector.[38] Waste generation in Türkiye is expected to increase from 36.4 million tonnes in 2020 to 58.2 million in 2050. On average, upper middle-income countries dump 30 percent of solid waste; Türkiye disposes of 45 percent of its waste in open dumps and 54 percent in sanitary landfills with gas capture. Its total estimated emissions from solid waste in 2020 are 27 million tonnes of carbon dioxide equivalent (MtCO2e); in a BAU scenario, these are expected to increase to 35 MtCO2e by 2035.

Improving waste management can reduce GHG emissions and generate significant positive environmental and health outcomes. Decreasing open dumping by 50 percentage points by 2035

[38] C40 Cities Knowledge Hub, www.c40knowledgehub.org/s/article/C40-cities-greenhouse-gas-emissions-interactive-dashboard?language=en_US.

could reduce GHG emissions from improperly managed waste by 85 percent compared with 2020.[39] Substantial co-benefits would include reduced soil and marine pollution; better local health and environmental outcomes; improved quality and access to a basic local government service; a more integrated informal sector; enhanced public environmental awareness; and stronger local economic development, city competitiveness, and livability conditions.

Türkiye has significant potential for circular economy practices that reduce emissions, such as recycling polyethylene terephthalate and polypropylene. As one of the largest polypropylene importers, having appropriate recycling capacities would reduce both emissions from waste and its dependence on imports. The Circular Economy Platform: Türkiye Materials Marketplace is a step in the right direction as it provides a digital marketplace, aimed at using secondary raw materials from one industry in another.[40] The government is also currently drafting a Circular Economy Action Plan.

3.2.5. Industry: a long-term challenge with short-term opportunities

Solutions for reducing emissions in industry and manufacturing are context-specific and include new and existing technologies and processes, as well as some that are under development. In the short term, the priority—also essential for competitiveness and productivity—is to increase energy efficiency and mobilize the most recent and most efficient technologies. This would allow the electrification of manufacturing, construction, and commercial and institutional buildings, reducing combustion-related low-temperature emissions, which are about 30 percent of total emissions in these sectors. For other subsectors—especially cement and steel and iron—decarbonization is more challenging. Under the RNZP, deep decarbonization in these sectors only takes place after 2030.

Cement emissions arise from heat and industrial processes and product use (IPPU), which produced around 25 and 30 MtCO2e in 2019, respectively. Total emissions from cement can be reduced by curbing demand—for example, by improving building design—but there are currently no commercial technologies for achieving deep decarbonization in the sector. Emerging technologies for reducing emissions from cement production include magnesium-based cement but this is unlikely to be commercial in the short to medium terms. Carbon capture usage and storage (CCUS) has the potential to capture up to 99 percent of process emissions at a cost of $60–100 per tonne of CO2 equivalent (tCO2e), provided the production is close to appropriate geology for long-term sequestration and that technologies to concentrate emissions succeed (Bataille 2019). Further emissions reductions can be achieved by installing waste heat recovery systems, which can provide up to 30 percent of a cement plant's electricity needs (IFC 2018). Heat-related emissions for cement cannot be electrified with current technologies, partly due to the high temperatures. But they could be avoided by using green hydrogen, produced using renewable energy during periods of oversupply, for instance. Alternatively, CCUS has the potential to capture up to 90 percent of heat-related emissions from cement production at a cost of $60–170 per tCO2e (Leeson et al. 2017).

Steel and iron emissions make up 19 percent of total IPPU and nearly 8 percent of energy-related emissions, at 11 and 5 MtCO2e in 2019, respectively. Steelmaking in Türkiye is already largely electrified: 70 percent of total steel production uses electric arc furnaces, which is much higher than the world average of 30 percent.[41] Unlike blast furnaces, electric arc furnaces do not need coal and can use scrap metal as the raw material. To supplement the scrap and make new primary steel, one possible option is to use direct reduced iron from methane-based syngas. Over the longer term, hydrogen-based steel production is an emerging technology that can reduce emissions in the sector, either by reducing the need for coking coal traditional blast furnaces, or as the sole reducing agent in a process known as direct reduction of iron, using an electric arc furnace. It is not feasible to use only

[39] The two scenarios were developed using the CURB Modeling Tool and the What a Waste 2.0 database, https://datatopics.worldbank.org/what-a-waste/.
[40] https://donguselekonomiplatformu.com/en/.
[41] https://worldsteel.org/wp-content/uploads/Steel-Statistical-Yearbook-2019-concise-version.pdf.

hydrogen in a blast furnace, so the electric arc furnace is considered the most viable solution for reducing emissions. However, the technology is still under development and is not expected to be commercially available at scale before 2030. If and when it becomes available,[42] the estimated cost is $38–77 tCO2e (Vogl and Nilsson 2018).

3.2.6. Forest and landscapes: maximizing carbon sequestration to facilitate net zero[43]

The forest landscapes sector offsets around 15–20 percent of total GHG emissions, all of which come from forest management and harvested wood products. Here, we explore a stylized RNZP scenario with a targeted set of policies and measures to maximize negative emissions from forest landscapes (table 3.3). For example, we considered policies and measures to optimize harvesting rates, reduce illegal logging, stop deforestation, strengthen control of forest fires, and increase forest landscape restoration efforts, leading to higher increment rates across the entire area of forest lands in the country.

Table 3.3: Key assumptions in the baseline and RNZP forest landscape scenarios

Mitigation options	Assumptions in the baseline	Assumptions under RNZP
Afforestation, reforestation -deforestation	No plantations	0.5 million hectares of reforestation with fast-growing species until 2053
	Deforestation follows historical trend	Zero deforestation after 2022
Sustainable forest management	No forest restoration	3 million hectares of degraded forest restored
	Harvest rate average over 2022–53 is 28.1 million m^3	Harvest rate average over 2022–53 is 23.4 million m^3
	Harvested wood product pool reaches 26.6 MtCO2e by 2053	Harvest wood product pool reaches 12.5 MtCO2e by 2053
	Illegal logging decreases in time	Illegal logging decreases faster than under BAU
	Burned area increases with recurring catastrophic wildfires	Burned area stabilizes with improved wildfire prevention and control
Sustainable grassland management	No grassland rehabilitation	1 million hectares of grasslands rehabilitated

Note: Under RNZP, it is assumed that reforestation occurs within existing temporarily unstocked forest lands, requiring no additional land allocation.

Under BAU, annual GHG removals drop to 77 MtCO2e by 2053,[44] mainly due to reduced increment rates, while the RNZP scenario reaches a full potential of 121 MtCO2e (figure 3.4a)**.** However, achieving this level of carbon sequestration will require much better fire prevention and control. If events as seen in the 2021 forest fire season—which released almost 20 MtCO2e (figure 3.4b)—increase in frequency, it would be difficult to achieve net negative emissions in the sector. Increases in the cost of fire prevention and suppression are difficult to estimate. The fire management (prevention and suppression) budget averaged around $210 million over the last 10 years. For 2022, after the 2021 fires, a new $314.3 million investment plan for fire suppression (including the purchase of five planes and 18 helicopters) was announced. Over the long run, the existing budget would need to increase at least 30 percent (around $60 million per year). Such additional spending on fire prevention and suppression would be expected to generate significant benefits in the form of avoided losses of lives and property, on top of the carbon benefits.

In the RNZP, the carbon sink potential is fully used to compensate for residual emissions from other sectors in 2053. Any reduction in negative emissions from forest landscapes would require additional efforts from other sectors to compensate. At the same time, more stringent reductions in other

[42] If hydrogen-based production never becomes competitive, the alternative is to use CCUS; the cost would be similar, but appropriate geology is required.

[43] A more detailed analysis of the forestry sector mitigation potential, along with a description of the scenarios used here, is available in Background Note 5.

[44] This reduction is considered conservative compared with Network for the Greening of the Financial System (NGFS) scenarios, which project a much starker drop.

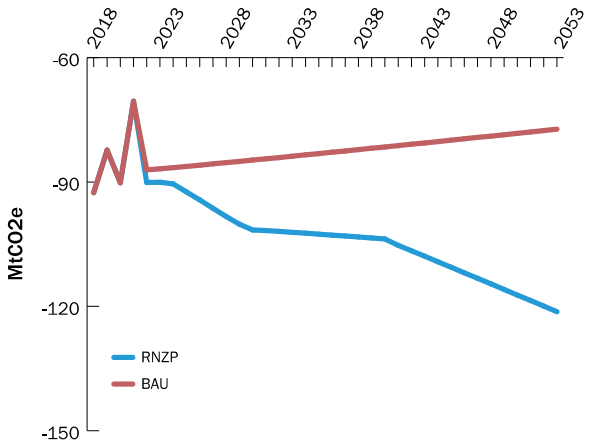
sectors would turn Türkiye into a net carbon sink, potentially opening opportunities for carbon trading under Article 6 of the Paris Agreement. If all sectors could reduce emissions by 80 percent—more than is assumed in the RNZP—Türkiye could have an annual surplus of about 20 MtCO2e by 2050. Significant revenues could be expected, although exact values depend on market prices and eligibility criteria. For illustrative purposes, we can use the range of global carbon prices in the NGFS 2050 net zero scenario ($600–860 tCO2 in 2050) to estimate the annual value of a 20 MtCO2e surplus as $12–17 billion.

As well as producing negative emissions, the activities in the RNZP scenario will generate significant co-benefits. Türkiye's forests provide considerable economic, environmental, and sociocultural benefits for green growth and sustainable development. While we do not attempt to quantify these benefits, they are significant. As an example, the economic value of Türkiye's Bolu forests was estimated at $666 million in 2013, half of which were indirect values from ecosystem services such as erosion-sedimentation and protection against floods, torrents, and landslides (World Bank Group 2015). Forestry also offers large employment opportunities, with 233 jobs created per $1 million spent in the forestry sector.

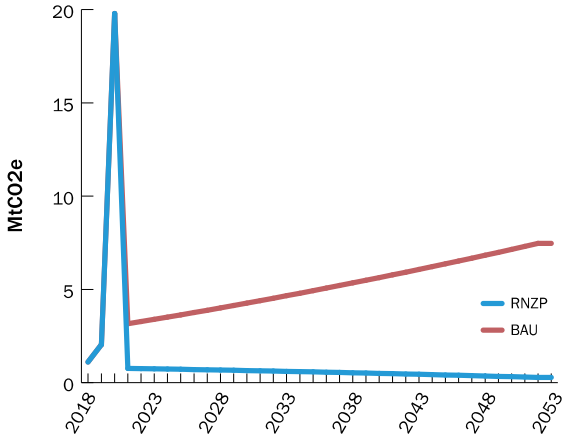
The agriculture and food sector is both part of the climate problem and an important contributor to its solution. It is relatively carbon intensive, compared with the rest of the economy, representing 13 percent of total 2019 GHG emissions, 62 percent of methane emissions, and 73 percent of all nitrous oxide emissions. Emissions from agriculture relate primarily to enteric fermentation (especially dairy and non-dairy cattle), agricultural soils (mainly fertilizer use), and manure management. Many solutions are available to reduce emissions from these activities, such as improved feed and forage/pasture management, proper treatment and storage of manure, nutrient management, and reduced food loss and waste. The sector also offers considerable potential for carbon sequestration via carbon farming and nature-based solutions applied to agriculture land. Through a proper mix of policy instruments and support, implementing such measures can, gradually, be achieved at scale.

Figure 3.4: GHG emissions in the forest landscapes sector

a) Aggregate effects of proposed activities and measures by scenario, 2018–53



b) Historic and projected GHG emissions from forest fires in Türkiye by scenario, 2018–53



Source: World Bank staff estimates

Adopting a food system approach will provide important gains for climate change mitigation and adaptation. Supply chain inefficiencies are often responsible for food losses and waste. A recent lifecycle assessment of carbon, water, and energy footprints in the Turkish food supply chain estimated 16 million tonnes in food losses and waste in 2016, representing 23.7 MtCO2e in GHG

emissions, 6.2×109 cubic meters of water and 13.5×10^4 terajoules of energy (Cakar et al. 2020). The government has undertaken successful food waste reduction awareness campaigns for consumers and supply chain actors.[45] In parallel, promoting healthy and sustainable diets also presents important opportunities for reducing GHG emissions from food systems and improving health outcomes.

3.3. Putting it all together: a resilient and net zero pathway

The RNZP requires large investments, but these remain small compared to the size of the Turkish economy. Compared with the baseline scenario, which does not include climate objectives, Türkiye would need to invest an additional $68 billion over 2022–30 (in present value terms) to be on the RNZP (that is 1 percent of discounted cumulative GDP over that period). Over 2022–40, this number grows to $165 billion, or 1.2 percent of discounted cumulative GDP over the period (table 3.4). These investments add 21 percent to the existing $319 billion needed in the power ($52 billion), residential ($243 billion), and transport ($24 billion) sectors over 2022–30 and 34 percent to the $482 billion needed over 2022–40. Total investments in these three sectors ($385 billion over 2022–30 and $644 billion over 2022–40) represent 21 percent of discounted cumulative gross fixed capital formation over 2022–30 (5.7 percent of discounted cumulative GDP) and 18 percent over 2022–40 (4.8 percent of discounted cumulative GDP).

Table 3.4: Investment needs and economic costs in the RNZP (additional compared to baseline)

	2022–30 ($, billions)	2022–40 ($, billions)
POWER		
Additional investment: new generation and storage capacity	+5	+33
Additional investment: transmission and distribution	+8	+14
Other economic costs: operational and fuel costs	-9	-23
Other economic costs: air pollution externality costs from coal[a]	-9	-38
Other economic costs: decommissioning of coal plants and mines	< +1	+1.4
RESIDENTIAL		
Additional investment: energy efficiency, electrification, and resilience	+45	+100
Other economic costs: gas import	-11	-46
Other economic costs: lives lost and injuries	-1	-3
TRANSPORT		
Additional investment: new resilient infrastructure	+8	+15
Other economic costs: fuel import	-12	-36
Other economic costs: cost of disruptions[b]	-3	-11
Other economic costs: air pollution, congestion, and road fatalities	-40	-171
FOREST LANDSCAPES		
Additional investment: restoration, reforestation, and fire management	+2	+3
Other economic costs: loss of harvest revenues[c]	+1	+5
AGRICULTURE		
Other economic costs: on-farm emissions reductions[d]	< +1	–
INDUSTRY AND MANUFACTURING		
Other economic costs: cement, iron, and steel[e]	–	+11
TOTAL INVESTMENTS AND ECONOMIC COSTS IN THEIR SECTORS		
Net economic costs	-15	-146
includes: additional investment	68	165

Notes: All amounts are discounted using a 6 percent discount rate. [a] This estimate applies a cost of $25/GJ in 2020 rising to $38/GJ by 2040; [b] Assumes a reduction in growth rate damages from 3% in the BAU to 0% in the RNZP scenario; [c] Applies a cost of $149/m³, the weighted average of the November 2021 timber price across Turkish cities; [d] Assumes $21/tCO2e which is the weighted average net cost of 15 key emissions reduction measures (Ahmed et al. 2020); [e] Assumes $120/tCO2e as the cost of emissions reduction or capture.

[45] In 2020, the Ministry of Agriculture and Forestry and the Food and Agriculture Organization of the United Nations launched *Save Your Food,* a joint national media campaign to raise awareness of the detrimental impacts of food loss and waste and stimulate action along the food supply chain.

The investments needed in the RNZP have many wider benefits and the net economic impact is positive over 2022–30 and increases over longer time horizons. Table 3.4 summarizes the quantified costs and benefits from our sectoral analyses. As Türkiye imports 99 percent of its gas and 93 percent of its oil, energy efficiency and renewable energy generate major benefits by reducing both energy imports and expenditure, as well as air pollution. When all costs and co-benefits are accounted for, the net economic impact is positive over 2022–30 and increases when we consider longer time horizons (table 3.4). When we account for savings and positive externalities, the net economic cost is negative: the RNZP leads to a net $15 billion gain over 2022–30 and a $146 billion gain over 2022–40, largely from reductions in fuel imports and from health benefits as a result of reduced air pollution.

What fraction of these investments would need to come from public resources? There are no robust estimates of the fraction of infrastructure capital costs that can be covered by direct cost recovery (Rozenberg and Fay 2019), and the attractiveness of infrastructure projects for private investors depends on many factors (chapter 4). While the forthcoming CPSD will investigate these opportunities in more detail, this CCDR assumes the following:

1. **Power:** The private sector can cover 80 percent of investment needs. This is consistent with large flows into renewable energy, as observed globally but dependent on appropriate, transparent, and consistently enforced regulations. Public resources will be needed to subsidize new technologies such as battery storage, green hydrogen, or CCUS; build transmission networks and charging and other infrastructure; compensate the owners of emitting assets that have to be retired early (box 3.6); and facilitate and accompany negatively affected workers and communities to ensure a just and inclusive transition. While compensations are transfers (and do not increase the overall cost of transition in table 3.4), they require public and concessional financing.

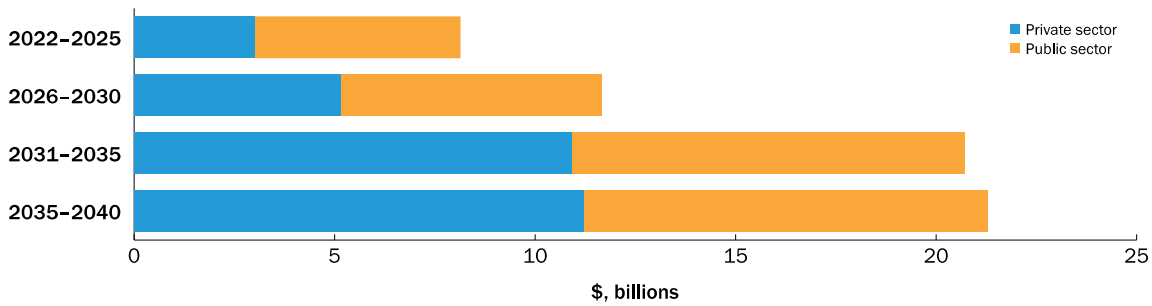
2. **Transport:** The private sector will cover 20 percent of the cost, with most infrastructure financed by the public sector.

3. **Residential buildings:** Most investment is private, but subsidies and incentives will be required to help homeowners and constructors increase energy efficiency and resilience—especially for owners with limited discretionary income—and we assume that 50 percent of the cost would need to be passed on to taxpayers.

4. **Forest landscapes:** Additional investments will be fully funded by the public sector.

With these assumptions, we find that additional annual (undiscounted) public investment needs for the RNZP in these sectors could be around $5 billion until 2025, and $6 billion by 2030 (figure 3.5).

Figure 3.5: Additional annual investment needs for the RNZP in the power, residential, transport, and forest landscapes sectors



4. Macroeconomic costs, obstacles, and implications

MAIN MESSAGES

The sectoral policies and carbon pricing necessary to achieve the RNZP are expected to increase GDP growth and employment, at least until 2035, thanks to benefits from energy efficiency and larger investments, and even if the benefits from avoided climate change impacts are not considered.

Inflation is expected to remain limited, and tax revenues to increase, making it possible to compensate low-income households and ensure that all household income classes benefit from the transition. Economic benefits can be larger if better air quality translates into higher labor productivity, labor market frictions can be minimized, and electricity prices do not increase much after 2035.

Although the additional investments to achieve resilience and net zero emissions in 2053 are significant, their impacts on the external balance are canceled by savings on oil and gas imports. Public debt levels only rise by 1–3 percent, making it possible to increase support to households and firms if necessary.

Climate action in other countries—which will lead to changes in global demand, technologies, and trade rules—will also affect Türkiye. The EU CBAM will have limited impacts at the macroeconomic level, but some key industries will face lower output and employment, requiring action to facilitate structure adjustments both within and between sectors.

Türkiye's fiscal policy could be better aligned with its climate objectives and energy taxes are heterogenous. Tax reforms, alongside a new carbon price (created through a carbon tax or an Emission Trading System) with revenues appropriately recycled in the economy, can support economic growth, employment gains, and GHG emissions reductions while cushioning the impact on the poor and facilitating the adjustment of carbon-intensive industries exposed to the CBAM.

Recent macroeconomic volatility hinders essential public, private, domestic, and foreign investment and associated technological innovation for climate investment by reducing fiscal space, putting pressure on corporate debt positions, raising risk premiums for foreign investors, and destabilizing financial sector intermediation. A more stable macroeconomic environment, and a well-regulated financial sector with appropriate disclosures, are needed to mobilize private investments for climate action and incentivize resilience and low-carbon decisions.

A just and inclusive transition must account for heterogeneity in the impacts of climate change and climate policies, and adjustment costs over time. Poorer people and communities are more vulnerable to natural disasters and climate change, because they are either more exposed or have lower capacity to cope with shocks and stressors, including inflation or the transition to greener jobs and occupations. Ensuring a just transition will require careful management of economic and labor market adjustments, investments in human capital and education, and strong and adaptive social protection systems.

Drawing from the sector assumptions and findings in chapter 3 on the necessary investments in physical capital and the technology that drives efficiency, in this chapter, we analyze the overall economic impacts of the RNZP transition and international efforts to decarbonize trade. We then consider the fiscal and financial sectors' climate vulnerability and potential to support the transition, and some of the macroeconomic hurdles to development and climate objectives, particularly in terms of adjustment costs for workers and poor households.

4.1. Economy-wide and sectoral impacts of decarbonization

4.1.1. The macroeconomic implications of the RNZP

Actions to align resilience and decarbonization objectives with economic and development policies will affect the Turkish economy through both the demand and supply sides, requiring a comprehensive

approach to analyzing impacts. On the demand side, the significant investment needs quantified in chapter 3 and fuel import savings will affect aggregate demand, and consumption patterns will also change between more and less carbon-intensive goods and services. On the production side, taxing and regulating carbon emissions will raise the price of fossil fuel inputs and change the energy mix and technologies, benefiting some agents and sectors and hindering others. Macroeconomic stability is a precondition for these changes to have the desired impact. The macroeconomic modeling approach in this CCDR allows a consistent assessment of the economy-wide impacts of Türkiye's green transition.[46]

It is common to use combinations of carbon pricing through carbon taxes or emissions trading systems (ETS), regulations, and non-price policies to shift economies toward a lower-emitting path. For pricing policies, instruments vary in terms of coverage, levels, or rebates in specific sectors. It is also important to carefully consider options for recycling the revenues through, for example, lower public debt, lower tax rates on existing direct or indirect taxes, or direct transfers to compensate the public for higher prices or incentivize technological innovation or adoption.

Here, we analyze the costs and benefits of achieving Türkiye's RNZP scenario through a carbon tax that complements specific sectoral interventions discussed in chapter 3. The full design of the appropriate package of possible policies is beyond the scope of this CCDR and requires stakeholder engagement and political processes. But we do analyze carbon pricing options and the implication of a carbon tax (or equivalent ETS with auctioned permits) designed to ensure that the sectors we modeled in chapter 3 deliver on their economic production and emissions reduction targets, and that those not covered by sectoral roadmaps also act to reduce emissions through emission-saving investments. The carbon price we explore here does not cover agriculture due to implementation challenges and the risk of increasing food prices. The carbon price level is designed to achieve RNZP and preserve government tax revenues at least at the level without climate action, growing from $11/tCO2 in 2022 to $211/tCO2 in 2040.[47] For the sectors covered in chapter 3, we assume sectoral policies complement the carbon price to ensure that they reduce emissions consistently with the RNZP.[48]

Even without considering the benefits from avoided climate change impacts, the overall growth impact of meeting the RNZP transition over 2022–40 is moderately positive and rises when we consider mitigation co-benefits and if labor market frictions are addressed (figure 4.1). The main short- to medium-term driver of the RNZP's positive growth outcome is investment in the transport and building sectors, and the resulting energy efficiency gains from these investments. After 2030, significant investments to electrify buildings further increase growth benefits. Considering the co-benefit of reducing air pollution and if labor market frictions are removed, making it easier for people in the most affected sectors to find jobs in growing sectors such as renewable energy (section 4.3), the growth benefits of the transition also increase.

Towards the end of the 2022–40 period, growth benefits begin to decline as the electricity price increases. Until 2035, energy efficiency gains compensate for raising electricity prices, partly due to the delay in electrifying heat in commercial and residential buildings until 2030. However, after 2035, the electrification of buildings and transport leads to higher electricity prices than in the baseline and economic growth slows down to its baseline average, especially if growth in RE production is

[46] We reproduce the RNZP scenarios with the Computable General Equilibrium (CGE) model MANAGE, incorporating the sectoral roadmaps for power, transport, forest landscapes, residential buildings, and industry. We supplement this with analysis of external and fiscal sustainability using an adapted MFMod. The objective is to combine the granularity of sectoral analysis with explicit representation of the asset stock (chapter 3) with the macroeconomic consistency offered by CGE or other macroeconomic models. Details of the methodology are available in Background Note 6.

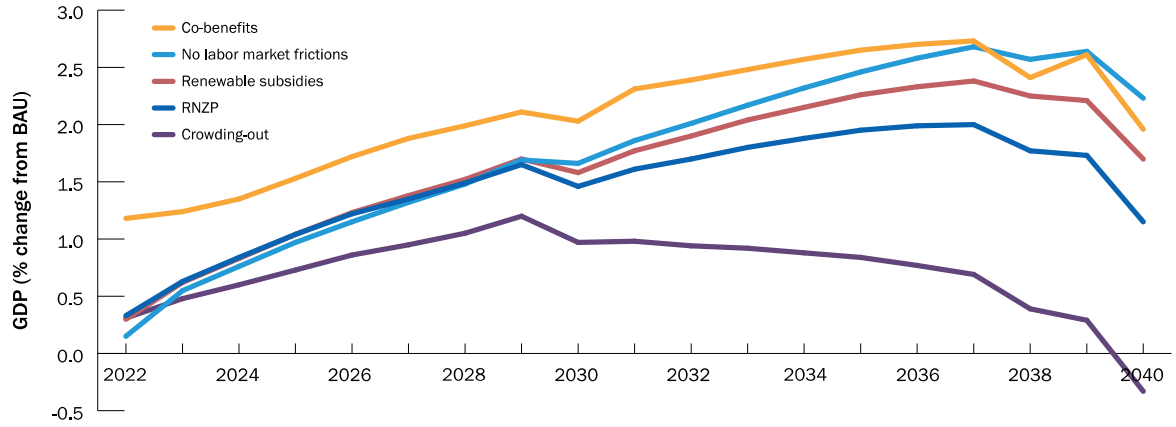
[47] Since refined petroleum products are heavily taxed in Türkiye, the government will lose a significant amount of tax revenue as consumption of refined petroleum products declines significantly due to transition. The carbon tax in the RNZP more than compensates these losses. At the sectoral level, we consider various approaches to replace fuel taxes in the financing of infrastructure—for example, financing road maintenance through distance-based charges.

[48] We also include investment needs identified in chapter 3, to ensure we account for their costs.

constrained. Energy sector policies (section 3.2.1) and carbon tax revenue recycling can both play a key role in preventing excessive price increases and the negative impact on growth after 2035.

Türkiye needs to manage the transition well, as growth benefits depend on the balance of two important trade-offs: crowding out investments in sectors other than energy, transport, and buildings, and recycling carbon tax revenues. In the RNZP, domestic savings increase to finance investment needs. However, if savings do not increase sufficiently, investments in other sectors might decrease, which could erase a significant part of the economic gains. And this effect would be magnified if carbon tax revenues are not recycled in a way that supports private sector investment. In that very conservative case, the pressure on reducing investments elsewhere would be higher and reduce growth benefits even further (see the *crowding out* scenario in figure 4.1). This would also cause a stronger shift toward greener sectors as it would deprive emission-intensive sectors of capital investments.

Figure 4.1: Projected growth benefits of transitioning to RNZP



Source: World Bank staff estimates

Offsetting price effects and productive efficiency gains mean that inflation will rise only modestly during the transition but adds to a trend of historically high inflation in Türkiye. Consumer price inflation in Türkiye averaged over 12.5 percent between 2016 and 2020, creating a challenging environment for reforms that add to price pressures. In a scenario where electricity prices increase in line with average generation costs (that is, by around 20 percent in 2040), food and manufacturing prices would increase, but only by roughly 2.5 percent. Thanks to efficiency gains, these increases are partly offset by the decline in service sector prices.

In a context of high unemployment in Türkiye relative to its peers, the RNZP would generate up to 230,000 jobs over 2022–30, but the growth slowdown after 2035 erases these gains. Jobs are mostly generated in RE sectors, and in upstream sectors that support them. Although the cumulative number of jobs created remains positive until the last year of simulations, the number of jobs created starts to decline as growth slows down between 2035 and 2040, eventually erasing the earlier gains.

The impact of the transition on government revenues is positive and debt levels rise only moderately as a share of GDP, although these results depend on the level of carbon tax and assumptions about revenue recycling, respectively. In the RNZP scenario, overall government revenues rise, providing significant additional resources to finance the transition and smooth social impacts. Initially the revenue declines alongside demand for heavily taxed liquid fuels, and the carbon tax rate is low, providing limited new revenues. However, a $50/tCO2e carbon tax would be enough to compensate for the loss of liquid fuel tax revenues. A carbon tax that reaches $211/tCO2e in 2040, as in the RNZP scenario, would generate $53 billion and $184 billion over the periods 2022–30 and 2022–40, respectively, allowing more fiscal space to manage the adverse effects of the transition on

vulnerable social groups, or to reduce other taxes to facilitate the transition for households or businesses.

The impact on government debt and the current account balance is small, unless the government decides to use the fiscal space to offer additional support to households and firms. Additional scenarios are produced using the World Bank MFMod, which offers a more detailed description of these dimensions. In the two models we use in this CCDR—the CGE and MFMod—the RNZP leads to small GDP gain and government debt-to-GDP levels increase only moderately, by 1.5–3 percentage points relative to the BAU scenario. This is mostly thanks to the increasing government revenues due to the carbon tax, which helps keep government borrowing requirements low. However, this also gives an indication of the space available to government, should it choose to save less and take on a larger share of the total investment needed in capital and innovation to support the transition. The negative effect of larger investments on the current account balance are counterbalanced by reduced oil and gas imports, leaving the current account almost unchanged in the RNZP, compared with the baseline (figure 4.2). The reduction in oil and gas imports would also lower Türkiye's exposure to energy supply and price instability from geopolitical risks. However, macroeconomic stability remains essential for preserving fiscal space and external buffers.

Figure 4.2: Current account balance in the RNZP, compared with the baseline

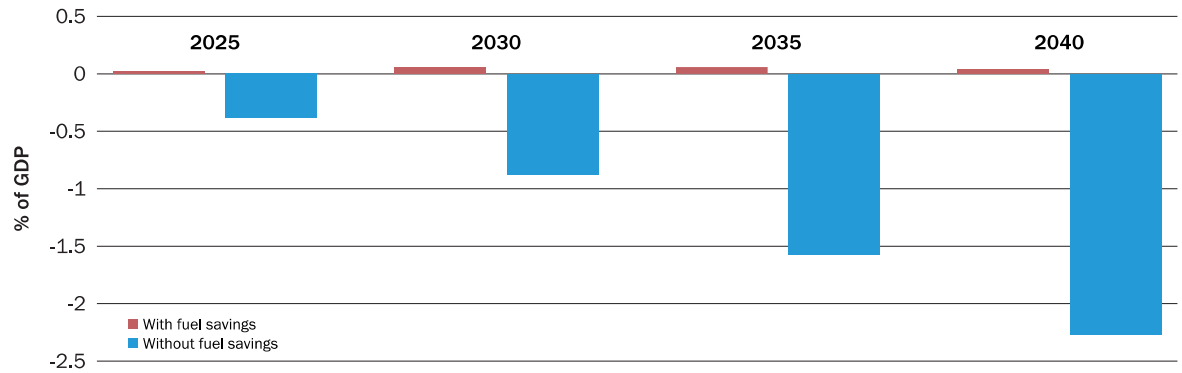
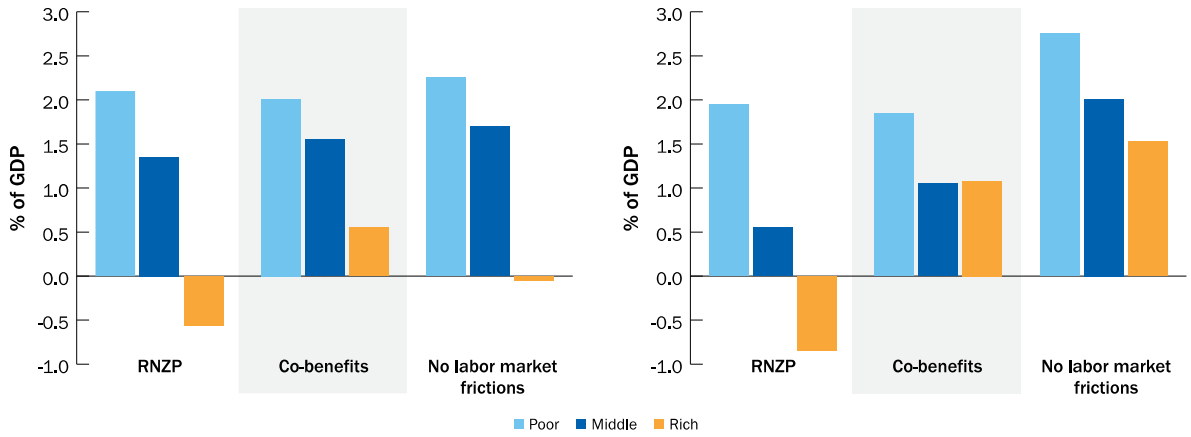


Figure 4.3: Impact on welfare for poor, middle, and rich households, in three scenarios

a) Impact by 2030

b) Impact by 2040



Mitigation policies in the RNZP are generally progressive, in the sense that they do less harm to poorer households than richer ones (figure 4.3). However, this assumes that 13 percent of carbon tax revenues are used to support income in the population, which would compensate low-income households for increasing energy prices. The increase in government revenues from a carbon tax and removing subsidies on fossil fuels creates enough fiscal space for the social protection programs required for a just and inclusive transition.

4.1.2. The EU CBAM: effect on Türkiye's emissions-intensive industries

As well as domestic action, Türkiye is exposed to transition risks as the world, and particularly the EU, works towards a low- or net zero carbon future. As part of its ongoing commitment to mitigating climate change, the European Commission is considering the use of a CBAM, which would put a carbon price on imports of certain goods to the EU, based on their emissions intensities. There is significant overlap between the sectors covered by the EU CBAM and the priority sectors identified in the 11th NDP.

The CBAM will have significant impacts on Türkiye, but only on a few emissions-intensive industries that have high trade exposure to the EU market.[49] Although the EU absorbs 49 percent of Türkiye's total goods exports, only 4 percent are likely to be covered by the current proposed CBAM. The iron and steel sector is of most concern: 37 percent of Türkiye's likely covered exports in this sector are absorbed by the EU, and its ferrous metals sector has higher emissions intensity than other major exporters, such as the EU and Republic of Korea, though they are lower than China and the Russian Federation.[50] Aluminum production is also highly exposed, although the emissions intensity of Türkiye's production of non-ferrous metals (including aluminum) fares slightly better when compared with other major exporters, such as the EU and China. The European Commission has kept the door open to a future expansion of the CBAM's scope, potentially covering sectors such as chemicals, petroleum products, and glass. The implementation of an EU CBAM presents opportunities for Türkiye to reduce emissions to capture market share at the expense of more emissions-intensive competitors.

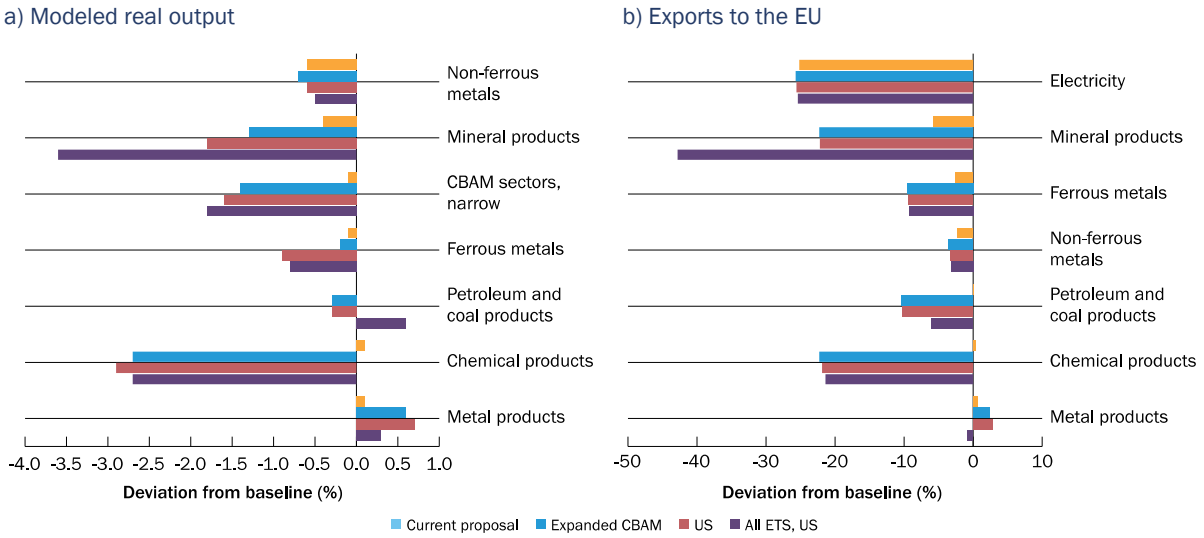
Under the current EU proposal, Türkiye's carbon-intensive exports to the EU covered by the CBAM would decline, but total exports would be less affected, with some diverting to unaffected destinations and others finding growth opportunities (figure 4.4). The modeling anticipates that, under the current CBAM proposal, mineral products exports to the EU, such as cement, would be around 5.8 percent lower than the baseline by 2030. But other products would divert to alternative non-EU markets, so total sector exports would only be 1.7 percent lower. Some non-covered, higher value-added sectors—such as metal products, machinery and equipment, motor vehicles and parts, and other manufacturing—have an opportunity to grow, as their EU competitors face higher input costs when the CBAM is applied to inputs such as iron and steel. As a result, some sectors face lower output and employment, but overall impacts remain small, especially if these opportunities are taken. Generally, the expected change in output and employment for each sector is less than 0.5 percent.[51]

[49] Details of the modeling are available in Background Note 7.

[50] Due to the high level of sector aggregation, country comparisons mask differences in the sector outputs between countries.

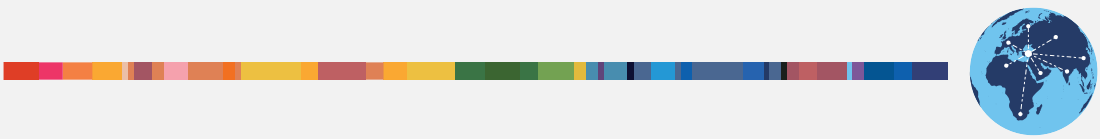
[51] The results of the impact of CBAM on Türkiye's trade and GDP are confirmed by another set of analysis undertaken in the World Bank, which similarly finds large negative impacts on Türkiye's exports to the EU in sectors affected by CBAM, but lower overall impacts on trade and negligible impacts on GDP.

Figure 4.4: Modeled real output and exports to the EU in 2030 for select sectors



Source: World Bank staff estimates
*Notes: Assuming that all countries reduce emissions in line with their NDCs as the baseline, we use the ENVISAGE model to run four scenarios to quantify the potential impact of the EU's CBAM on Türkiye's economy: **Current proposal:** Scope 1 emissions (cement, electricity, aluminum, iron and steel, and fertilizers); **Expanded CBAM:** Scope 1 and 2 emissions (includes chemicals, petroleum products, and glass); **US:** the United States introduces a CBAM covering the same emissions and sectors as the EU; and **All ETS, US:** expanded ETS, applying CBAM to all products in all ETS sectors in both the EU and the US.*

With a CBAM expanded to include Scope 2 emissions or other markets like the United States, the impacts would increase, especially at sectoral level. Exports of mineral products to the EU could fall by as much as 43 percent and chemical exports by more than 20 percent if the CBAM covers all ETS sectors and is adopted by the United States. However, as long as Türkiye can diversify its exports, this should have limited impact on output and employment—generally below 3 percent.[52] Those higher value-added sectors could see growth in exports to the EU of between 1 and 2.8 percent. At the macroeconomic level, all CBAM scenarios remain negligible in their impact.



Box 4.1: Competitiveness in green global value chains

New export markets are emerging from the global transition to a green economy. Demand for more environmentally friendly 'green products'—such as solar PV, wind turbine, and EV technologies—is rapidly growing and expected to grow immensely as countries decarbonize. These products are largely produced within global value chains (GVCs): complex production networks spanning multiple countries.

[52] The elasticity of substitution of exports among Türkiye's trade partners are kept very low in this model. We also ran sensitivity analyses by further reducing the substitution elasticities, and the main findings did not change.

Türkiye's comparative advantage is more aligned with the green products necessary for the green economy. While Türkiye lags comparator countries in terms of the overall complexity of its exports (ranking 100th of 231 countries on the Economic Complexity Index), its competitiveness in green technologies and products with environmental benefits is comparably higher (ranking 26th on the Green Complexity Index, or GCI). Many of the products necessary for the green transition are also technologically sophisticated and therefore associated with greater knowledge spillovers.

Türkiye's potential to diversify into green, technologically sophisticated products is also excellent. Ranked 6th in Green Complexity Potential (GCP) over the last five years, Türkiye has made steady gains since 1995–99, when it was ranked 25th, suggesting it is well placed to develop competitiveness in additional green complex products.[a]

The country is already competitive in some segments of green value chains—such as wind turbines and electric vehicles—that are set to see significant demand uplift in the next 10 years. For example, it is in a strong position to build on its competitiveness in end-products in the EV value chain to take advantage of the global shift to low-carbon transport. Its range of subcomponents for the wind turbine value chain—such as liquid dielectric transformers and other parts and components, including wind turbines and hubs—will help Türkiye reap economic benefits from the continued growth and expansion of wind power around the world. With the right competencies and capabilities, Türkiye could gain a competitive advantage on green goods close to its existing capabilities. Its exports of—and global demand for—electric motor and generator parts, electricity meters, framed glass mirrors, and other products have seen positive growth in recent years.

A broad horizontal policy agenda to help Türkiye seize these opportunities should focus on strengthening capabilities and the enabling environment to participate in GVCs—including in more sophisticated green products. First, to facilitate GVC growth, Türkiye must improve market access globally and deepen economic integration with major partners such the EU, especially by reducing barriers to trade in services. Second, it needs to increase FDI and productive investment and scale up the presence of lead firms, including by ensuring a conducive and transparent business environment for the mobilization of domestic and international private sector capital. Third, a committed and consultative approach to business can also raise FDI and other GVC-linked investment and scale up GVC upgrading effects. Finally, improving economic infrastructure and workforce skills in lagging regions and addressing constraints to female employment can help improve the absorptive capacity of domestic firms.

Sources: Background Note 7 and World Bank 2022a

[a] While the GCI provides an indication of countries' existing capabilities to competitively produce green, complex products, the GCP measures countries' capabilities that are close to other green, complex products they are not yet competitive in. It has been shown to be a significant predictor of future GCI increases and growth in green trade (Mealy and Teytelboym 2020).

4.1.3. Redirecting private investments and improving the macroeconomic situation

Türkiye's fiscal policy is at odds with its climate objectives. Türkiye taxes petroleum but subsidizes other fossil fuels such as gas and coal and does not tax many non-energy sector emissions. Several meaningful taxes on road and maritime transport fuels are applied through the Special Consumption Tax (SCT) framework, contributing most of the revenue generated by energy taxation. But more than 70 percent of energy is used outside this sector. Natural gas is included in the framework and has a much higher tax rate (TL 0.8599 per cubic meter) when used for transport fuel than for residential or industrial use (TL 0.023 per cubic meter), but there are no excise taxes on kerosene, other aviation fuels, or coal. And while there is an excise tax on electricity (the Electricity Consumption Tax), it does not relate to carbon intensity or underlying electricity production.

Türkiye could extend pollution pricing to untaxed sources, through the tax system (including using existing taxes such as excise duties) or an ETS (box 4.2). Including coal and natural gas used for electricity generation, and industrial, fugitive and wastewater emissions, supported by Türkiye's existing emissions monitoring, reporting and verification (MRV) system (Government of Türkiye 2014),

would cover up to 70 percent[53] of Türkiye's GHG emissions. The MRV system would need to be extended to report methane emissions from industry and the energy sector.[54] Carbon pricing for agriculture emissions can be delayed at this stage given the complexities and lack of cost-effective options to mandate GHG reporting across farming systems in Türkiye. It would also contribute to higher food prices, affecting the poorest most. Covering emissions from landfills would be equally challenging, given the complexities of passing costs through the supply chain, and may not be a priority, since Türkiye has made good mitigation progress with landfill gas capture.

Box 4.2: Piloting an emissions trading system

Since 2013, with support from the Partnership for Market Readiness, Türkiye has been conducting studies on the applicability of carbon pricing instruments in the country. This included a GHG MRV pilot in the electricity sector, based on current MRV regulation, and analytical work on establishing a Turkish carbon market. The Climate Change Law, ETS bylaw, ETS auctioning communiqué, offset communiqué, and institutional setup drafts established the legal, institutional, and technical infrastructure for the ETS pilot. As part of the process, technical studies on a national cap and an allocation plan were undertaken and an ETS transaction registry was created. The pilot also involved emissions trading simulation, stakeholder training, and public awareness activities.

Subsidizing coal production drives up emissions, has other unintended adverse outcomes, and presents fiscal risks. Subsidies to the state-owned Turkish Hard Coal Enterprises amounted to $200 million in 2018 and to coal-fired power plants amounted to $475 million in 2020. Continuing these subsidies would generate more emissions and increase energy costs, even if the share of renewable energy in the power mix follows the government's ambitious targets. Eliminating the coal subsidy, on the other hand, could reduce GHG emissions by as much as 5 percent without a significant loss to GDP. Subsidizing coal use by poor families is an even more significant direct budgetary expenditure, and an inefficient way to help them,[55] and encourages burning coal for household heating, a major contributor to health problems from air pollution. Reallocating the fiscal resources gained from reducing coal subsidies to help poor families directly, without linking aid to coal consumption, would do more for poor people and remove an incentive to use a dangerously polluting fuel.

There are several important vehicle taxes, but these could better reflect the environmental costs associated with their use. The annual Motor Vehicle Tax is based on purchase price and engine size, but the rate declines steeply with age, resulting in an old vehicle fleet and therefore higher emissions. Over a third of all cars in Türkiye are at least 16 years old. Older cars are responsible for 40 percent of vehicular CO2 emissions, 67 percent of nitrous oxide emissions, and 23 percent of particulate matter emissions, but contribute only 9 percent of vehicle tax revenue. Türkiye's National Energy Efficiency

[53] Based on data from Government of Türkiye (2022), this estimate is the sum of emissions from the energy (excluding road transport), wastewater, and industrial process and product use sectors, divided by total emissions.

[54] GHG emissions from thermal power plants and industrial sectors such as cement, iron-steel, refinery, ceramics, lime, paper, glass production have been monitored at operation/facility level since 2015. They represent around half of total emissions.

[55] In 2019, over 2 million families received 1,500,000 tonnes of coal, with an estimated budgetary transfer of TL 1.315 billion. Since 2003, this policy has supported vulnerable households and the continued use of coal as a heating fuel.

Action Plan[56] proposes adjusting passenger vehicle tax rates to match the vehicle efficiency labelling scheme, thus taxing high-emitting vehicles the most.[57]

Although investment incentives are an effective policy for energy development, aspects of the existing investment framework—including special incentives for coal power—do not provide consistent signals to invest in cleaner assets. Türkiye's investment incentives program[58] encourages priority energy projects and includes coal-fired power, transport, and energy efficiency projects, which qualify for a corporate tax reduction of 40–55 percent of investment expenditure. Manufacture of "strategic products",[59] such as solar panels, gets direct financial support and a 70 percent reduction in corporate tax. Incentives for participating in tenders to build and operate coal power plants with associated mining leases include tax reductions and guaranteed exemption from paying any future price on carbon emissions.

A broad range of tax exemptions further incentivize fossil fuel use, reduce government revenue, and complicate the tax system. Multiple activities are currently exempt from excise duty on fuels. While public information on the revenue impact of fuel tax exemptions is difficult to find, the Turkish Revenue Administration estimates that the government forewent TL 66.6 billion in revenues in 2021.

Box 4.3: Repurposing support for a greener, more climate-resilient agriculture sector

Market price support and payments linked to output are inequitable, increase pressure on resources—including through impacts on water quality—and can raise GHG emissions. Yet in 2018–20, market price support and input subsidies represented 80 percent of Türkiye's transfers to producers, averaging nearly $10 billion each year. Public expenditure on general services that benefit the sector represented 2.6 percent of Türkiye's agricultural value-added on average over 2018–20 (versus 5.6 percent on average for OECD countries); investment in agricultural knowledge and innovation averaged only 6.5 percent of this support, well below shares in the EU and other middle-income countries.[a]

Investing in and disseminating agricultural technologies can help increase productivity, enhance climate resilience, and reduce emissions. According to a recent study commissioned by the World Bank (Gautam et al. 2022), repurposing approximately 1 percent of current public expenditure to the agriculture sector (about 7–8 percent of gross agricultural revenues) towards productivity-enhancing innovations showed an increase in national real income and a 24 percent fall in emissions from productivity gains. Extrapolating from the global model, if Türkiye repurposed 1 percent of its support to the sector towards R&D, it could increase real national income by 1 percent, reduce production emissions by 14 percent, increase crop yields by about 17 percent, and reduce the price of healthy foods by 19 percent, making them more affordable to a wide range of consumers.

[a] In high agriculture-producing countries such as Brazil, 92 percent of General Services Support Estimate transfers goes to innovation; in Norway, Australia, the EU, and Argentina, half of all general service expenditure supports agriculture innovation.

[56] enerjiapi.etkb.gov.tr//Media/Dizin/EIGM/Mevzuat/253490-national-renewable-energy-action-for-turkey.pdf.

[57] The upfront SCT on new cars is based on price and engine size and encourages people to buy cheaper vehicles with smaller engines.

[58] www.invest.gov.tr/en/investmentguide/pages/incentives-guide.

[59] The investments incentives program describes *strategic products* as technology-intensive, high-added value, import-dependent products with minimal or no local production. Successful funding recipients include projects that manufacture solar panels, polypropylene, aluminum, and carbon fiber products.

4.2. The financial sector's crucial role in mobilizing capital[60]

Meeting the investment needs for resilience and reaching net zero requires more private investment as well as public spending. Climate risks for the financial sector also need to be addressed. The Turkish banking sector provides considerable financing, especially in renewable energy. As of September 2021, total loan financing for renewable energy reached TL 200 billion ($22.6 billion), amounting to 4.9 percent of total loans. But green finance[61] is falling short of what is required for climate adaptation and mitigation. At the same time, climate change poses risks to financial stability and institutions.

4.2.1. Exposure to physical and transitional climate change risks

Physical and transition risks can affect credit, market, underwriting, operational, and liquidity risks, posing risks to the profitability and solvency of financial institutions. Banks, which hold more than 90 percent of Türkiye's total financial system assets, are exposed to both physical and transition risks. Physical risks—including droughts, forest fires, floods, and landslides—affect economic performance and asset value, potentially leading to a rise in non-performing loans (NPLs). Transition risks could lead to NPLs in the carbon-intensive and transition-sensitive sectors. Risks can differ significantly across banks, depending on their respective exposures.[62] And while it is a relatively small part of Türkiye's financial sector, climate-related risks can have substantial impact on the insurance sector, affecting the insurability of policyholder property and assets as well as insurers' operations and investments.

With geographically concentrated loan portfolios, Turkish banks are exposed to significant physical risks. Many of their credit portfolios are in regions at elevated risk of climate events; 45 percent of all bank loans ($205.5 billion as of 2021 Q3) are concentrated in Istanbul, Tekirdag, and Kocaeli, which are at high risk of drought and earthquake. Tourism sector loans are mostly concentrated in Antalya and Muğla, which were hit by massive forest fires in 2021. And while not a climate disaster, the 2011 Van earthquake is an example of the substantial impact that natural disasters can have on NPLs.

Transition-related risks can be approximated through banks' exposure to carbon-emitting sectors. The top five carbon-emitting sectors—energy, manufacturing, transport, wholesale trade, and agriculture— have a 49 percent share of credit ($223.7 billion in 2021 Q3). The energy and agriculture sectors, both high carbon emitters, also have relatively high NPL ratios, while manufacturing and some service sectors that may be subject to CBAM are exposing banks to additional transition risks (figure 4.5b).

Regulators and supervisors should continue building internal capacity to enable adequate risk assessment and integrate climate risk throughout the supervisory framework (World Bank 2022b). Key steps to be taken include using event- or scenario-based stress tests to assess risks, establishing guidelines on integrating climate risk in risk management, governance, disclosure practices, and supervisory scoring models and approaches, and assessing how to embed climate risk in existing regulations.[63] As regulators, the Capital Market Board (CMB) and the Banking Regulation and Supervision Agency (BRSA) can play an important role in supporting and enforcing disclosure and

[60] A more in-depth discussion of the risk to and the role of the financial system is available in World Bank 2022b. Climate risks and opportunities for the financial sector will also feature in the 2022 Financial Sector Assessment Program.

[61] *Climate finance* refers to local, national, or international financing that is drawn from public, private, and alternative sources to support mitigation and adaptation actions that will address climate change. *Green finance* includes all lending and investment that contributes to climate mitigation, climate adaptation, resilience, and other environmental objectives.

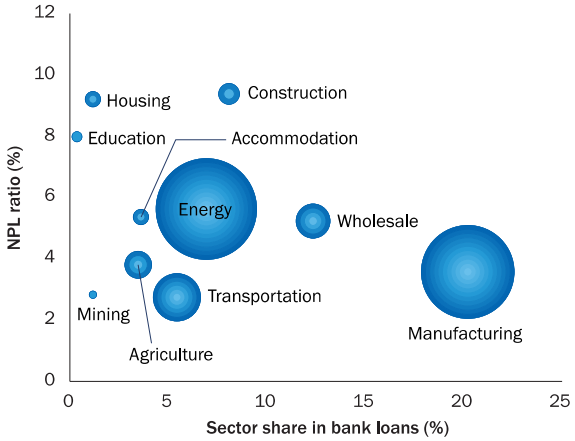
[62] As previous analyses in other countries (for example, World Bank climate risk analysis in Morocco and Colombia) have shown, risk exposure could differ strongly between individual banks, depending on their specialization—for example, agricultural banks. As such, bank-level data would be required for a more in-depth physical and transition risk analysis.

[63] These should be aligned with NGFS supervisory guidelines (https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guide_for_supervisors.pdf) and a recent publication of draft Principles for the effective management and supervision of climate-related financial risks by the Basel Committee (https://www.bis.org/bcbs/publ/d530.htm).

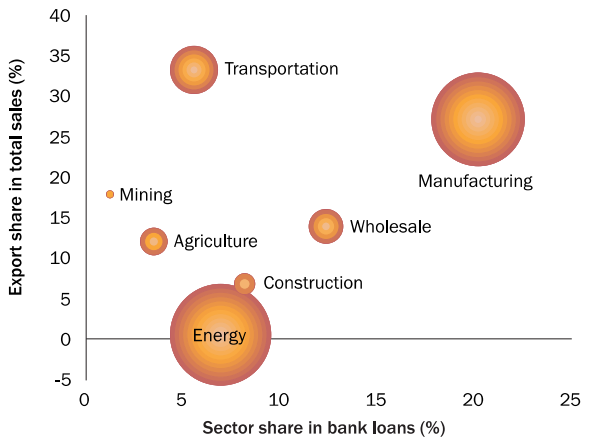
labeling, in line with international standards such as the Financial Stability Board's Task Force on Climate-related Financial Disclosures and the forthcoming EU Sustainable Finance Disclosure Regulation. This holds in a similar way for the insurance supervisor. The CMB took an important step in this direction in October 2020, publishing the *Sustainability Principles Compliance Framework*. The BRSA's recently published strategic plan is also encouraging. Such guidance will support a portfolio shift away from climate risky assets towards green investments, therewith stimulating change in the real economy.

Figure 4.5: Sectors most at risk from a green transition

a) Sectoral loan shares and NPL ratio



b) Export shares and carbon emissions for selected sectors



Source: World Bank staff calculations, based on data from TurkStat (sectoral carbon emissions, 2020), BRSA (credit and NPL data), and Central Bank of the Republic of Türkiye spell data, 2021
Notes: Bubble size shows carbon emissions. Carbon emissions data in panel b are reported by NACE2 definition for aggregate and 2-digit sectors. As the credit and NPL data did not properly report by the NACE2 definition, we chose sectors according to data availability.

4.2.2. Mobilizing green finance

Creating an overall strategy or roadmap on green, blue, or sustainable finance would align financial sector policies, regulations, and incentives with environmental and climate goals. A roadmap covering both the risks and opportunities of climate change can help prioritize actions and coordinate the activities of different stakeholders, including financial and environmental policy makers, regulators, and financial institutions. It would also provide clear signals to potential investors and help create an enabling environment for increased green investment—for example, though sustainable, green, or blue bonds or *sukuks*. This would build on recent public and regulatory initiatives aimed at developing green finance in Türkiye and an EU Green Deal Action Plan.[64]

Disclosure requirements and a green, blue, or sustainability-based taxonomy can foster transparency and boost public and private investment to finance the transition. Although several banks in Türkiye voluntarily apply sustainable finance guidelines, a taxonomy—possibly aligned with the EU taxonomy—to identify which assets or economic activities can be classified as green, blue, or sustainable, could not only boost investment but also contribute to developing new capital market instruments to support the transition. CMB and BRSA, in particular, have stepped up to guide financial sector players, build capacity, and develop data, analytics, and innovative products on sustainable and green finance that draw on international best practice and standards.[65]

Considering the investment needs identified in this report, neither the public sector nor banks will be able to meet the financing needs for the transition alone. National development banks and the

[64] These include Türkiye's New Economic Reform Package, the Ministry of Treasury and Finance's Sustainability Finance Framework, the CMB's Green Bond and Sukuk Guideline, and the BRSA's Sustainable Banking Strategic Plan (all 2021).

[65] The CMB's guideline is aligned with EU and International Capital Market Association standards on green bonds and *sukuks*. BRSA also aims to take actions based on the European Green Deal and NGFS. It joined NGFS in 2021.

Credit Guarantee Fund can be highly effective in mobilizing private finance for the green transition, including through financial innovation and de-risking instruments. The potential of capital markets—both debt and equity markets—and FDI to channel long-term finance is significant but remains limited, with Türkiye lagging peer emerging markets in terms of green issuance.[66] Barriers to the growth of green capital market instruments are primarily macrofinancial and structural, given an underdeveloped enabling environment and institutional investor base. Yet, aside from the potential positive impact of a green taxonomy and regulatory guidance, issuers and investors can be encouraged via incentives and by creating demonstration effects through pilot transactions and investment platforms (World Bank 2022b). A green strategic investment fund—with a double bottom-line mandate of financial and economic returns and focus on green investments, especially in the private equity space—is another opportunity to crowd in private capital. More generally, de-risking investments by maintaining a stable macrofinancial environment, and targeted guarantees and temporary cost-reducing incentives to bond issuances can play a role.

Insurance solutions can help improve protection against and speed up recovery after natural hazards and other climate-related events. Insurance can help restore livelihoods and rebuild critical infrastructure so that people, communities, and the economy can rebound more quickly, but Türkiye's insurance industry is underdeveloped.[67] The authorities can encourage increased insurance uptake by adopting a tailored disaster risk financing and insurance strategy, building on recent efforts by Türkiye's Natural Disaster Insurance Institution and Insurance Regulation and Supervision Agency,[68] to help improve protection against climate-related events. Specific instruments include catastrophe bonds and/or expansion of homeowner, private and municipal asset insurance, catastrophe insurance risk pools, contingent financing, and weather-related parametric insurance.

If climate finance is mobilized, municipalities could play an important role in low-carbon, climate-resilient urban development. In 2016, Türkiye's municipalities accounted for only 10 percent of total public expenditure, well below the 29 percent average in OECD unitary countries. Of these, municipalities (including metropolitan municipalities) represent the lion's share of expenditure, compared to the provincial administrations (SNG-WOFI 2019). Opportunities for mobilizing climate finance for cities include: leveraging intergovernmental fiscal transfers to incentivize municipalities to make low-carbon and resilient investments; developing their capacity to incorporate climate change considerations into spatial and investment planning; facilitating their access to climate finance; and mobilizing private investments and FDIs, including under public private partnerships or private finance initiatives, particularly for larger municipalities carrying international credit ratings.[69]

4.3. A just and inclusive transition for workers and households

Decoupling emissions from growth will involve economic restructuring as demand and output in carbon-intensive sectors contracts and other sectors expand, and Türkiye's economy will take time to adjust. Reallocating labor across sectors (figure 4.6), occupations, and locations as the economy shifts toward a low-carbon development path will lead to changes in the fuel mix, costs to firms, skills required by workers, and economic and social adjustment costs that could exacerbate challenges in Türkiye's labor market. This will all be compounded by the impact of climate change, especially on vulnerable sectors.

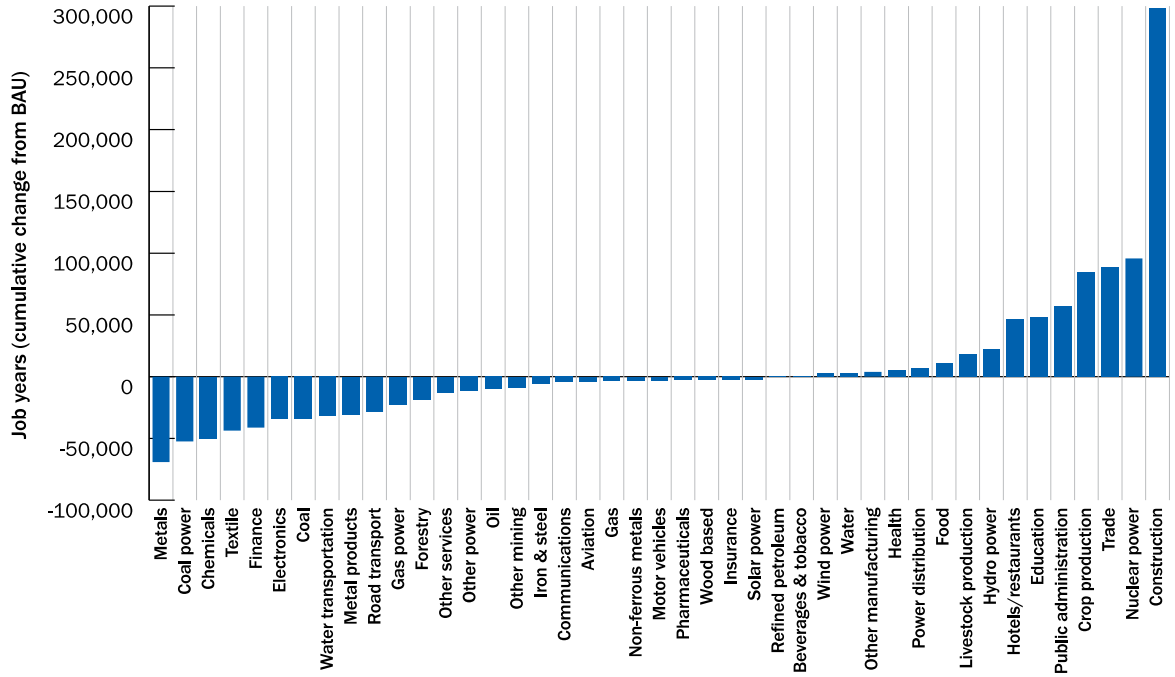
[66] https://www.climatebonds.net/market/data/.

[67] Türkiye's insurance sector—especially life insurance, which is normally considered a key source of long-term funding—is significantly smaller than its peers'. Insurance penetration stands at 1.32 percent, and life insurance penetration at 0.23 percent, significantly lower than other upper middle-income countries and several lower middle-income countries.

[68] DASK, the Turkish natural disaster insurance institution (https://dask.gov.tr/tcip/) established in 2000 after the 1999 earthquake, is responsible for providing, implementing, and managing compulsory earthquake insurance. See also https://seddk.gov.tr/.

[69] For further discussion of this topic, see World Bank. 2021. *State of Cities Climate Finance 2021 Part 2: The Enabling Conditions for Mobilizing Urban Climate Finance* (https://openknowledge.worldbank.org/handle/10986/35929).

Figure 4.6: Impact of the RNZP on labor demand by sector, 2022–30



We expect the effect of climate action on prices to remain limited, but it takes place in an already high inflation environment. Simulations suggest a moderate impact (less than 1 percent by 2030), except in the fossil fuel sectors. This would take place in a context where consumer price inflation reached 36 percent year-on-year in December 2022. Producer price inflation (PPI) reached 79.9 percent over the same timeframe. Energy price increases contributed 58 percent of the increase in PPI between January and October 2021. As Türkiye is a net energy importer, energy prices are rising because international oil and gas prices are rising and due to currency depreciation. Analysis shows that the oil price pass through to domestic PPI is around 6.5 percent, while the exchange-rate pass through to domestic PPI is around 70 percent. Stabilizing the lira will help stabilize energy prices. In the longer term, changing energy use to a greater share of cheaper renewables that do not need to be imported will also help remove a key driver of producer input prices.

4.3.1. Potential for green jobs: a focus on reskilling[70]

Economy-wide adjustments towards a low-carbon, greener economy will have implications for employment and labor markets (Vona et al. 2015, 2018). Türkiye's green transition will likely create new jobs in environmentally friendly production processes and outputs, and place other jobs at risk, particularly in sectors with fewer options for transitioning towards more sustainable ways of production. An overarching policy question to be addressed is the extent to which Türkiye is equipped to facilitate green jobs and skills, in the context of significant poverty, large population of refugees, and low labor force participation rate, especially for women and youth. Promoting the green transition while ignoring women's lower participation in the sectors that need transformation, including extractive industries, risks leaving women unable to participate in the green transition and will likely exacerbate the gender pay gap. Policies can be implemented to ensure that men and women are given equal opportunities to participate in the training, information, and access to finance that supports these investments.

[70] For a deeper discussion on human capital, see Background Note 8.

Categorizing jobs based on different impacts of the greening process shows that Türkiye lags comparable European and Central Asian countries with respect to the share of green jobs and jobs requiring upskilling for the green transition. In the absence of a standard definition of or classification for green jobs, this CCDR follows Vona et al. (2018):

- *Green jobs* are occupations where time is spent working on tasks complying with environmental sustainability—for example, environmental engineer, climate change analyst, soil and water conservationist. We expect these to remain in demand.

- *Brown jobs* are occupations in the most polluting industries and sectors, such as coal mining. We expect jobs in these sectors to be significantly changed and/or replaced.

- *Jobs that require upskilling* are occupations that are expected to undergo significant changes in task content due to the green transition—for example, nuclear power reactor operators, automotive specialty technicians, mechanical engineers. We expect these to remain but require retraining.[71]

Upgrading the Turkish workforce's skills seems to be the first major challenge to adapting to the green transition. Türkiye has a lower share of green jobs and a higher share of both brown jobs and jobs that require upskilling for the green transition than its peers in Europe and Central Asia. Between 13 and 18 percent of all Turkish workers can be exposed to dismissal risks through restructuring of brown jobs or to upskilling towards greener tasks and competences. The manufacturing sector in particular is characterized by many subsectors with a high share of brown jobs.

The need to retrain seems more evident when considering that 62 percent of brown job workers and 55 percent of those in jobs that need upskilling have achieved lower secondary education at most (figure 4.7). Looking at the population subgroups that are more likely to be affected by the green transition, 48 percent of brown job workers are under 34 years old, and 42 percent are aged 35 to 50. This means that for brown jobs, early retirement policies alone might not be an option; safety net or skills retraining programs will need to be in place for young workers and those in their prime. In terms of gender differences, the incidence of both brown jobs and jobs requiring upskilling on total employment is greater for male (6 vs. 3 percent) than for female (16 vs. 6 percent) workers.

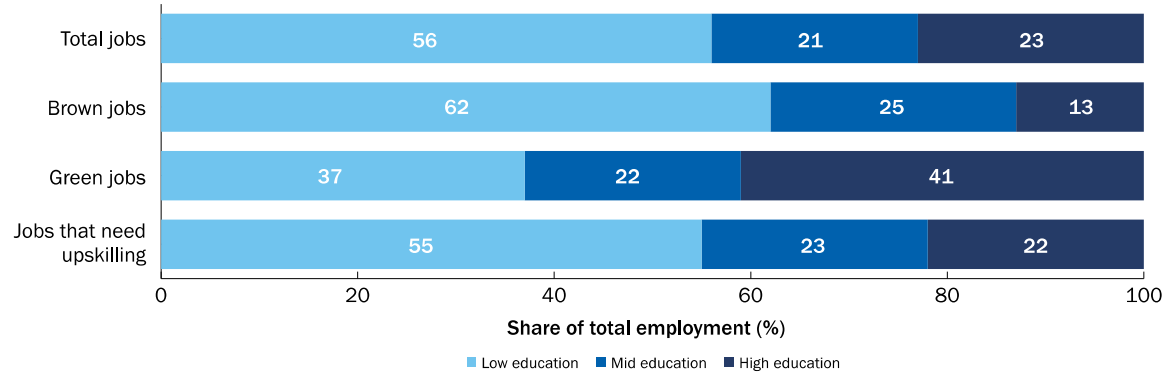
Both brown jobs and jobs that require upskilling are geographically concentrated, raising the risk of community-level impacts that are more difficult to manage economically and politically. Figure 4.8 shows these jobs are more concentrated in Türkiye's western provinces, reflecting the relative importance of jobs in energy, transport, and high-GHG-emitting manufacturing sectors in these areas.

Labor transition costs extend the period of economic adjustment, implying larger economy-wide losses. Moving jobs is not without cost, in terms of periods of unemployment, job search, retirement, retraining, or relocation. These costs are magnified by skills mismatches and other types of rigidities, including high hiring and firing costs that can adversely affect job creation and labor reallocation (OECD 2020). In Türkiye, this is compounded by already-low labor force participation, which is 52 percent overall, and only 34 percent for women (seasonally adjusted as of February 2022), and a national mandatory minimum wage that is high compared to the median OECD wage.[72] As clear in the macroeconomic simulations presented in section 4.1.1, these labor market frictions have a material impact on the macroeconomic cost of the transition.

[71] Classification is on the basis of the prevailing task content of specific occupations as defined in the O*NET database (https://www.onetonline.org/help/onet/database) as well the pollution intensity of certain industries where such occupations are prevalent.

[72] https://data.tuik.gov.tr/Kategori/GetKategori?p=istihdam-issizlik-ve-ucret-108&dil=1; https://stats.oecd.org/Index.aspx?DataSetCode=MIN2AVE.

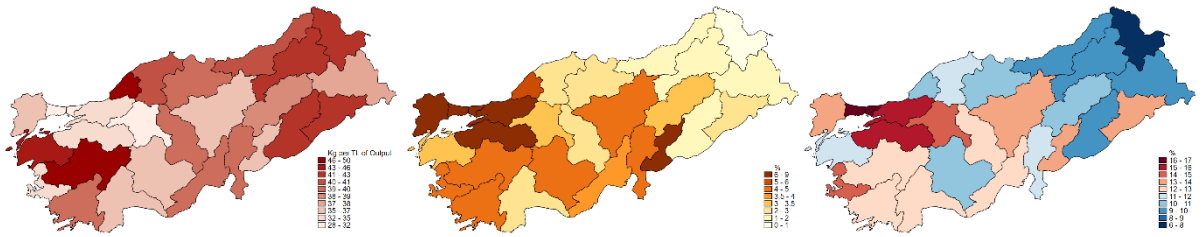
Figure 4.7: Distribution of worker education levels in Türkiye, by job type (2017)



Source: World Bank staff calculations, based on data from Turkish Labor Force Statistics 2017
Note: High education means tertiary education or above, mid education means upper secondary education, and low education means lower secondary education or below in terms of highest educational attainment.

Figure 4.8: Regional disparities in jobs exposed to the green transition

a) GHG emission intensities (2019) b) Share of brown jobs c) Share of jobs that require upskilling



Source: World Bank staff calculations, based on data from Turkish Labor Force Statistics 2017 and Aguiar et al. 2019

4.3.2. Disaster impacts have a disproportionate impact on the poor[73]

Like transition risks, climate and geological risks affect households unequally. This arises not only because poor households are more exposed to certain hazards, but also (and mostly) because they have a lower ability to prepare for, cope with, and recover from extreme events (Hallegatte et al. 2020). In terms of exposure, analyses for wildfires, earthquakes and floods show the following.

- **There is a strong spatial overlap between poverty and wildfires, which are expected to become more frequent as temperatures rise.** Two regions in particular, Şanliurfa and Mardin, stand out as hotspots of wildfire hazards and socioeconomic vulnerability, where the annual share of land burned averaged 6.6 and 5.4 percent, respectively, between 2011 and 2021. As the first and third cities with the largest poor population in Türkiye (1,250,000 and 720,000, respectively), this means that about 1 in 5 of Türkiye's poor people live in areas with high wildfire risk.

- **There is no correlation between poverty and seismic risks, but some exposed areas have a large number of poor people.** Poverty density is also high in three of the country's highest-risk areas—Istanbul, and the Van and Agri subregions in the east—which account for over 15 percent of the country's poor people. This exposure explains why a single 200-year earthquake around Istanbul could push 500,000 people in poverty (Kerblat et al. 2021).

[73] For a more detailed discussion of the issues in this section, see Background Note 8.

- **All areas, rich and poor, are affected by floods.** However, some regions, such as Antalya, Adana, and Hatay on the Mediterranean coast, and the more developed but highly populated Istanbul subregion, demonstrate relatively higher vulnerability. Along the Mediterranean coast, a 200-year flood could push 100,000 people in poverty (Kerblat et al. 2021).

4.3.3. The role of labor adjustment assistance and social protection

Boosting resilience and the green transition can be facilitated by well-functioning labor markets and broad social protection, complemented by dedicated interventions targeting heavily affected sectors, occupations, or regions.

Labor adjustment programs could include developing training programs to retrain dismissed workers or those in need of skills upgrading. The associated fiscal costs could be substantial.[74] In the case of brown jobs (around 1.2 million workers, considering only those aged below 55), one might assume that around 10 or 20 percent of jobs will be dismissed over the next eight years, receiving a year's salary as compensation, with the remaining workers (or at least half) undergoing retraining. Under these hypotheses, the yearly cost would amount to $237 million per year ($249 million, assuming 20 percent of dismissals).[75] For jobs requiring upskilling because of the green transition (around 3.3 million workers aged under 55), the yearly cost of retraining is estimated at $620 million (4.2 percent of carbon tax revenue in 2030 or 1.4 percent in 2040).[76] We can expect the costs of the green transition to be higher in areas with higher geographic concentration of brown jobs and jobs requiring upskilling, in the presence of externalities and spillover effects on households and the local economy. This is particularly relevant in Türkiye, where the share of workers requiring upskilling in some regions reaches 15 percent of total employment.

For social protection, options include a combination of expanding coverage, regional targeting approaches, community-based targeting, and community-driven platforms. To manage political economy challenges, regions negatively affected by the transition can be prioritized when deciding on green investment opportunities, and community benefit-sharing programs can be introduced to maximize social co-benefits. In places affected by industry closure, dedicated funding and appropriate resources are needed to facilitate the transition, complementing other approaches, such as active labor market programs, retraining and reskilling programs, and benefit schemes. Investing in communities and local infrastructure to make them attractive to outside investment and new industries and sectors would also help (Botta 2019).

Social protection systems can also be mobilized in case of natural disaster or environmental shock. Building on good progress with early warning and disaster preparedness programs, a flexible social protection system with targeted approaches that respond to shocks and disasters can complement market insurance to help people, communities, and local economies cope with shocks and recover more rapidly, reducing overall macroeconomic costs (box 3.4). The interventions are in synergy: strong social protection systems, including unemployment insurance and reskilling opportunities, make it easier to build targeted interventions, using them as a foundation.

[74] Box 3.6 looks at these costs in detail for the closure of coal power plants and mines, but the impacts will affect a larger group of workers in vulnerable activities.

[75] This scenario assumes that: workers in brown jobs aged 55 to 64 (around 111,000 workers) will move into early retirement; among the non-dismissed workers in brown jobs, only half will undergo training. The annual training cost is constant at $3,000.

[76] Again, this scenario assumes that only half of workers will undergo training and the training costs $3,000 a year.

5. Conclusions and 2022–30 policy recommendations

The CCDR brings together Türkiye's development goals with its climate commitments—in the form of its 2053 net zero pledge—its adaptation and resilience needs, and its aims to prioritize synergies and manage trade-offs across these parallel objectives. It explores how climate action and policies can generate short-term benefits, raise potential growth and the quality of economic growth, and protect the economy against longer-term risks, such as large-scale disasters or fallout of the global transition toward reduced greenhouse gas emissions.

5.1. A no-regret path to 2030

The RNZP can be used to define intermediate milestones that can be used more directly to design policies, identify investments, and inform the next NDC. Table 5.1 presents the 2030 milestones for our RNZP, which the government can use as medium-term targets—including for medium-term plans such as NDCs—sectoral ministries and agencies can use for proposals and investment plans, and the Ministry of Treasury and Finance, the Presidency of Strategy and Budget, the MoEUCC, and the CCACB can use to allocate budgets, track progress over time, and report to Parliament and the population.

Table 5.1: Summary of sample 2030 sectoral milestones for the illustrative RNZP

Sector	2030 milestones
Power 27% of total gross emissions in 2020	• 75% share of RE in power generation *(42% in 2020)* • 37% share of variable RE in power generation *(12% in 2020)* • 9% share of coal in power generation *(32% in 2020)* • 10 GW battery storage capacity *(0 GW in 2020)*
Transport 15% of total gross emissions in 2020	• Share of rail in total freight transport: 8% *(4% in 2020)* • Public transit (buses and rail) modal share for surface transport: 49% *(47% in 2020)* • Electrification of cars and buses: 12% and 19%, respectively *(both 0% in 2020)* • New investment screened for risks, critical assets identified and strengthened
Buildings 12% of total gross emissions in 2020	• New and retrofitted buildings to achieve Class A energy rating *(Class C in 2021)* • From 2030, electrification of heating in new and retrofitted residential buildings • Combined seismic and energy retrofit of 2.5 million residential buildings • 100% of urban plans updated to account for future climate risks
Forest landscapes Carbon sequestration offsetting 11% of gross emissions in 2020	• Harvest rate 24.3 million m^3 *(26 million m^3 in 2020)* • Zero deforestation after 2022 • Average burnt area per wildfire reduced to below 2 ha *(6.2 hectares in 2020)* • 102 MtCO2/year emissions removals *(57 MtCO2/year in 2020)*
Rest of economy 46% of gross emissions in 2020	• Agriculture: emissions reduced by 19% to 55 MtCO2e • Fugitive emissions reduced by 18% to 17 MtCO2e • Manufacturing/construction (except IPPU) reduced by 19% to 44 MtCO2e • Solid waste reduced by 19% to 14 MtCO2e

Notes: GW = gigawatts; MtCO2e = million tonnes of carbon dioxide equivalent. IPPU = industrial processes and product use.

The CCDR distinguishes actions that are urgent from interventions that can be delayed to reduce short-term costs, benefit from the expected decline in the cost of green technologies, and allow strategy adjustments as more information becomes available. Some policy changes or investments can be delayed without increasing the cost of the entire transition, making it possible to prevent early trade-offs with other development objectives. This is the case for the electrification of buildings, for instance. While electrifying heat and other residential energy use is needed to achieve net zero emissions in 2053, doing it immediately has a strong impact on electricity demand, magnifying the challenge of decarbonizing the power system and reducing the share of coal. In contrast, the cost of electrifying existing buildings is manageable, so delaying this action to 2030 brings the benefits of cheaper technologies (heat pumps, induction cooking) and electricity with a lower carbon intensity. Similarly, decarbonizing Türkiye's carbon-intensive industrial sector will require new technologies, such as hydrogen-based steel making and CCUS, and it is more realistic to implement these technologies after 2030. **However, delayed implementation does not mean delayed action:** for

technologies to be available and cost-competitive in 2030, investments in R&D and pilot projects—including to identify carbon sequestration opportunities—should start immediately.

The short-term interventions of the RNZP (over 2022–30) are largely "no regret" ones: taken together they lead to aggregate economic gains. To keep short-term costs as low as possible, and maximize development benefits, short-term interventions are focused on subsidy reform and tax reform, energy efficiency (in residential buildings and transport), renewable energy (the cheapest energy source), and interventions with large co-benefits in the form of reduced air pollution, urban congestion, or exposure to geopolitical risks and energy price volatility on global and regional markets. The most expensive transformations—such as the last 10 percent of decarbonizing the power sector or the electrification of residential heating—are postponed to after 2030 or 2040.

Not everything can be postponed: some changes are urgent, because inaction is locking Türkiye into carbon-intensive patterns that will increase costs and create financial risks, such as stranded assets. Particularly urgent are the changes that affect long-lived infrastructure assets: decarbonizing the power system, modal shift in transportation with supportive risk-informed urban planning, and energy efficiency and resilience in buildings. Among the most urgent measures, some create challenges in terms of financing (for example, energy efficiency of buildings, and pilot projects for new technologies), social impacts (for example, the exit from coal), or implementation and enforcement (for example, forestry). As such, they require specific attention and support. And even delayed implementation does not mean delayed action: for technologies to be available and cost-competitive to decarbonize heavy industries in 2030, investing in R&D and pilot projects—including to identify sequestration opportunities—should start immediately.

5.2. From medium-term milestones to short-term policy recommendations

Due to its multisectoral nature, this CCDR cannot describe in detail the policy changes and investments needed to make these transitions happen. However, it can highlight the most important policy priorities. Some of these are already well covered in other reports or policy documents; others are priorities for future analytical and policy work.

Some interventions that tackle underlying structural obstacles to Türkiye's growth and development can also promote the achievement of climate objectives. Recommendations in these domains are available in other World Bank documents,[77] and include:

- **Macroeconomic stability:** Reducing macroeconomic volatility and boosting investor confidence by stabilizing inflation and exchange rates and maintaining a predictable and transparent regulatory framework; building external reserves, resolving corporate distress, cleaning bank balance sheets; maintaining a prudent level of public debt; and accounting for contingent liabilities, including those arising from public private partnerships or private finance initiatives.

- **Human capital, labor markets, and social protection:** Investing in people, through health, education, and upskilling investment, to support the transition to greener occupations; facilitating workers' transition from declining to growing sectors with appropriate labor market regulations; boosting social support to mitigate the transition's impact on poverty and employment and increase the population's resilience to climate and environmental shocks;

[77] These include: Turkey Economic Monitors, https://www.worldbank.org/en/country/turkey/publication/economic-monitor; Türkiye Public finance Review (forthcoming); Firm Productivity and Economic Growth in Turkey (2018), https://openknowledge.worldbank.org/handle/10986/31931; Leveraging Global Value Chains for growth in Turkey (2022), https://openknowledge.worldbank.org/handle/10986/37095.

expanding coverage and implementing regional and/or community-based targeting approaches, using community-driven development platforms.

- **Institutional strengthening:** Ensuring robust and efficient national and subnational processes for economic decision making, aligning policy documents, budgeting, tax collection, access to finance, public spending and procurement, and public investment management. Embracing digitalization, which offers opportunities to boost resilience and efficiency in public services and infrastructure system through smart meters, smart irrigation, smart manufacturing, smart waste management, e-mobility, and so on.

Improvements in these three domains create obvious synergies between development and climate objectives, and would immediately accelerate growth and improve population well-being, while improving the economy's ability to manage the transition at a lower cost.

Priority 1. Realign energy policies to exit from coal and decarbonize the power sector: Make parallel efforts, through a new energy security compact, to commit a just and inclusive transition from coal, by (i) not building new coal plants; (ii) retiring most existing coal power plants and mines by 2040 and compensating for lost future revenues; (iii) supporting laid-off workers and affected communities; (iv) facilitating environmental remediation; (v) scaling up renewable energy; (vi) deploying grid integration measures, particularly battery and pumped storage, remunerating storage services, and expanding and digitalizing transmission networks; and (vii) ensuring well-designed power markets, with careful consideration of implications for reliability and electricity prices.

Priority 2. Maximize the economic benefits of the transition with a supportive macroeconomic and financial environment: Implement macro-stabilizing and structural interventions to raise economic productivity by (i) alleviating factor market rigidities; (ii) removing or repurposing fossil fuel and agricultural subsidies, and deploying de-risking instruments; (iii) enabling public investments and mobilizing private investments through a tax reform that combines subsidy reform with a carbon tax (or an equivalent ETS) in all sectors except agriculture and landfills; (iv) mainstreaming climate objectives in macro-fiscal and monetary policy; and (v) reforming the financial sector to extend tenor and taxonomy, developing green and blue bonds, and improving transparency and disclosure of climate-related risks in the financial system. The latter will be further explored in the forthcoming Financial Sector Assessment Program.

Priority 3. Make the economy more energy efficient: Establish a more ambitious National Energy Efficiency Action Plan to 2030 for transport, buildings, urban industry, and waste sectors, with (i) more stringent and well-enforced building standards and codes; (ii) strategies and investments to support modal shifts in transport and transit-oriented urban development; (iii) a national program for building renovations; (iv) national schemes to support energy efficiency in factories, including energy audits and efficiency reporting, and improved recycling programs for metals, e-waste, and other waste; and (v) a progressive and coordinated shift toward electrification in industries, as well as space and water heating, coupled with rooftop solar schemes to offset impacts on the grid.

Priority 4. Maximize negative emissions from forests and landscapes: Mainstream sustainable forest management to enhance carbon sinks and manage climate risks (especially wildfires), with investment in landscape restoration through reforestation, forest and grassland rehabilitation, cropland management, and wetland conservation.

Priority 5. Make growth more resilient and sustainable: Adopt an economy-wide approach that mainstreams (i) resilience and future climate change impacts in public and private sector decisions, by including climate risks in budgeting procedures; (ii) infrastructure and building construction

standards; (iii) procurement and public investment management; (iv) urban and infrastructure planning; (v) water management plans and regulations, complemented by modernized irrigation and drainage and diversified freshwater resources; (vi) agriculture policies and support, including subsidy repurposing; and (vii) social protection systems.

Priority 6. Minimize social disruptions and ensure a just and inclusive transition: Build a strategy that (i) identifies at-risk sectors and workers; (ii) anticipates and prepares for retraining and reskilling needs; and (iii) strengthens social protection systems to make them more reactive, flexible, and better able to absorb expected and unexpected shocks. Repurposing retired coal power plants and closed coal mines can not only lead to economic and energy transition, but also mitigate the social impacts and disruption of these closures.

5.3. The way ahead

This CCDR explores some of the most important issues and opportunities created by climate change for Türkiye. But more work is needed to provide specific policy recommendations and sectoral roadmaps. There are two priorities for future analytical work.

First, Türkiye needs to design a long-term strategy that is integrated into development and economic plans and policies. The RNZP we propose in this CCDR is an illustrative pathway to demonstrate feasibility and explore costs and benefits. A necessary next step is a long-term strategy, developed and owned by the government, which it can then use as the basis for its NDC and policy design. Two current World Bank engagements—on the energy transition and low-carbon long-term development—aim to support this process.

Second, we need to translate the broad recommendations of this CCDR into more detailed policy advice. It is not possible to explore the full complexity of each recommendation in an economy-wide report like the CCDR. In some cases, extensive explorations already exist—see, for example, the latest Türkiye Economic Monitor[78] or recent analytical work on water or agriculture. Further sector-specific work is still needed, with more engagement from government and stakeholders. Detailed policy recommendations regarding the design of a just exit from coal, for example, were out of the scope of this CCDR, but are the topic of follow-up engagements.

One important conclusion of this CCDR is the need for immediate actions to boost resilience and reduce carbon emissions, and these actions should not be delayed by further analytical work. Like economic and development policy, climate policy takes place in a context of incomplete knowledge and large irreducible uncertainties. Analytical work can help, but many uncertainties will only be resolved as the country implements its climate policies, carefully monitors their impacts and results, and learns from its successes and failures.

A long-term strategy for climate change adaptation and mitigation is necessarily an adaptive strategy that will be regularly evaluated and revised to account for both new knowledge and technologies, and actions in the rest of the world. Contexts of deep uncertainty require flexible and regularly adjusted policies. While it is important to consider the longer-term pathway over 2022–40 or even to 2053, this strategy can and will be adjusted between now and 2030, based on new learnings and knowledge. For the next eight years, this CCDR identifies a short-term strategy that minimizes short-term trade-offs and maximizes synergies and can contribute to successfully achieving Türkiye's development objectives and accelerating its progress toward high-income status.

[78] https://www.worldbank.org/en/country/turkey/publication/economic-monitor.

COUNTRY CLIMATE DEVELOPMENT REPORT:

APPENDIX A

Appendix A: Türkiye climate and development data

	Unit	#	Year	#	Year	#	Year	Source
CURRENT MACROECONOMIC CONTEXT								
GDP per capita (annual growth rate)	%	7.4	1990	–	–	0.7	2020	https://databank.worldbank.org/source/world-development-indicators
Labor productivity (annual growth rate)	%	5.7	1990	–	–	6.9	2020	https://data.oecd.org/lprdty/labour-productivity-and-utilisation.htm#indicator-chart
Informal economic output	% of GDP	36.6	1990	30.3	2005	25.6	2018	https://www.worldbank.org/en/research/brief/informal-economy-database
Average unemployment	% of labor	8.2	1991	10.6	2005	13.9	2020	https://databank.worldbank.org/source/world-development-indicators
Current account balance	% of GDP	-1.7	1990	-4.1	2005	-4.9	2020	
Central government debt	% of GDP	30.2	1990	41.2	2008	31.7	2016	
Energy tax revenue	% of GDP	–	–	–	–	1.4	2020	https://databank.worldbank.org/source/country-climate-and-development-report-(ccdr)
Fossil fuel pre-tax subsidies	$/capita	42.8	2015	57.0	2017	57.2	2019	
Coal export level	million short tons	9.5	1990	21.0	2005	56.0	2020	https://www.eia.gov/international/data/world#/?
Oil export level	million barrels/day	0	1990	0	2005	0	2020	
Self-sufficiency, coal	% domestic	58	2000	48	2005	41	2019	https://www.iea.org/reports/Türkiye-2021
Self-sufficiency, oil	% domestic	9	2000	8	2005	8	2019	
Self-sufficiency, natural gas	% domestic	4	2000	4	2005	1	2019	
Carbon intensity of ferrous metals	tCO2/million $	–	–	–	–	619	2020	World Bank staff calculations
Carbon intensity of non-ferrous metals	tCO2/million $	–	–	–	–	232	2020	World Bank staff calculations
CLIMATE CHANGE MITIGATION								
GHG EMISSIONS								
Emissions per capita	tCO2e/capita	3.0	1990	3.8	2005	5.0	2018	https://databank.worldbank.org/source/country-climate-and-development-report-(ccdr)
Total GHG emissions, including LULUCF	MtCO2e	163.7	1990	262.6	2005	466.2	2020	https://unfccc.int/documents/271544
Agriculture	MtCO2e	46.0	1990	42.3	2005	73.2	2020	
Buildings	MtCO2e	27.2	1990	32.5	2005	64.0	2020	
Electricity/ heat	MtCO2e	37.2	1990	90.4	2005	142.0	2020	
Fugitive emissions	MtCO2e	4.5	1990	5.7	2005	8.6	2020	
Industrial processes	MtCO2e	22.8	1990	33.6	2005	66.8	2020	
Manufacturing/ construction	MtCO2e	37.1	1990	63.0	2005	60.2	2020	
Other fuel combustion	MtCO2e	6.4	1990	10.1	2005	11.3	2020	
Transport	MtCO2e	26.9	1990	42.0	2005	80.7	2020	
Waste	MtCO2e	11.0	1990	17.3	2005	16.4	2020	

LULUCF	MtCO2e	-55.7	1990	-74.6	2005	-56.9	2020	
Emissions scenario – BAU	MtCO2e	410	2030	500	2040	600	2053	World Bank staff calculations
NDC target – unconditional submission	MtCO2e	–	–	–	–	999	2030	https://climateactiontracker.org/countries/Türkiye/targets/
NDC target – 21% below BAU	MtCO2e	–	–	–	–	323.9	2030	World Bank staff calculations
ENERGY CONSUMPTION AND THE POWER SECTOR								
Energy intensity of economy (2011$PPP[a])	kWh/$	0.98	1990	1.09	2005	1.06	2016	https://databank.worldbank.org/source/country-climate-and-development-report-(ccdr)
Building – residential, single-family	kWh/m²/year	–	–	–	–	220	2015	https://www.giz.de/en/downloads/giz2019-en-turkish-building-sector.pdf
Building – residential, multi-family	kWh/m²/year	–	–	–	–	175	2015	
Building – industrial	kWh/m²/year	–	–	–	–	270	2015	
Final consumption – industry	%	–	–	–	–	36.0	2018	https://www.iea.org/reports/Türkiye-2021
Final consumption – transport	%	–	–	–	–	27.0	2018	
Final consumption – residential	%	–	–	–	–	20.0	2018	
Final consumption – services[b]	%	–	–	–	–	17.0	2018	
Electricity generation – fossil fuels	GWh	34,315	1990	122,120	2005	170,818	2019	
Electricity generation – renewables	GWh	23,148	1990	39,703	2005	121,860	2019	
Energy potential – solar	kWh/kWp/day	–	–	–	–	4.3	2018	https://globalsolaratlas.info/
Energy potential – wind	GW	–	–	–	–	75.8	2019	https://esmap.org/esmap_offshorewind_techpotential_analysis_maps
Renewable target – solar capacity	GW	–	–	–	–	10	2030	https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx
Renewable target – wind capacity	GW	–	–	–	–	16	2030	
EXPOSURE AND VULNERABILITY TO THE GREEN TRANSITION								
Share of brown jobs	%	2012	4.5	–	–	2017	4.7	Background Note 8
Public spending – social assistance	% of GDP	–	–	–	–	13.5	2014	https://databank.worldbank.org/source/country-climate-and-development-report-(ccdr)
Population – financial access[c]	%	57.6	2011	56.7	2014	68.6	2017	https://databank.worldbank.org/source/global-financial-inclusion
Government effectiveness[d]	Percentile rank	56.9	2000	–	–	52.4	2020	http://info.worldbank.org/governance/wgi/
Political stability	Percentile rank	–	–	–	–	11.7	2020	https://databank.worldbank.org/source/country-climate-and-development-report-(ccdr)

CLIMATE CHANGE ADAPTATION AND RESILIENCE								
EXPOSURE AND VULNERABILITY								
Agriculture, forestry, fishing: value added	% of GDP	17.4	1990	9.2	2005	6.7	2020	https://databank.worldbank.org/source/country-climate-and-development-report-(ccdr)
Freshwater withdrawal/ available water	%	23.5	1992	37.5	2012	44.5	2017	
Urban population	% of population	59.2	1990	67.8	2005	74.6	2020	
Flood exposure	% of population	–	–	–	–	14.2	2017	
Access to energy	% of population	100	2010	100	2015	100	2019	
Poverty headcount ratio[e]	% of population	37.8	1994	24.6	2005	10.2	2019	
Access to drinking water[f]	% of population	93.6	2000	94.5	2005	97.0	2020	
Social insurance program coverage	% of population	–	–	31.0	2005	37.2	2019	
CHANGE IN CLIMATE CONDITIONS								
Mean average temperature[g]	˚C	11.6	1991 – 2000	–	–	13.5	2040 –59	https://climateknowledgeportal.worldbank.org/
Mean average annual precipitation[g]	millimeters	576.8	1991 – 2000	–	–	594.2	2040 –59	
Days with heat index > 35˚C[g]	# days	0.19	2021	0.31	2030	0.69	2050	
Hazard level – coastal flood	Hazard level	–	–	–	–	HIGH	2020	https://thinkhazard.org/en/
Hazard level – extreme heat	Hazard level	–	–	–	–	HIGH	2020	
Hazard level – urban flood	Hazard level	–	–	–	–	HIGH	2020	
Hazard level – wildfire	Hazard level	–	–	–	–	HIGH	2020	
ECONOMIC IMPACT OF NATURAL DISASTER								
Risk to asset – average annual loss	% of GDP	–	–	–	–	0.3	2016	https://databank.worldbank.org/source/country-climate-and-development-report-(ccdr)
Risk to well-being – average annual loss	% of GDP	–	–	–	–	0.5	2016	

[a] *PPP = purchasing power parity.*
[b] *Services include agriculture and fisheries.*
[c] *Account at a financial institution or with mobile-money provider (ages 15+).*
[d] *Percentile rank [0 to 100], higher values = better outcomes.*
[e] *Poverty headcount ratio at $5.50 a day (2011 PPP).*
[f] *Drinking water defined as "least basic".*
[g] *Projection from SSP2-4.5 Ensemble (SSP = shared socioeconomic pathways).*

References

Aguiar, A, Chepeliev, M, Corong, E L, McDougall, R and van der Mensbrugghe, D. 2019. "The GTAP data base: version 10." *The Journal of Global Economic Analysis*, 4(1). https://www.gtap.agecon.purdue.edu/databases/default.asp.

Ahmed, J, Almeida, E, Aminetzah, D, Denis, N, Henderson, K, Katz, J, Kitchel, H and Mannion, P. 2020. *Reducing Agriculture Emissions Through Improved Farming Practices*. McKinsey and Company. https://www.mckinsey.com/industries/agriculture/our-insights/reducing-agriculture-emissions-through-improved-farming-practices.

Baez, J, Inan, O K and Nebiler, M. 2021. *Getting Real? The Uneven Burden of Inflation Across Households in Turkey*. World Bank. https://openknowledge.worldbank.org/handle/10986/36645.

Baglee, A, Connell, R K, Haworth, A, Rabb, B, Bugler, W, Uluğ, G, Capalov, L, Hansen, D S, Glenting, C, Jensen, C S and Laugesen, F M. 2013. *Pilot Climate Change Adaptation Market Study: Turkey.* IFC and European Bank for Reconstruction and Development. www.semanticscholar.org/paper/Pilot-climate-change-adaptation-market-study-%3A-Baglee-Connell/ed6cec2c061aa2da9afb5bff63131c9cfcbd1ba0.

Bataille, C. 2019. "Physical and policy pathways to net-zero emissions industry". *Wiley interdisciplinary reviews: Climate Change*. 12(1). http://dx.doi.org/10.1002/wcc.633.

Botta, E. 2019. *A Review of "Transition Management" Strategies: Lessons for Advancing the Green Low-carbon Transition*. OECD Green Growth Papers. https://doi.org/10.1787/4617a02b-en.

Cakar, B, Serdar, A, Varank, H and Ozcan, K. 2020. "Assessment of environmental impact of food waste in Turkey." *Journal of Cleaner Production*. 244, 118846. www.sciencedirect.com/science/article/pii/S0959652619337163.

Chakraborty, T and Lee, X. 2019. "A simplified urban-extent algorithm to characterize surface urban heat islands on a global scale and examine vegetation control on their spatiotemporal variability." *International Journal of Applied Earth Observation and Geoinformation,* 74: 269–280.

Çoban, D, Demircan, M D and Tosun, DD, eds. 2020. *Marine Aquaculture in Turkey: Advancements and Management.* Turkish Marine Research Foundation (TUDAV) Publication No 59: Istanbul, Türkiye.

Dengizb, O and Uzunera, C. 2020. "Desertification Risk Assessment in Turkey Based on Environmentally Sensitive Areas." *Ecological Indicator,* 114. https://doi.org/10.1016/j.ecolind.2020.106295.

Gautam, M, Laborde, D, Mamun, A, Martin, W, Piñeiro, V and Vos, R. 2022. *Repurposing Agricultural Policies and Support: Options to Transform Agriculture and Food Systems to Better Serve the Health of People, Economies, and the Planet*. World Bank. http://hdl.handle.net/10986/36875

Government of Türkiye. 2014. "Regulation on the monitoring of greenhouse gas emissions." *Official Gazette* 29003, May 17. https://pmrturkiye.csb.gov.tr/wp-content/uploads/2017/04/Turkey_GHGE-Regulation.pdf.

Government of Türkiye. 2022. *Turkish Greenhouse Gas Inventory 1990–2020.* https://unfccc.int/documents/461926.

Hallegatte, S and Vogt-Schilb, A. 2016. *Are Losses from Natural Disasters More Than Just Asset Losses? The Role of Capital Aggregation, Sector Interactions, and Investment Behaviors.* Policy Research Working Paper 7885. Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/25687.

Hallegatte, S, Rentschler, J and Rozenberg, J. 2019. *Lifelines: The Resilient Infrastructure Opportunity*. https://openknowledge.worldbank.org/handle/10986/31805.

Hallegatte, S, Rentschler, J and Rozenberg, J. 2020. *Adaptation Principles: A Guide for Designing Strategies for Climate Change Adaptation and Resilience.* Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/34780.

Hallegatte, S, Vogt-Schilb, A, Rozenberg, J, Bangalore, M and Beaudet, C. 2020. "From Poverty to Disaster and Back: A Review of the Literature." *Economics of Disasters and Climate Change*, 4(1): 223–247. https://doi.org/10.1007/s41885-020-00060-5.

Hallegatte, S, Jooste, C, Mclsaac, F J. 2022. *Macroeconomic Consequences of Natural Disasters: A Modeling Proposal and Application to Floods and Earthquakes in Turkey*. Policy Research Working Paper 9943. Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/37060.

IEA. 2019. *Multiple Benefits of Energy Efficiency: From "Hidden Fuel" to "First Fuel".* https://www.iea.org/reports/multiple-benefits-of-energy-efficiency.

IEA. 2021. *Turkey 2021: Energy Policy Review*. https://www.iea.org/reports/turkey-2021.

IFC. 2018. *Waste Heat Recovery in Turkish Cement Industry: Review of Existing Installations and Assessment of Remaining Potential*. International Finance Corporation. https://www.ifc.org/wps/wcm/connect/0d4f43ee-018d-4f26-9fbe-a47d2927363b/Waste+Heat+Recovery+in+Turkish+Cement+Industry.pdf?MOD=AJPERES&CVID=maKQJNl.

IICEC. 2020. *Turkey Energy Outlook 2020*. Sabanci University, Istanbul International Center for Energy and Climate. https://iicec.sabanciuniv.edu/teo.

Jägermeyr, J, Müller, C, Ruane, A C, Elliott, J, Balkovic, J, Castillo, O, Faye, B, Foster, I, Folberth, C, Franke, J A, Fuchs, K, Guarin, J R, Heinke, J, Hoogenboom, G, Iizumi, T, Jain, A K, Kelly, D, Khabarov, N, Lange, S, Lin, T, Liu, W, Mialyk, O, Minoli, S, Moyer, E, Okada, M, Phillips, M, Porter, C, Rabin, S S, Scheer, C, Schneider, J M, Schyns, J F, Skalsky, R, Smerald, A, Stella, T, Stephens, H, Webber, H, Zabel, F, Rosenzweig, C. 2021. "Climate impacts on global agriculture emerge earlier in new generation of climate and crop models". *Nature Food*, 2: 873–885. https://doi.org/10.1038/s43016-021-00400-y.

Kaza, S, Yao, L, Bhada-Tata, P and Van Woerden, F. 2018. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Urban Development Series. Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/30317.

Kerblat, Y, Arab, A, Walsh, B J, Simpson, A L, Hallegatte, S. 2021. *Overlooked: Examining the Impact of Disasters and Climate Shocks on Poverty in the Europe and Central Asia Region*. Washington DC: World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/493181607687673440/overlooked-examining-the-impact-of-disasters-and-climate-shocks-on-poverty-in-the-europe-and-central-asia-region.

Kose, M A, Kurlat, S, Ohnsorge, F, Sugawara, N. 2017. *A Cross-Country Database of Fiscal Space*. Policy Research Working Paper 8157. Washington DC: World Bank. http://hdl.handle.net/10986/27964.

Kulp, S A and Strauss, B H. 2019. "New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding." *Nature Communications* 10: 4844. https://doi.org/10.1038/s41467-019-12808-z.

Leeson, D, Dowell, N M, Shah, N, Petit, C and Fennell, P S. 2017. "A techno-economic analysis and systematic review of carbon capture and storage (CCS) applied to the iron and steel, cement, oil refining and pulp and paper industries, as well as other high purity sources." *International Journal of Greenhouse Gas Control*. 61: 71–84. https://doi.org/10.1016/j.ijggc.2017.03.020.

Li, S, Zhu, X, Ma, Y, Zhang, F and Zhou, H. 2020. *The Role of Government in the Market for Electric Vehicles: Evidence from China.* Policy Research Working Paper 9359. Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/34356.

Maus, V, Giljum, S, Gutschlhofer, J, da Silva, D M, Probst, M, Gass, S L B, Luckeneder, S, Lieber, M and McCallum, I. 2020. "A global-scale data set of mining areas." *Scientific Data*, 7: 289. https://doi.org/10.1038/s41597-020-00624-w.

Mealy, P and Teytelboym, A. 2020. "Economic complexity and the green economy." *Research Policy*, 103948. https://doi.org/10.1016/j.respol.2020.103948.

OECD. 2020. *Employment Outlook 2020*. www.oecd-ilibrary.org//sites/1686c758-en/1/3/3/index.html?itemId=/content/publication/1686c758-en&_csp_=fc80786ea6a3a7b4628d3f05b1e2e5d7&itemIGO=oecd&itemContentType=book#.

Raimi, D. 2017. *Decommissioning US Power Plants: Decisions, Costs, and Key Issues*. RRF Report. https://media.rff.org/documents/RFF20Rpt20Decommissioning20Power20Plants.pdf.

Rentschler, J and Salhab, M. 2020. *People in Harm's Way: Flood Exposure and Poverty in 189 Countries.* Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/34655.

Rozenberg, J and Fay, M. 2019. *Beyond the Gap: How Countries Can Afford the Infrastructure They Need while Protecting the Planet*. Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/31291.

Salihoglu, B, Arkin, S, Akoglu, E and Fach, B. 2017. "Evolution of future black sea fish stocks under changing environmental and climatic conditions." *Frontiers in Marine Science*, 4. https://doi.org/10.3389/fmars.2017.00339.

SNG-WOFI. 2019. *2019 Report: Country Profiles*. World Observatory on Subnational Government Finance and Investment. www.sng-wofi.org/publications/SNGWOFI_2019_report_country_profiles.pdf.

Taheripour, F, Tyner, W E, Sajedinia, E, Aguiar, A, Chepeliev, M, Corong, E. de Lima, C Z and Haqiqi, I. 2020. *Water in the Balance: The Economic Impacts of Climate Change and Water Scarcity in the Middle East.* Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/34498.

Tekinay, A A and Güroy, D. 2007. "İklim değişikliği Türkiye balık üretimini nasıl etkileyecek?" I. *Türkiye İklim Değişikliği Kongresi Bildiri Kitapçığı*. İstanbul: İTÜ.

Turkish State Meteorological Service. 2020. *State of the Climate in Turkey in 2019*. https://mgm.gov.tr/eng/Yearly-Climate/State_of_the_Climate_in_Turkey_in_2019.pdf.

UNISDR. 2015. *Global Assessment Report on Disaster Risk Reduction 2015.* https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2015.

Vogl, V, Åhman, M and Nilsson, L J. 2018. "Assessment of hydrogen direct reduction for fossil-free steelmaking". *Journal of Cleaner Production*. 203: 736–745. https://doi.org/10.1016/j.jclepro.2018.08.279.

Vona, F, Marin, G, Consoli, D and Popp, D. 2015. *Green Skills*. NBER Working Paper 21116.

Vona, F, Marin, G, Consoli, D and Popp, D. 2018. "Environmental regulation and green skills: an empirical exploration." *Journal of the Association of Environmental and Resource Economists* 5(4). http://dx.doi.org/10.1086/698859.

World Bank Group. 2015. *Valuing Forest Products and Services in Turkey: A Pilot Study of Bolu Forest Area.* Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/22961.

World Bank. 2019. *Enterprise Survey for Turkey.* https://microdata.worldbank.org/index.php/catalog/3558.

World Bank. 2022a. *Turkey Country Economic Memorandum: Leveraging Global Value Chains for Growth in Turkey.* Washington, DC: World Bank Group. http://hdl.handle.net/10986/37095.

World Bank. 2022b. *Unlocking Green Finance in Turkey. Türkiye Green Growth Analytical and Advisory Program. Thematic Paper 1*. http://documents.worldbank.org/curated/en/099040002232227038/P174569076d6f30a20916807841092b30f3.

World Bank. 2022 (forthcoming). *Türkiye: Adaptation and Resilience Assessment. Türkiye Green Growth Analytical and Advisory Program. Thematic Paper 2*.

World Steel Association. 2019. *Steel Statistical Yearbook 2019.* Concise version. https://worldsteel.org/wp-content/uploads/Steel-Statistical-Yearbook-2019-concise-version.pdf.