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Assessing Recent Climate Policy Initiatives in the Netherlands

NETHERLANDS

Chen Chen, Koralai Kirabaeva, Emanuele Massetti, Danielle Minnett, Ian Parry, Tjeerd Tim, Sylke von Thadden-Kostopoulos (all FAD), and Geoffroy Dolphin (EUR)

SIP/2023/022

***IMF Selected Issues Papers* are prepared by IMF staff as background documentation for periodic consultations with member countries.** It is based on the information available at the time it was completed on December 16, 2022. This paper is also published separately as IMF Country Report No 23/034.

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ABSTRACT:
The Netherlands has committed to the EU's ambitious targets for cutting greenhouse gas emissions by 2030 and emissions neutrality in 2050 but at the same time is also vulnerable to sea-level rise and flood risks. This paper reviews recent mitigation policy initiatives in the Netherlands, including carbon levies for the industry and power sectors, energy and car tax reforms, and air passenger taxes, and recommends some modifications to these initiatives. The paper also provides assessments of hazards and macroeconomic risks from weather shocks and climate change and assesses the adaption plan against key principles on mainstream climate change into macro-fiscal planning.

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SELECTED ISSUES PAPERS

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INTERNATIONAL MONETARY FUND

KINGDOM OF THE NETHERLANDS-THE NETHERLANDS

SELECTED ISSUES

February 8, 2023

Approved By
European Department

Prepared By Geoffroy Dolphin (all EUR), Chen Chen, Koralai Kirabaeva, Emanuele Massetti, Danielle Minnett, Ian Parry, Tjeerd Tim, and Sylke von Thadden-Kostopoulos (all FAD).

CONTENTS

TABLES

ANNEXES

ASSESSING RECENT CLIMATE POLICY INITIATIVES IN THE NETHERLANDS[1]

A. Introduction

1. **Climate change is an important consideration in Dutch national policies.** The Netherlands committed to EU targets of 55 percent emission reduction in 2030 relative to 1990 levels and climate neutrality in 2050. The recent energy price surges added urgency to transitioning away from fossil fuels. At the same time, the country is vulnerable to sea-level rise (SLR) and flood risks, as about one-quarter of the country is below sea level and a large part of the lowlands are in a delta. The impacts of higher temperature and changes on the frequency of extreme events appear to be modest for the Netherlands by mid-century, but highly uncertain depending on warming scenarios, which in turn depend on global mitigation actions.

2. **The Netherlands is pursuing strong policies on emission mitigation and on climate change adaptation.** The government's mitigation actions include a comprehensive set of measures and investments that are effective and designed with acceptability in mind. The government has also introduced a variety of measures to assist households for sharply higher energy prices. And thanks to a centuries-long tradition of effective coastal and flood management, the country is uniquely prepared to deal with SLR. The climate adaptation strategy is well-developed, reflecting strong institutional capacity, financial resources, and knowledge support.

3. **The paper is organized as follows.** Section II reviews recent policy initiatives in climate mitigation in the Netherlands and suggests some modifications to existing policies that might be considered. It covers carbon levies for the industry and power sectors, energy and car tax reforms, and air passenger tax. Section III provides assessments of hazards and macroeconomic risks from weather shocks and climate change in the Netherlands. The adaptation plan is reviewed and assessed against key principles on how to mainstream climate change into macro-fiscal planning recently developed at the IMF. The section further analyses sea-level rise risks and costs of protection, using the global model of the Coastal Impacts and Adaptation Model (CIAM). A final section summarizes policy recommendations.

B. Mitigation

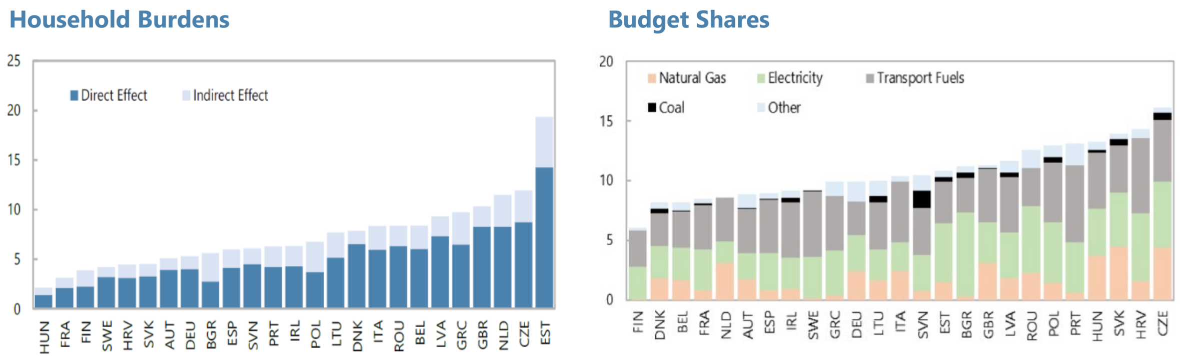
4. **An immediate priority for the Netherlands authorities is to provide robust assistance to help households with higher energy bills.** According to the International Energy Agency (IEA), consumer prices for electricity and natural gas more than tripled between January 2020 and November 2022, though pump prices for gasoline only increased about 5 percent. These price shocks imposed a burden on the average Dutch household of 12 percent of their consumption,

[1] Prepared by Chen Chen, Geoffroy Dolphin, Koralai Kirabaeva, Emanuele Massetti, Danielle Minnett, Ian Parry, Tjeerd Tim, and Sylke von Thadden-Kostopoulos.

higher than in most other countries reflecting relatively high household budget shares for natural gas in the Netherlands—see Figure 1.

Figure 1. Household Burden from Price Shocks and Budget Shares for Energy, Selected European Countries, 2022

(Average in percent of total consumption)



Source: Ari and others (2022)

Notes: Direct and indirect burdens in panel (a) are from higher prices for energy products and other (general) consumption goods respectively. Burdens are assessed by comparing actual prices in mid-2022 with price projections for mid-2022 as of early 2021.

5. **The Dutch government has introduced a variety of measures to assist households for sharply higher energy prices.** These include:

- *Reduced taxes on selected energy products*: the VAT rate on natural gas, electricity and heat from district heating was temporarily lowered to 9 percent (from 21 percent) effective July 1, 2022; the excise duty rate on gasoline and diesel was reduced by 17.3 and 11.1 cents/liter,[2] respectively, bringing respective rates to 65.1 and 41.8 cents/liter. The reductions in excise duty are applicable from April 1, 2022.

- *A cap on electricity and natural gas prices for households and other low-volume users*: at the level of January 2022, starting on January 1, 2023. For gas the maximum rate will be €1.45 per cubic meter (m^3) up to a consumption of 1,200 m^3. For electricity the maximum rate will be lowered to €0.40 per kilowatt hour (kWh) up to consumption of 2,900 kWh. For usage that exceeds these thresholds, the rates for low-volume users remain as is stated in their energy contract.

- *One-off financial support measures:* A one-off (lump-sum) energy allowance of €1,300 for lower-income households (in 2022 and 2023) and €190/month rebate on energy (natural gas for heating and electricity) bills for small-scale consumers in November and December 2022. It was also decided that the energy tax refund (per electricity grid connection) would increase from €560 to €785.

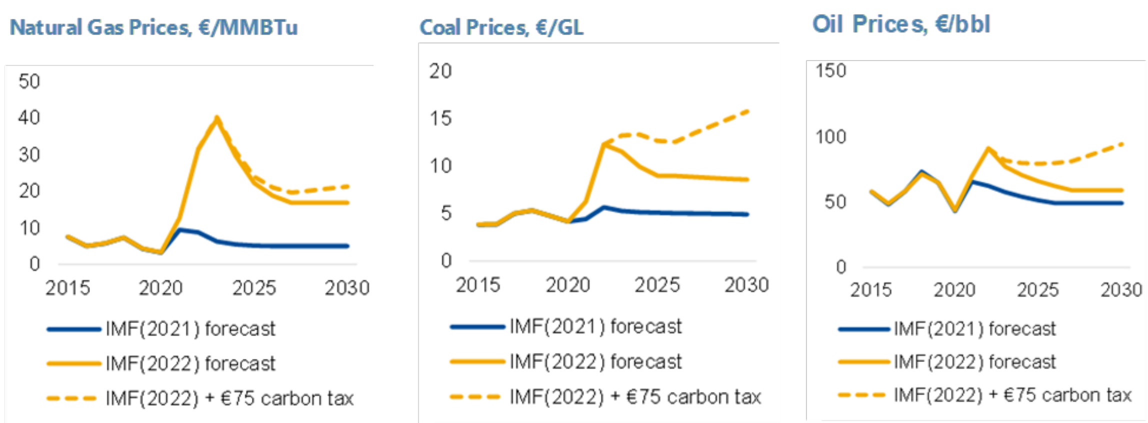
Ideally household assistance should be targeted (to limit fiscal costs) and unrelated to energy consumption (to preserve incentives for energy conservation). In this regard, the Dutch government

[2] All monetary figures below are in €.

might consider continuing to emphasize the temporary nature of the cap on electricity and natural gas prices.

6. The energy price surge has also strengthened the case for accelerating the transition away from fossil fuels—both to address the climate crisis and reduce dependence on insecure energy sources. Higher energy prices have caused only a modest reduction in global CO_2 emissions, as there has been a sharp increase in the price of gas relative to coal (causing some switching from the former to the latter, for example, in Germany), and investors expect much of the surge to be reversed as markets adjust.[3] Indeed, opposition to higher carbon prices, energy tax reform, and other mitigation measures could decline in the future as energy prices recede from peak levels—even an additional €75 per tonne increase in carbon prices on top of predicted international energy prices for 2030 would still result in international natural gas prices that are 30 percent lower than recently experienced levels. See Figure 2.

Figure 2. Trends in International Fuel Prices



Source: Black and others (2022).
Notes: Prices in real 2021€, deflated by respective IMF projections. Carbon tax starting at €10 in 2022 and rising to €75 in 2030 is assumed on top of IMF (2022b) baseline assuming elastic supply (this assumption is likely reasonable for coal and gas, although possibly less so for oil). Natural gas prices are a weighted average of natural gas in Europe, North America (Henry Hub), and LNG market (Japan). Coal prices are a weighted average of domestic sectoral coal prices in China, India, and the United States. Oil prices are an average of Brent, Dubai Fateh, and West Texas Intermediate. The carbon tax is assumed to be fully passed forward into demand prices. Figure uses USD to euro exchange rate from 11/9/2022 where 1USD=1Euro; bbl=billion barrels; GJ= gigajoule; MMBTu = Million British Thermal Units.

7. At the EU level, the key climate goal under the Fit for 55 Plan is to reduce EU greenhouse gas (GHG) emissions 55 percent below 1990 levels by 2030.[4] The EU has also pledged to achieve net zero GHGs by 2050. The centerpiece of EU-level mitigation policy is the Emissions Trading System (ETS) which specifies a trajectory of progressively tightening emissions caps for GHG emissions, primarily from power generation and industry, aligned with reducing combined emissions from these sectors 61 percent by 2030 below 2005 levels. For the non-ETS

[3] Black and others (2022).

[4] See https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/.

sector, primarily buildings, transport, and agriculture, Netherlands has been assigned a target of reducing emissions 48 percent below 2005 by 2030.[5]

8. A separate emissions trading system (ETS II) is being developed at the EU level for specific sectors. The new system—expected to start in 2027—will apply to distributors that supply fuels to the buildings, road transport, and certain other sectors that have been difficult to decarbonize so far. To smoothen the entry into force, the total amount of allowances auctioned in the first year will increase by 30 percent while a stabilization mechanism would automatically release additional allowances if the price per allowance exceeds €45 per tonne of CO_2 over a certain period to avoid excessive price increases.

Box 1. Supporting Public Investments in Clean Technology Infrastructure

There are two sources of public investments for clean energy infrastructure in the Netherlands over the next few years. First, the national climate and transition fund, which will mobilize €35 billion over the next ten years to help upgrade the energy infrastructure and make mobility and the built environment more sustainable.

Second, the Dutch Recovery and Resilience Plan allocates €846.9 million in funding for the following four climate-related investment programs—see Table 1 for the funding amounts.

Wind at Sea. This program seeks to double wind energy in the North Sea to 21 gigawatts by 2030. The financing is for integration costs (e.g., guaranteeing shipping safety, enhancing nature and protecting species, making the fishing sector more sustainable) rather than construction of wind farms themselves.

Green hydrogen. This program, which runs to 2028, provides funding for demonstration projects testing the feasibility of large-scale electrolysis, an R&D program to further develop hydrogen technology, and to ensure an adequate supply of relevant trained personnel.

The Zero Emission Services. This project provides funds for batteries, 45 fully electric inland vessels, and charging stations (with green electricity) to help kick start the market for fully electric inland shipping and the associated technologies and infrastructure.

Aviation in Transition. This multi-year program promotes the decarbonization of the aviation sector by 2050. The focus is on breakthrough technologies for ultra-efficient aircraft development and the associated long-term research and accompanying activities.

[5] Annex to the Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 2018/842 on binding annual GHGs reductions by Member States from 2021 to 2030. The target presented in this proposal is not final and may change before final legislation is passed.

Table 1. The Netherlands: Climate-Related Investments in the Dutch Recovery and Resilience Plan

Investment program	Investment amount (€ million)
Wind at Sea	693.7
Green Hydrogen	68.5
Zero Emission Services	56
Aviation in Transition	28.7
Total	846.9

Source: MOF (2022).

9. At the national level, the Netherlands has implemented, and recently strengthened, a comprehensive set of national policies to complement EU level policy. Recent tax initiatives include revisions to the carbon dioxide (CO_2) levy for industry, an energy tax reform, a CO_2 price floor for power generation, a car tax reform, and an increase in the air passenger departure tax—most of these measures are outlined in the *Dutch Recovery and Resilience Plan*.[6] Other measures in the Plan include complementary public investments in clean technology infrastructure—see Box 1—and stronger regulatory and reporting requirements.[7] In addition, the stimulation of sustainable energy production scheme (SDE+) was expanded into SDE++, which now provides funding for renewable electricity, renewable heat, renewable gas, low-carbon heat and low-CO_2 production for entities in power generation, industry, transport and agriculture.[8]

10. This section describes and evaluates the recent tax measures. A 2022 IMF paper[9] provides a more extensive discussion of mitigation strategy in the Netherlands and fiscal policy options for enhancing the effectiveness of the strategy at the national and sectoral level.

CO_2 Industry Levy

11. In January 2021, Netherlands introduced a levy or target price on industrial CO_2 emissions. This scheme involves a charge equal to any positive difference between an escalating

[6] MOF (2022).

[7] The Energy Act aims to provide a modernized and updated regulatory and legal framework for gas and electricity.

[8] See OECD (2021), Netherlands Enterprise Agency (2020). Under the scheme, firms submit bids for subsidies based on the difference in costs between a CO_2-reducing technology and benchmark technology, net of savings in purchases of allowances under the EU ETS.

[9] Nicoletta Batini, Simon Black, Oana Luca, and Ian Parry, 2021, "A Comprehensive Greenhouse Gas Mitigation Strategy for The Netherlands." Working paper, IMF.

target price—the levy rate—and the prevailing EU ETS price. The levy applies to large industrial companies that also fall under the EU ETS as well as waste incineration plants and companies that emit large quantities of nitrous oxide. As an incentive to cut the emissions intensity of production, while avoiding significant reductions in production levels, the levy does not apply to all firm emissions but rather emissions over and above their "dispensation rights", where the latter are calculated as:

production × CO_2 related to this production based on EU ETS benchmarks × reduction factor

The EU ETS benchmark refers to the emission rate from the cleanest ten percent of firms in the industry at the EU-level and the reduction factor is set at 1.2 for 2021, declining to 0.69 by 2030. By itself, if binding, the scheme cost-effectively promotes reductions in the emissions intensity of production for firms with emissions exceeding their dispensation rights.

12. Initially the levy rate started at €30 per excess tonne of CO_2 emitted in 2021 and was set to rise in a straight line to €125 per excess tonne in 2030.[10] This rate schedule was aligned with an emission reduction target of 14.3 million tonnes in 2030 compared with business as usual (BAU) emissions projections for 2030 by the Netherlands Environmental Assessment Agency (PBL).[11] If, for example, the EU ETS price were €75 per tonne in 2030, the levy would impose a charge of €50 per excess tonne for ETS installations and €125 per tonne for the covered non-ETS installations. The reduction target has however been increased to 18.3 million tonnes and, accordingly, the rate schedule will be re-assessed in 2023 and 2025—PBL monitors, through the Climate and Energy Outlook, whether emissions are on track to meet the 2030 target.[12] Indeed, based on recent EU ETS price projections the CO_2 industry levy may not be binding under the current price schedule.[13]

13. The levy strikes a compromise between efficiency and competitiveness/leakage concerns… A pure tax on all industry emissions would be more efficient in the sense that it would induce a larger reduction in domestic production levels as charges on all (rather than a portion of) remaining emissions are reflected in higher production costs. This would imply a larger loss in competitiveness for domestic firms (as foreign producers are not subject to the same charge on their emissions) and greater risk of emissions leakage.[14] In quantitative terms however the differences between a pure tax and a levy are not large—for example, a €50 tax (on top of the prevailing EU ETS price) in 2030 would increase production costs for selected Dutch industries by 2 percent or less—see Figure 3 (though this general picture masks significant differences at finer levels of industry disaggregation) and is more practical administratively than other options. A carbon

[10] See https://carbonmarketwatch.org/2020/12/21/what-can-we-learn-from-the-dutch-national-carbon-tax.

[11] PBL (2019).

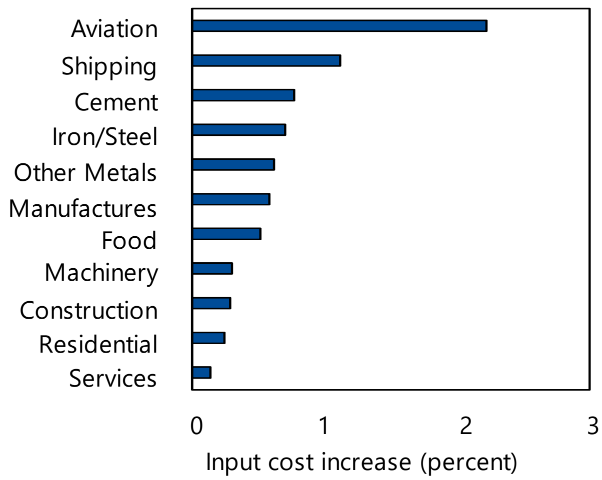
[12] Dispensation rights for 2023 have been reduced to align with the new target. However, no adjustment to the rate has yet been made. The government of the Netherlands is planning to decide on an additional climate policy package this spring. An increase of the rate could be a part of this package.

[13] Pietzcker and others (2021) projected an EU ETS emissions price of €129 per tonne in 2030.

[14] See www.pbl.nl/publicaties/economische-effecten-van-co2-beprijzing-varianten-vergeleken for modelling results on leakage and Parry and others (2021a) on policies to address it.

tax could be combined with output-based subsidies for industrial firms, but these approaches are more administratively complex than the Dutch levy

Figure 3. Impact of €50 Pure Carbon Charge on Production Costs for Selected Industries in the Netherlands, 2030



Source: IMF staff.

14. A modest reform to the levy—converting it into a feebate—could provide more robust incentives for relatively clean firms. Currently, if a company emits less CO_2 than allowed based on its dispensation rights, the unused dispensation rights can be carried back to the previous five years or sold to other firms subject to the levy, but this leaves incentives uncertain. A modification of the levy is a feebate under which firms would pay a fee given by:

$$CO_2 \text{ price} \times \{CO_2/\text{production} - \text{pivot point } CO_2/\text{production}\} \times \text{production}$$

The CO_2 price could be the same as currently envisioned for the levy, but the base of the feebate would reflect the difference between a firm's emission rate and a 'pivot point' emission rate—firms with emission rates above the pivot point would therefore pay taxes, while those with emission rate below the pivot point would receive subsidies. In the latter regard, the scheme would generalize the subsidies provided by SDE++ by directly linking them to the observed emission rates of firms. If the pivot point is set equal to the average emission rate for the domestic industry in the previous year, and updated annually, the feebate would be (approximately) revenue neutral over time.[15] The feebate is slightly more effective and efficient than the levy, as all firms face the same ongoing and

[15] In sectors dominated by one or a few firms (for example, steel), if an above-average polluter tries to decrease its emissions, the benchmark emissions also drop, which may erode incentives to reduce emissions (that is, such a firm would likely internalize its own impact on the benchmark). In these cases, the pivot point emission rate could be set exogenously and made progressively more stringent over time.

certain reward for cutting emissions by an extra tonne, regardless of whether they are currently paying fees or receiving subsidies.

Energy Tax Reform

15. This reform includes a shift in taxation away from electricity consumption (and onto natural gas) and a termination of the renewable energy tax (*Opslag Duurzame Energie, ODE)*. The tax rate on natural gas increased by 4 cents per cubic meter (m^3) in 2020 and the rate in the 1st bracket of gas was supposed to increase by a further 5.23 cents per m^3 a year during 2023–2028. The rate for the 1st bracket for electricity is supposed to be reduced by 5.23 cents per kilowatt hour (kWh) during 2023-2028—. These planned reductions would benefit households—especially low-income households—more than businesses. In parallel, it was decided to repeal the ODE, whose revenue was used to finance SDE+ (now SDE++). SDE++ will now be funded with revenues raised through general taxation and energy taxes.

16. Changes to the tax rate for natural gas and electricity implemented in 2022 and 2023 (see Table 2) follow the principle set out in the energy tax reform but further adjustments would be needed to achieve the initially intended shift.[16] The rate changes differ from those initially announced in the reform. In particular, (due to the energy price shock) the tax rate on natural gas is not increasing as much as planned. A review is scheduled for 2023 to examine whether the proposed increase in natural gas tax is still necessary for mitigation objectives, in view of market developments.[17]

17. The reform seeks to reinforce demand shifting away from gas to electricity, thereby lowering domestic CO_2 emissions. Natural gas combustion generates 0.055 tonnes of CO_2 emissions per gigajoule (GJ) of energy while at present power generation in the Netherlands produces 0.09 tonnes of CO_2 per GJ. The latter, however, will decline progressively with decarbonization of the power sector and, more importantly, additional generation capacity to meet higher demand will likely come from renewable sources (rather than the current mix of renewable and fossil sources).[18] Raising the relative price of natural gas will reinforce behavioral responses like adoption of electric space heating and conservation (e.g., turning down the heating).

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[16] This section focuses on the reform of energy taxation. However, subsidies to fossil fuel consumption are equally important to assess a country's fiscal measures on fossil energy. For a discussion of such subsidies in the case of the Netherlands, see OECD/IEA (2020).

[17] The reform also broadens the base of energy taxes by removing favorable rates for glasshouse horticulture, the energy tax exemption for mineralogical and metallurgical processes, and limits the input exemption for combined heat pumps.

[18] Even if extra power generation in the Netherlands caused more CO_2 emissions, at the EU level (if the Market Stability Reserve is not operating) there would be no change in emissions from the power and industry sector which are fixed by the EU emissions cap.

Table 2. The Netherlands: Tax Rates on Natural Gas and Electricity by Consumption Bracket

Natural Gas, €/m³

Consumption Bracket, m³				
Year	**0 – 170,000**	**170,001-1 million**	**1 – 10 million**	**> 10 million**
2021	0.349	0.065	0.024	0.013
2022	0.363	0.066	0.024	0.013
2023	0.49	0.096	0.051	0.04

Electricity, €/kWh

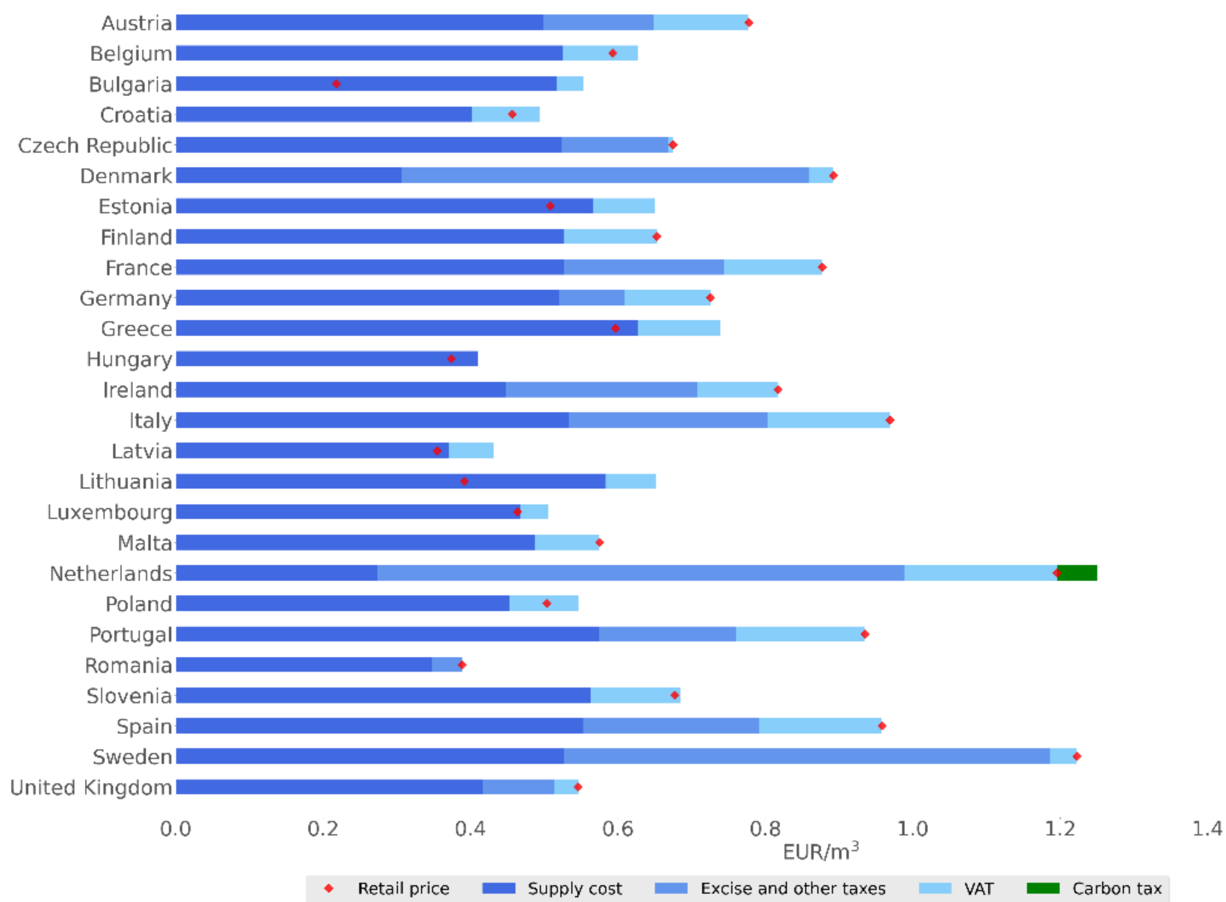
Consumption Bracket, kWh					
Year	**0-10,000**	**10,001 – 50,000**	**50,001 – 10 million**	**> 10 million (household)**	**> 10 million (business)**
2021	0.094	0.052	0.014	0.001	0.0006
2022	0.037	0.044	0.012	0.001	0.0006
2023	0.013	0.1	0.039	0.002	0.001

Sources: Tax Administration Netherlands and Budget proposal 2023. [1/]
Notes: Tax rates exclude VAT.
[1/] Tabellen tarieven milieubelastingen (belastingdienst.nl)

18. Building a charge on CO_2 emissions—aligned with prevailing CO_2 prices for power and industry—could promote cost-effective emissions reductions across the building and ETS sectors, depending on prices that might emerge in the planned introduction of an EU-level ETS for the transport and building sectors. The retail (i.e., including taxes) natural gas price for residential use in the Netherlands is already among the highest in Europe. The introduction of a charge on CO_2 emissions on natural gas for residential use (e.g., €25/tCO_2) would further increase the retail price, but only moderately (to approximately €1.27/m3).[19] See Figure 4.

[19] A €25/tCO_2 tax is the current price in the German emissions trading system for heating and road transport fuels in force since January 2021. A full alignment with carbon prices prevailing in EU ETS sectors would raise the retail price further.

Figure 4. Impact of a €25/tCO₂ Carbon Tax on Residential Natural Gas Prices in the Netherlands



Source: IMF staff.

CO_2 Price Floor

19. The Netherlands has also implemented a price floor on CO_2 emissions from power generation, but applying to all emissions, and with much lower rates than for industry. The floor price came into effect on April 5, 2022, following final passage of a legislative proposal initially introduced in June 2019. As with the CO_2 industry levy, it imposes a charge equal to the difference between a target rate and the price of EU ETS allowances. Unlike the CO_2 industry however: (i) there is no exemption analogous to dispensation rights (i.e., the levy applies to all emissions); and (ii) at present it has a much lower set of target prices. Indeed, the target rate is €14.9 per tonne in 2022 and, while it is set to rise to €31.9 in 2030, these targets are far from binding.

20. Converting the scheme into a feebate, and harmonizing it with the industry levy, would increase effectiveness and efficiency, while avoiding a significant increase in electricity prices. If the current power sector price floor were binding it would impose a first-order charge on generators equal to the emissions price times their remaining emissions—at the industry level these charges would be largely passed forward in higher electricity prices.[20] In turn, this would work against the goal of the energy tax reform to induce switching from gas to electricity. Converting the power sector price floor into a feebate—applying fees to electricity producers with above average emission rates and rebates for generators with below average emission rates—would avoid the pass through of first order charges into electricity prices. The feebate cost-effectively promotes the same responses for fuel switching in power generation as carbon pricing but it does not promote the same reduction in electricity demand. Harmonizing emissions prices across the power and industry sector would then strike the cost-effective balance between emissions reductions across both sectors.[21] That is, both feebates would bind at the same time, and only when the EU ETS price is below the current target level for industry.

Car Tax Reform

21. The Netherlands plans to transition to a nationwide system of taxing driving in passenger cars and delivery vans in proportion to vehicle kilometers (km) driven, thereby providing a more robust source of revenue. The tax system will replace revenues from vehicle and fuel taxes, which are declining with greater penetration of electric vehicles (EVs) into the new, and on road, vehicle fleets.[22] Developments in metering technologies such as global positioning systems imply that people's driving could be tracked and billed accordingly. Exemptions from vehicle purchase taxes for internal combustion engine commercial vans will also be phased out from 2024-2026, while the exemption for electric delivery vans (which has an environmental justification) will continue.

22. Maintaining current fuel/vehicle tax revenue as a percent of GDP requires a projected charge of 4.5 cents per vehicle km in 2030. Projected revenues are only slightly sensitive to alternative assumptions about the price responsiveness of vehicle km travelled. See Figure 5.

23. Ultimately, the reform could also effectively address the remaining external costs of driving. As internal combustion engine vehicles are progressively retired from the vehicle fleet this will reduce, and eventually eliminate, externalities associated with fuel combustion—CO_2 emissions and local air pollution. In the interim, the km-based tax is projected to reduce CO_2 emissions by 2.5 million tonnes in 2030.[23] Important externalities will remain however, including traffic congestion—which is severe in many European countries—accidents, and (for trucks) road damage, all of which vary with km driven for all vehicles (including EVs). In European countries (see Figure 6), current gasoline and diesel prices largely fall short of efficient fuel prices—that is the prices needed to cover supply costs, environmental costs, and (where fuels are consumed at the household level)

[20] For example, Bushnell and others (2013), Sijm and others (2006).

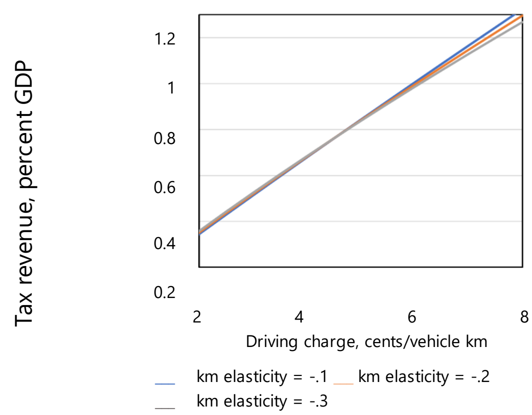
[21] See Batini and others (2021) for further discussion of these types of feebates.

[22] The tax will be non-discriminatory in the sense that it applies to both cross-border and domestic driving.

[23] MOF (2022).

general consumer taxes—aside from countries where traffic congestion externalities are more moderate.

Figure 5. Projected Revenue from Km-Based Taxation, 2030



Sources: IMF Staff calculations
Notes: Km elasticity refers to the fuel price elasticity conditional on a fixed level of fuel economy.

24. A charge averaging upwards of 8 cents per km is warranted by congestion, though it should vary according to where driving occurs and time of day.[24] The efficient charge on a road class is the marginal external congestion cost (MECC), that is, the added cost to other road users from the extra congestion caused by an additional vehicle km driven.[25] At the nationwide level, the MECC for Netherlands has recently been estimated at around 8–16 cents per vehicle km,[26] though MECCs are highly sensitive to region and time of day. The government decided against nationwide congestion pricing for now due to public opposition. But the policy may gain traction over time, for example if local pricing schemes emerge, people gain familiarity with km-based taxes, and successful experiences elsewhere (e.g., London, Milan).

25. In principle, accident externalities could be effectively reduced by varying km-based charges according to driver and vehicle characteristics... Some accident costs are internal to drivers (e.g., own-driver injury risks in single vehicle collisions) but other costs are external (e.g., injuries to pedestrians/cyclists, injury risk to others in multi-vehicle collisions, insurance and medical costs borne by third parties).[27] Accident risks vary with both driver and vehicle characteristics (e.g., heavier vehicles pose greater injury risks to occupants of lighter vehicles in multi-vehicle collisions).

[24] Ideally, charges would also rise and fall over the course of the rush hour to promote a flattening of the distribution of trip departure times (e.g., Arnott and others 1993).

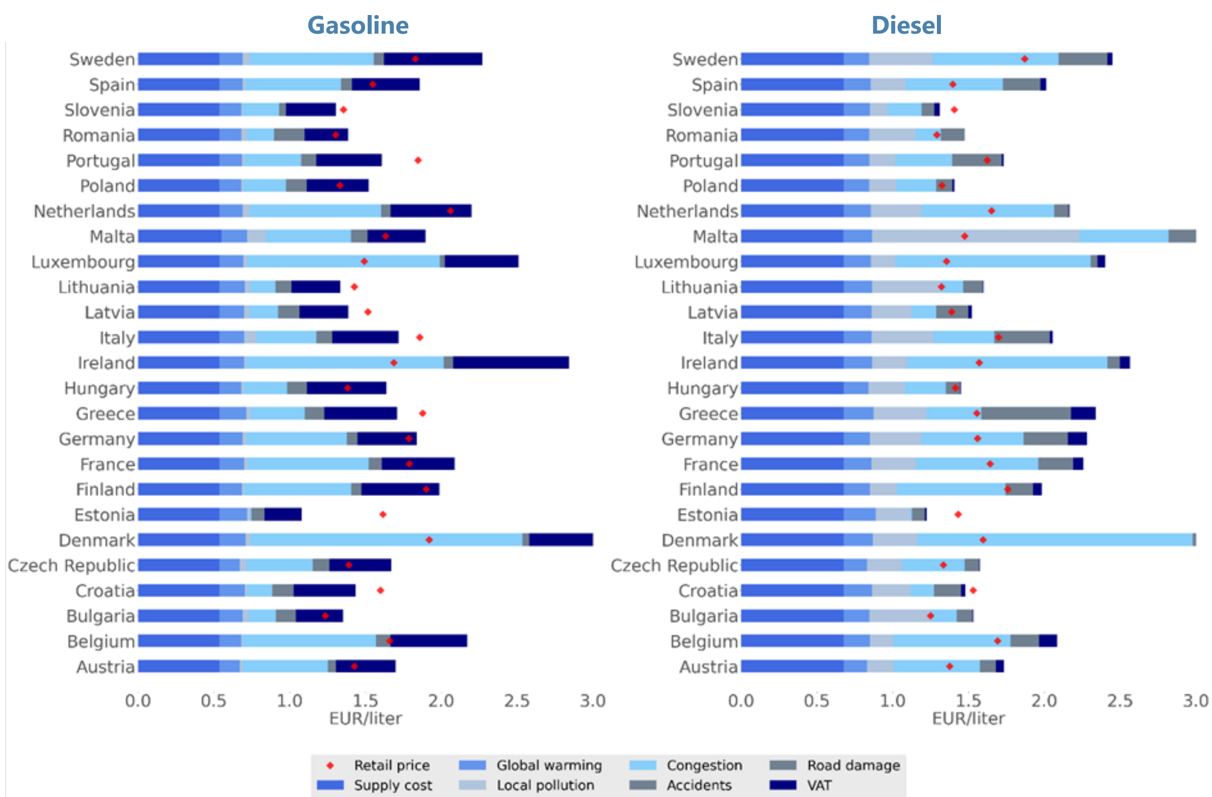
[25] The MECC depends on how extra km driven affects road speeds and travel delays for other road users which can be inferred from speed-flow relationships on different road classes and data on average vehicle occupancy rates. It also depends on how people value travel time, which is a function of the prevailing market wage. See, for example, Small and Verhoef (2007).

[26] From CE Delft (2019) and IMF staff calculations from CPAT.

[27] See for example Parry (2004).

It may, however, be more practical to promote pay-as-you-drive (PAYD) vehicle insurance.[28] A system of per km fees varying with both drivers and vehicles would be complex—both in terms of assessing, and updating, fee structures and administration. Another option is to build off existing private sector capacity at auto insurance companies. To an approximation, traditional insurance premiums are lump-sum and do not vary according to how much people drive. In contrast, under PAYD a driver's annual premium would equal km driven times their premium per km. Existing rating factors, as determined by insurance companies, could be used to set per km charges for different drivers as an (albeit imperfect) proxy for external accident risk: drivers with higher rating factors would pay higher variable charges and would have the greatest incentive to drive less.[29]

Figure 6. Current and Efficient Fuel Prices, Selected European Countries, 2020



Source: Parry and others (2021b).
Note: Calculations assume a CO_2 price of €55 per tonne.

[28] See also https://cedelft.eu/publications/pay-as-you-drive-payd/.

[29] A significant portion of traffic accidents are caused by drunk drivers. For this case, an option is to mandate interlock technologies (which prevent the vehicle being started, or driven, by a driver under the influence) in vehicles driven by convicted drunk drivers.

26. The transition to PAYD could occur on a voluntary, market-driven basis, with the government reinforcing the process through fiscal incentives. Drivers with below-average annual km driven would have the strongest incentives to take up PAYD and, as they switched, premiums would rise for the remaining pool of drivers with lump-sum insurance, encouraging further shifting to PAYD. The transition could be reinforced through fiscal incentives at the level of the household or insurance company. On average, PAYD would raise the marginal cost of driving by about 5 cents per km.[30]

Air Passenger Tax

27. The departure tax (paid by airline operators) for passenger flights is set to triple on January 1, 2023, from its current rate of €7.95 per trip. With the increase, the tax will generate projected annual revenues of €600 million from 2023 (up from €200 million).

28. The charge helps to address fiscal distortions… International air travel is undertaxed from a broader fiscal perspective. It is not subject to value added tax (unlike most other consumer products) and, due to the 1944 Chicago Convention and bilateral air service agreements, aviation fuel is not subject to excises that are routinely applied to other transportation fuels. The air passenger duty helps to counteract the bias in air travel over other transport modes and excessive fuel use promoted by these broader tax exemptions.[31]

29. …and environmental concerns—but to a limited degree. The increased tax will be equivalent to a charge of about €90 per tonne of CO_2 from air travel out of the Netherlands,[32] which above the current EU ETS price, though well below recent estimates of the social cost of carbon (SCC).[33] And while the fee is levied per trip, rather than in proportion to flight distance, it imposes disproportionately large price increases on shorter flights which has some justification from an environmental perspective as environmental costs are also disproportionately larger for shorter trips (given the large amount of fuel combusted during takeoffs). A fee on aviation fuel use would be more effective as it would also promote travel in more fuel-efficient planes.[34] This would complement efforts by the Dutch government on the supply-side to advance cleaner aircraft technologies.[35]

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[30] Assumes annual insurance premium of €900 and annual driving of 17,000 km (https://dutchreview.com/expat/car-insurance-the-netherlands).

[31] For example, Keen and others (2015).

[32] From dividing expected revenue by CO2 emissions from international aviation (from https://di.unfccc.int/detailed_data_by_party).

[33] The SCC is the present discounted value of global damages from an extra tonne of CO_2 emissions. Rennert and others (2022) put the SCC at $185 per tonne.

[34] Although there is scant empirical evidence, Keen and others (2013) suggest that about 40 percent of the reduction in aviation fuel use in response to fuel taxes would come from higher fuel economy (60 percent would come from reductions in travel demand).

[35] MOF (2022).

30. If international agreements preclude fuel taxation, another option would be to vary the fee with a metric related to CO_2 emissions per passenger trip. In principle, emissions per passenger trip could be based on fuel consumption for the trip divided by number of passengers. This would be complicated to administer however, as it would require operators to report their fuel consumption and number of passengers per trip and the resulting fee structure would be very granular. A more practical approach might be to link passenger fees to an aircraft's fuel economy and default load factors.

31. Airport congestion is also a growing problem, but this is more efficiently addressed through peak-period landing fees. Airport congestion raises costs for operators and leads to risk of flight delays for passengers—congestion is related to the frequency of aircraft landings over the course of the day (relative to airport capacity). The most efficient approach is to vary aircraft landing fees according to the expected level of congestion, thereby encouraging more flights at off-peak period.[36]

C. Assessing Climate Risks and Adaption Initiatives in the Netherlands

32. This section reviews climate trends and scenarios for the Netherlands, estimates of macroeconomic risks, and climate adaptation policies. A sub-section is dedicated to risks from coastal and river flooding. The climate adaptation strategy in the Netherlands is well-developed and documented, which reflects strong institutional capacities, financial resources, and knowledge supports. Thanks to a centuries-old tradition of effective coastal and riverine flood management, the Netherlands is much better prepared, than other countries, to address challenges from sea-level rise and changes in river flows in the 21st century. Nonetheless, the discussion suggests further efforts to mainstream climate change adaptation at all government levels and provides guiding principles for efficient adaptation strategies.

Overview of Climate Trends and Scenarios

33. The Netherlands has a temperate oceanic climate, with mild temperatures and evenly spread precipitations across seasons. Ocean currents play an important role in shaping climate in the Netherlands, by mitigating winter cold and summer heat for countries at the same latitudes. During the period 1991–2020 winter average temperature was equal to 3.9°C and summer average temperature was equal to 17.3°C (World Bank Climate Change Knowledge Portal). Precipitations are evenly distributed across the year, with an average of 67 mm/month (World Bank Climate Change Portal).

34. Average temperature in the Netherlands is increasing, a trend that is expected to continue even in low emission scenarios, but precipitation scenarios are more uncertain. Average annual temperature in 1991–2020 was about 1°C higher than in the period 1901–1990, when there was no discernible trend. The warming trend has accelerated in recent decades (Figure 7, panel a). Future scenarios indicate additional warming of 1.0 °C, 1.2 °C, and 1.4 °C in 2041–2060 with

[36] This applies even at hub airports where there is a dominant carrier and a competitive fringe (see Brueckner 2002).

respect to the period 1995–2014 (panel b). Warming will be stronger during summer months in all scenarios[37](panel c). There is a moderate long-term trend in total annual precipitation, but the trend is small compared to natural variability (panel d). Future scenarios do not indicate discernible changes in total precipitations with respect to historical trends and among different emission scenarios (panel e). Future scenarios suggest a possible shift of the seasonal distribution of precipitations, with a modest decline (approximately 10 percent) during summer months and an increase of similar magnitude during winter months. Large natural variability (panel c) and large differences across projections from different climate models (panels d and e) suggest that precipitation changes are not robust.

35. Climate models project increased frequency of extreme heat and heavy precipitation. Dangerously hot days with maximum temperature above 35 °C (Hot Days) are historically rare but are expected to increase without strong global mitigation action (Figure 8, panel a). Heavy precipitation events are projected to increase slightly (panel b) but uncertainty is large, and a substantial invariance of present trends cannot be ruled out (panel c) However, projections of extreme events from models can be inaccurate. In the Netherlands, models tend to underestimate trends in extreme hot days. Models are also unable to describe convective process that give rise to thunderstorms that are responsible for heavy precipitation events. KNMI combines observations, simulations, conceptual models and physical principles to project with high confidence an increase of heavy precipitation on a sub-hourly and daily timescale (KNMI, 2014). A significant increase in thunderstorms is found using the highest warming scenarios during the summer season.

36. There is substantial uncertainty about trends in drought conditions at national level using global models, but drought conditions intensify according to KNMI analysis. The SPEI Drought Index—which accounts for the effect of both temperature and rainfall on soil moisture availability—does not show any significant trends in all scenarios (Figure 9, panel a). Models project an increase in the maximum number of consecutive dry days in a year—an alternative indicator of drought-like conditions—especially during summer months, but with considerable uncertainty (panels b and c). KNMI projects an increase of the mean highest precipitation deficit during the growing season in all scenarios (KNMI, 2014).

37. The Netherlands is a delta country with approximately 55 percent of the land exposed to potential flood risks. With a long coastline relative to its area, about one-quarter[38] of its total area below sea-level, and at the delta of major rivers, the country has been historically exposed to coastal and riverine floods, for which strong defenses are in place. As sea-level rise and intense precipitations will intensify over the next decades, risks will increase if planned upgrades to the flood

[37] The lowest amount of warming is associated with strong climate mitigation action (SSP1-2.6). The intermediate warming scenario assumes continuation of present trends (SSP2-4.5). The highest amount of warming assumes no effort to curb emissions (SSP3-7.0).

[38] Source: https://www.pbl.nl/correctie-formulering-over-overstromingsrisico.

protection system will not be in place.[39] Because of its importance, the risks from floods and sea-level rise in particular will be discussed in Section D.

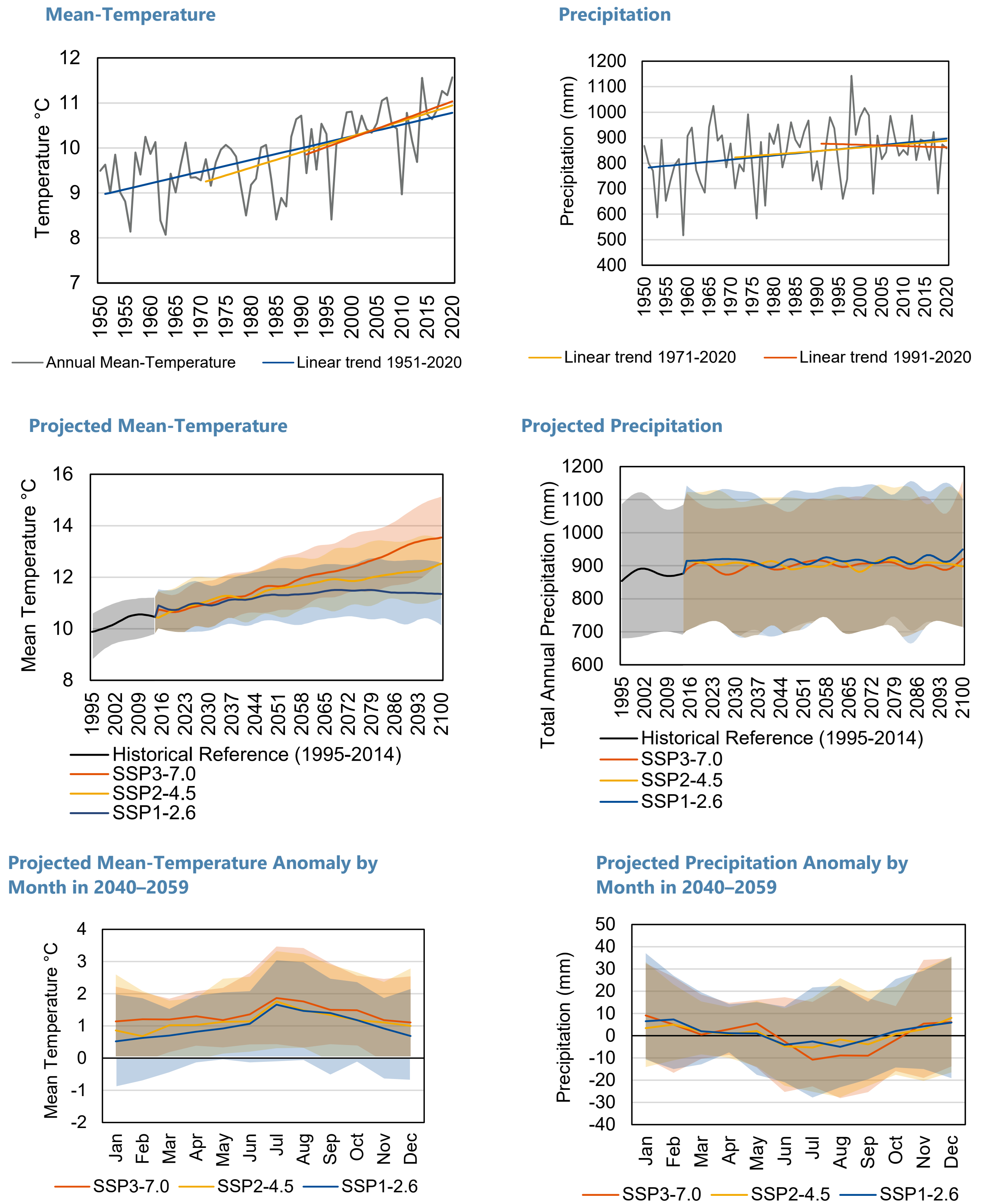
38. Projected increase in river discharge, particularly from the Meuse can add further stress if adequate measures are not put in place. The occurrence of conditions that may lead to riverine floods depends on meteorological and topographical conditions, land use, economic activity, and policy responses along the entire catchment basins of the Rhine and Meuse rivers. In Summer 2021 the peak discharge of the Meuse reached the record high since 1911 and was highly unusual because conditions that can lead to floods usually occur in winter.[40] Looking forward, climate scenarios point to the further intensification of extreme rainfall events in the major catchment basins in the Netherlands.[41] This is in line with the projection of more erratic water discharges (Klijn et al, 2015). In all KNMI'14 scenarios high water discharges in 2050 will increase sharply. Uncertainty about the medium-term has declined with new evidence.

[39] Source: https://www.pbl.nl/correctie-formulering-over-overstromingsrisico.

[40] Source: https://www.deltares.nl/en/issues/high-water-on-rivers/.

[41] IPCC Interactive Atlas https://interactive-atlas.ipcc.ch/. Maximum 1- and 5-day precipitation. Western and Central Europe Region. Fewer than 66 percent of the models show change greater than the internal-variability bounds.

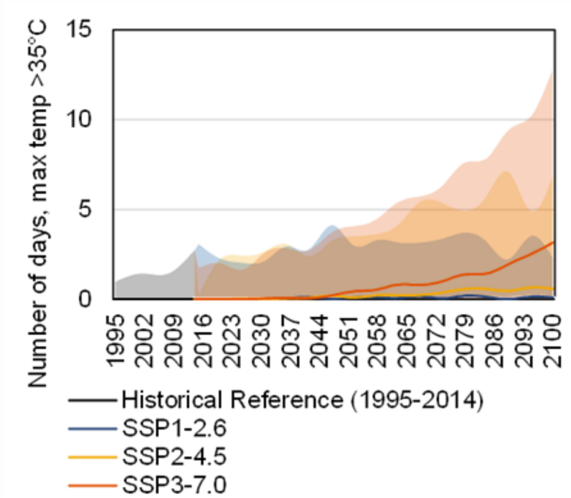
Figure 7. Temperature and Precipitations: Observed Trends and Projections



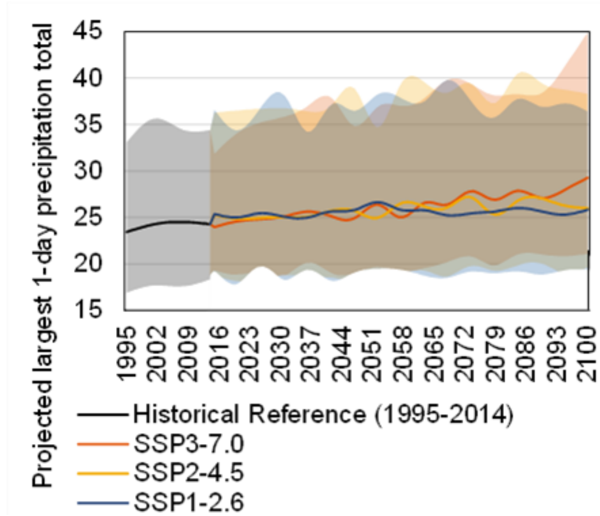
Source: World Bank Climate Change Knowledge Portal based on CMIP6 database.
Notes: Graphs (c) to (f) display the multi-model ensemble mean, 10th and 90th percentiles. Graphs (e) and (f) are with respect to 1995–2014.

Figure 8. Extreme Heat and Intense Rainfall: Projections

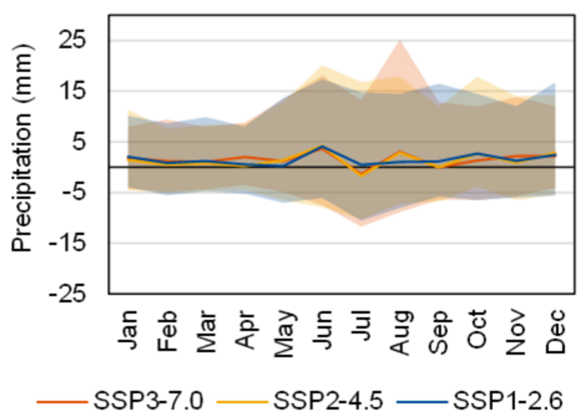
Projected Number Hot Days



Projected Largest 1-Day Precipitation



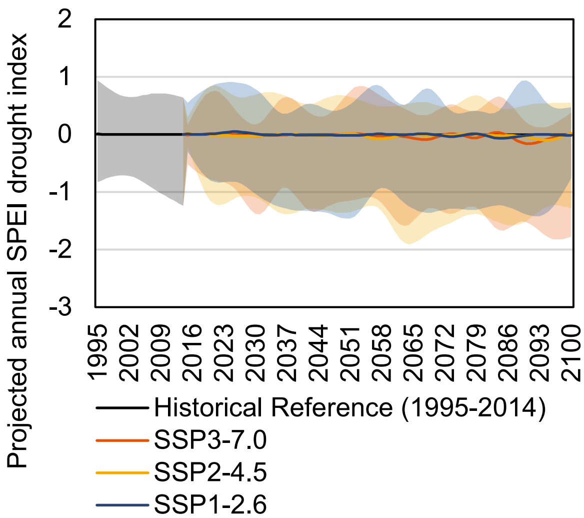
Projected Largest 1-Day Precipitation Anomaly by Month in 2040–2059



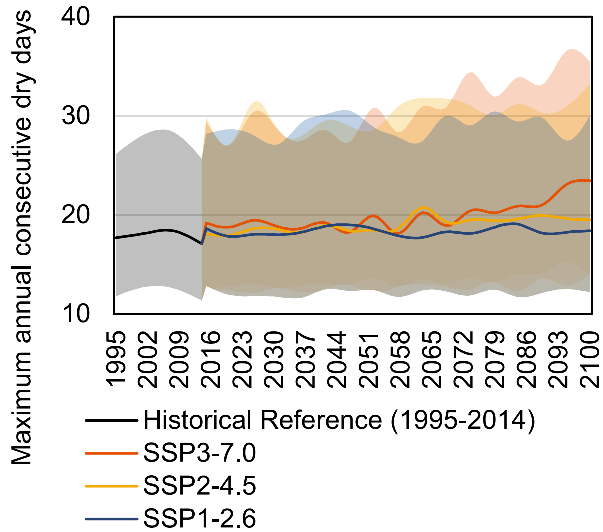
Source: World Bank Climate Change Knowledge Portal based on CMIP6 database.
Notes: (a) Projected number of days with maximum temperature greater than 35C; (b) Projected largest 1-day precipitation total, averaged over the entire country; and (c) Projected largest 1-day precipitation total, averged over the entire country, monthly anomaly in 2040–2059 with respect to 1995–2014. All panels display the multi-model ensemble mean, 10th and 90th percentiles

Figure 9. Projections of Drought Indicators

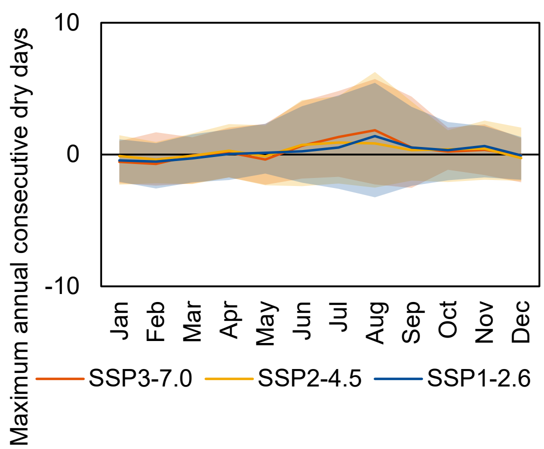
Projected Annual SPEI Drought Index



Projected Max Number of Consecutive Dry Days



Projected Max Number of Consecutive Dry Days Anomaly by Month in 2040–2059



Source: World Bank Climate Change Knowledge Portal based on CMIP6 database.
Notes: (a) Projected annual SPEI drought index. Negative values of the SPEI indicate below normal moisture; positive values indicate above normal moisture; (b) Projected maximum annual number of consecutive dry days (days with less than 1 mm of precipitation); and (c) Projected maximum annual number of consecutive dry days, monthly anomaly in 2040-2059 with respect to 1995-2014. All panels display the multi-model ensemble mean, 10th and 90th percentiles.

Assessment of Macroeconomic Risks

39. Climate change has the potential to generate macro-critical impacts, that may vary greatly across countries. Climate affects the macro-economy with productivity shocks, such as losses of labor productivity or low crop yields due to sub-optimal temperature, or with direct destruction of physical and human capital, usually due to extreme events such as floods. Damage to capital stock and lower investment due to weaker growth prospects and higher uncertainty would result in lower capital accumulation in the longer-term. Households' welfare is negatively affected because of higher health risks resulting in increased mortality and hospital admissions as well as lower income prospects and potential need for relocation. Climate change has also the potential to increase productivity, for example by extending the growing season. Higher temperatures during winters reduce heating costs in cold countries. Higher winter temperature reduces mortality and morbidity from cold-related diseases. The net balance of negative and positive effects is affected by the initial climate of each country.

40. As the rise in global temperature is a gradual process and the frequency of extreme weather changes slowly, the near-term impact of climate change may be limited and not easily distinguishable from normal variabilities. Average temperature rise and sea-level rise pose a gradual but constant challenge. Intensification of extreme events may lead to less frequent but potentially more severe losses.

41. Estimates of climate change impacts on the economy of the Netherlands are highly uncertain but several estimates indicate that losses may be relatively small by mid-century. Large differences in sectoral coverage, warming scenarios, climate phenomena considered, methods, and assumption complicate the comparison of different studies, but the overall picture that emerges from the available evidence is that warming and changes in precipitations up to 2050 may lead to modest economic losses, or even some gains according to some studies. The high level of development of the country, effective risk-management, a small share of value added from agriculture, forestry, and fishing (less than 2 percent of GDP)[42] and relatively mild temperatures also during summer, contribute to explaining the relatively low sensitivity of the economy to projected changes in climate until mid-century.

42. Top-down econometric estimates of warming that include adaptation indicate no losses or even modest gains up to 2050. By extrapolating the estimated relationship between GDP per capita growth and temperature trends observed with present warming trends, GDP per capita in 2050 does not change under a fast warming scenario, and modest gains are possible with a low

[42]Source: FAOSTAT.

warming scenario (Kahn et al, 2021). [43] These estimates assume slow but gradual adaptation to higher temperatures– such as increased penetration and use of air conditioning – and exclude impacts from sea-level rise, or changes in the frequency or intensity of extreme weather events (Table 3).

Table 3. The Netherlands: Percent Change in GDP per Capita

	2030	2050	2100
SSP1-2.6	0.11	0.25	0.43
SSP2-4.5	0.02	0.05	0.11
SSP3-7.0	-0.11	-0.31	-0.89

Notes: Staff calculations based on Kahn et al. (2021). Positive number indicate a gain. SSP1-2.6 is an emission scenario compatible with the Paris Agreement goal of keeping global mean temperature increase below 2 °C by 2100. SSP2-4.5 assumes continuation of current trends, including committed emission reductions. SSP4-7.0 is a high emission scenario that assumes no efforts to reduce emissions.

43. **Estimates of economic impacts from changes in the frequency of extreme events are rare and highly uncertain.** With slow (SSP1-2.6) and fast warming (SSP3-7.0), respectively, IMF Staff estimates a very small reduction of annual real GDP per capita growth rates between 2020 and 2050 from changes in the frequency of extreme heat, severe droughts, and moderate temperature. This leads to annual total losses of GDP ranging between €0.5-1.5 billion in 2030 and €2.2-6.2 billion in 2050.[44] These estimates rely on machine learning methods to select only the most important climate variables among hundreds potential candidates (Berkay, Bellon and Massetti, 2022). The analysis is limited to weather shocks that occur within the country and do not include, for example, the impact from changes in river flows due to extreme precipitations in other countries. As a comparison, the European Environmental Agency estimates that the total economic damage caused in the country by weather and climate-related extreme events between 1980-2020 is equal to €9.3 billion, or 1.2 percent of 2020 GDP. The annual average loss is equal to €0.2 billion.

[43] Losses and gains are measured by comparing a scenario with present warming trends to scenarios with trends compatible with long-term scenarios of temperature change used in the literature. Kahn et al (2021) use the RCP2.6 scenario (slow warming) and the RCP8.5 scenario. As the RCP8.5 scenario is considered to be extreme and inadequate for studying socio-economic impacts of climate change, we interpolate impacts linearly to determine GDP per capita changes for the high warming RCP7.0 scenario. Using the RCP8.5 scenario Kahn et al. (2021) find that GDP per capita declines by 0.42 percent in 2050 relative to baseline warming.

[44] The scenario assumes a 25 percent increase in the frequency of droughts for the slow warming scenario, and a doubling for the fast-warming scenario. As changes in the frequency of droughts are highly uncertain, these are conservative assumptions that may overestimate costs.

Table 4. The Netherlands: Economic Damage from Weather and Climate-Related Extreme Events, 1980–2020

	Euros	Percent of 2020 GDP
Cumulative losses, in bn €	9.3	1.2
Annual losses, in bn €	0.2	0.0
Cumulative losses per capita, in thousand €	5.1	11.1
Annual losses per capita, in €	0.1	0.3

Sources: European Environmental Agency, IMF Staff calculations

44. National bottom-up estimates of climate impacts indicate similar output losses. The Climate Damage Atlas estimates that total damages over the period 2018-2050 are expected to be in the range of €54 to €122 billion, or €1.7–€3.8 billion on average per year (see table 5) under assumption of no further adaptation measures. Damages from drought and heat contribute with €15–€72 billion, and €7–€8 billion, respectively[45]. Damages from pluvial floods are estimated to range between €32–€42 billion (reflecting large uncertainty about precipitation trends) or €1.0–€1.3 billion per year. Annualized total losses are less than 0.5 percent of GDP. Flood risk management, including land-use regulations that prohibit building in unprotected areas, greatly contributes to reduce losses from floods, which also helps to reduce financial stability risks. Caloia and Jansen (2021) find that the banking sector is sufficiently capitalized to withstand floods in unprotected areas, where there is relatively little real estate. However, they show that capital depletions could increase quickly in case more severe floods hit the densely populated part of the country.

Table 5. The Netherlands: Estimated Damage for 2018–2050

	Cumulative				Annual			
	in billion euros		in percent of 2018 GDP		in billion euros		in percent of 2018 GDP	
	min	max	min	max	min	max	min	max
Drought	15.3	72.7	2.0	9.4	0.5	2.3	0.1	0.3
Flooding	31.9	41.5	4.1	5.4	1.0	1.3	0.1	0.2
Heat	7.1	8.1	0.9	1.0	0.2	0.3	0.0	0.0
Total	**54.3**	**122.3**	**7.0**	**15.8**	**1.7**	**3.8**	**0.2**	**0.5**

Source: Jacobs et al., 2019, IMF Staff calculations

[45] The updated estimates for droughts by the Climate Damage Atlas are €38.5–€124 billion (€1.1–€3.9 billion annual average), increasing total damage estimates to €77.5–€173.6 billion (€2.4–€5.4 billion per year on average).

45. A comprehensive bottom-up analysis for Europe confirms that impacts for the Netherlands tend to be small and may even be positive in a low warming scenario. This is in large part explained by the relatively mild climate of the country. Table 6 displays impact estimates from a large study led by the Joint Research Centre of the European Commission. Impacts are reported for two warming scenarios equal to +1.5 ˚C and +3.0 ˚C with respect to the pre-industrial level.[46] Estimates for the whole EU indicate larger losses, reflecting significantly larger negative impacts in southern countries. Compared to the EU, the Netherlands and other countries in the Central Europe North region (Belgium, Germany, Luxemburg, Poland) have smaller estimated impact from droughts and improvement in agriculture productivity. Human mortality from extreme heat (increase) and cold (reduction) dominates the overall impact.

Table 6. The Netherlands: Welfare Change from Selected Climate Impacts for the Central Europe North Region and EU-27+UK for Two Levels of Global Warming

(Percentage of GDP)

The results represent change with respect to current economy.

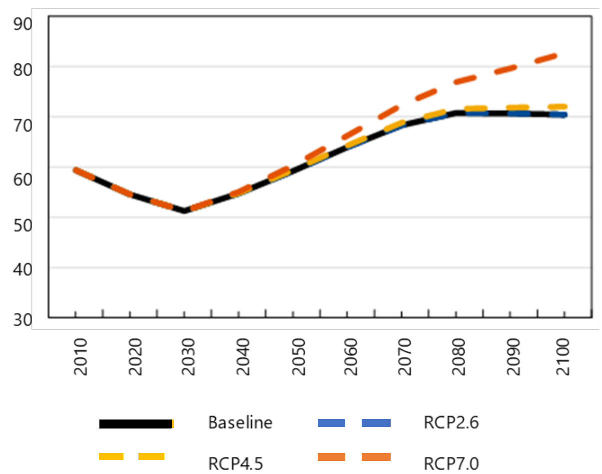
Sector	**Region**	**Welfare Change as Share in GDP (%)**	
		1.5ºC	3ºC
Inland Floods	Central Europe North	-0.03	-0.13
	EU + UK	***-0.04***	***-0.16***
Coastal Floods	Central Europe North	-0.01	-0.08
	EU + UK	***-0.02***	***-0.16***
Agriculture	Central Europe North	0.09	0.05
	EU + UK	***0.03***	***-0.03***
Droughts	Central Europe North	0.01	-0.02
	EU +UK	***-0.01***	***-0.08***
Energy	Central Europe North	0.00	0.00
	EU +UK	***0.00***	***0.00***
Mortality	Central Europe North	-0.17	-0.43
	EU +UK	***-0.29***	***-0.96***
Sum of the Sectors	Central Europe North	-0.11	-0.61
	EU +UK	***-0.33***	***-1.39***

Source: PESETA IV, 2020 (Szewczyk et al. 2020).

[46] Impacts are estimated using a comparative static exercise in which different levels of global temperature are used to estimate impacts on the current economy using a CGE model. This is a comparative static exercise that does not consider changes in technology, economy and society. This exercise also does not include effects associated with triggering climate tipping points, ecosystems degradation and loss of habitats and species. Therefore, the integrated economic impacts do not constitute the totality of economic impacts of climate change in Europe. Only very aggressive global mitigation can stabilize temperature increase to +1.5 ºC while +3.0 ºC can be reached in 2100 with continuation of present policy trends (SSP2–4.5).

46. Public finances in the Netherlands could be adversely affected by lower economic productivity growth only if climate change were drastic. In the RCP2.6 and RCP4.5 climate change scenarios, the average temperature increase is not expected to significantly affect productivity growth per capita[47]. However, in the more severe RCP7.0 climate change scenario, and in the absence of any policy change, debt-to-GDP could increase as lower economic productivity would translate into lower government revenues (Figure 10). As presented in the chart below, illustrative calculations[48] indicate that by 2100, in the RCP7.0 scenario, debt-to-GDP could be 10 percentage points higher compared to the baseline scenario. However, the annual buildup of debt-to-GDP towards the 10 percent point difference by 2100 could be offset by modest annual budgetary adjustment.

Figure 10. Debt-to-GDP Under Different Climate Change Scenarios



Source: IMF Staff estimates

47. While the available empirical evidence indicates that macro-economic risks for the Netherlands may be small, uncertainties are large. Some impacts may be missed – as for example cross-border spillovers[49] from neighboring countries or global upheaval due to extreme weather conditions in vulnerable nations. Evidence based on the observation of the economic impact of past shocks may fail to capture the compounded effect of multiple new risks occurring simultaneously or in rapid sequence. These risks can be explored only by developing scenarios and uncertainty cannot be quantified objectively.

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[47] IMF staff estimates for the impact of higher average temperature on productivity growth is based on empirical data generated by IMF Staff in accordance with the Kahn (2019) methodology.

[48] The calculations and chart are developed for illustrative purposes to show the possible deviations from the baseline path for debt-to-GDP and they are not representing IMF-views on a likely debt-to-GDP path for the baseline scenario. The calculation assumes that a GDP deflator of 2 percent, 2.3 percent interest rate on government debt, nominal GDP growing in line with total population, revenue remaining constant as percent of nominal GDP and high expenditure rigidity.

[49] The shares of agricultural goods in exports and imports are small (less than 1 percent of GDP), especially with non-EU countries. So, the trade-associated risks are likely to be limited.

48. Impact estimates do not account for global climate tipping points. Quick disintegration of the Greenland and West-Antarctica Ice Sheets may pose the most challenging threat to the country due very high sea-level rise, but risks are low during this century (Dietz et al, 2021). A more imminent threat is an acceleration of warming due to release of methane hydrates, which could also increase the intensification of extreme events. An abrupt collapse of the Atlantic Meridional Overturning Circulation (AMOC) does not appear to be likely before 2100, but if it were to occur it would cause abrupt cooling in the Netherlands and shifts in the water cycle (IPCC AR6, TS, Box TS.3).

Assessment of Adaptation Policies

49. Climate adaptation policy in the Netherlands is governed by the National Climate Adaptation Strategy (NAS) and by the Delta Programme. The Climate National Adaptation Strategy (NAS) serves as the overarching policy framework that sets out the overall agenda for climate change adaptation. The country published its NAS in 2016 and its implementation program in 2018 (Uitvoeringsprogramma Nationale klimaatadaptatiestrategie, UP NAS). [50] The 2020 National Climate Adaptation Perspective report reviews accomplishments and contains guidelines for a NAS working program for 2020 and beyond. The government is in the process of updating the NAS, based on the 2023 KNMI climate scenarios published in 2023, which will include a climate change adaptation monitoring framework that the government is currently developing. The Delta Programme, implemented since 2010, deals with adaptation to climate change with a particular focus on protecting the Netherlands from high water and flooding, freshwater availability, and spatial adaptation. The 2023 Delta Programme provides the most recent assessment of risks, adaptation measures, and budget.[51]

50. Considering the long-term process of climate change, the approach of the GON is to update its climate strategies and programs to reflect new information. The same inherently adaptive approach of coastal protection and flood defense strategies can be extended to cover all other climate hazards. While incremental adjustments—for example higher flood barriers—can be sufficient to deal with future risks for an extended period, it is important not to ignore "policy tipping points" (Klijn et al. 2012), when totally new approaches are needed to abrupt changes in physical risks and/or non-linearities in costs and benefits of adaptation. The establishment of the National Knowledge Programme on SLR—a six-year study programme to gain information on the effects of SLR up to 5 meters, is an example of analysis of alternative approaches to long-term challenges.[52]

51. Generally, the optimal level of governance should closely match the geographic or sectoral scope of climate risks. Through various centrally coordinated institutions and knowledge platforms, national, regional and local governments are stimulated to integrate climate change

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[50] https://ruimtelijkeadaptatie.nl/publish/pages/125102/nas_implementation_programme.pdf

[51] Home | Delta Programme (deltaprogramma.nl)

[52] https://english.deltaprogramma.nl/delta-programme/knowledge-development/sea-level-rise-knowledge-programme

adaptation considerations into their investment and policy plans. Climate adaptation has a regional approach. For instance, water district boards are responsible for the flood risk management in their district and municipalities are responsible for climate adaptation at the local level. Coordination is done through e.g., the delta programme or the union of the water boards.

52. There is a clear role for the central government in ensuring that adaptation principles are embedded in national legislation, policy and public finance management. In line with the EU legal framework for climate adaptation, the Netherland has been putting in place a comprehensive legal and regulatory framework that provides climate mitigation and adaptation regulations and guidelines. On the policy front, the purpose of the UP NAS was to integrate climate adaptation into policy and implementation by embedding climate adaptation considerations in government investment programs. This entails factoring climate risks and adaptation measures into medium- and long-term planning, budgets, the management of public investment, and assets and liabilities management. Important progress has been made to integrate climate change considerations into investment planning, and the authorities indicated to be developing a framework for monitoring and evaluation climate adaptation at the central government level. However, opportunities seem to exist to integrate climate adaptation considerations more comprehensively in all stages of the government investment and policy frameworks. For example, ex-post reviews, such as climate informed impact assessments, are at an early stage and there is no (legally enshrined) accountability mechanism in place that ensures that authorities at all levels of the government are held accountable for the (un)successful implementation of climate adaptation considerations.

53. Adaptation plans would be most effective if holistically integrated into long-term planning frameworks of the government. Amid competing needs, the efficient allocation of resources across sustainable development goals will deliver the highest net social returns. Staff welcomes and encourages the explicit mention in the UP NAP of the importance of weighing cost and benefits of alternative adaptation strategies. Despite its limitations, cost-benefit analysis, complemented by analysis and adjustment of distributional impacts, can help to ensure the best use of scarce resources, as for other development objectives.

54. Government action will be most effective and efficient if it focuses on:

- Adaptations that have large positive externalities—e.g., research about adaptation technologies, updating building codes, reinforcing infrastructure, developing early warning systems—are not efficiently provided by markets and should be a priority for governments.
- Removing barriers to efficient private adaptation—e.g., by removing legislative obstacles or other market imperfections—would allow firms and individuals to choose the efficient mix of adaptations leveraging their specific knowledge of costs and benefits of alternative options (Bellon and Massetti, 2022).
- Dealing with equity issues, for example by compensating vulnerable parts of the population that are negatively affected by adaptation policies.

55. The UP NAP would benefit from highlighting the cost of distortions and distributional impacts in markets for inputs and outputs. Distorted markets lead to inefficient allocation of resources, including in climate change adaptation. Future NAPs could assess the impact of market inefficiencies on adaptation costs and benefits and their distributional effects – a principle also stressed by OECD (2014). For example, implicit or explicit subsidies to fresh- and groundwater use may lead farmers to use water inefficiently to deal with higher summer temperature. Investing in efficient irrigation or switching to methods or products that are less water intensive would be discouraged, causing welfare losses. Efficient allocation of water would have immediate positive welfare impacts and would facilitate dynamic efficient adaptation but may be opposed by the beneficiaries. There could also be undesirable distributional effects if subsidies are used for income support. To facilitate market reforms and alleviate equity concerns, compensations could be paid to individuals adversely affected.

56. The UP NAP correctly highlights the importance of insurance in dealing with residual climate risks but could also support reforms to ensure efficient risk pricing. As fully offsetting climate change impacts may be either too expensive or impossible, government, individuals, and firms will have to deal with residual risks. Insurance can help spread these risks efficiently across time and across society. The UP NAP mentions this important role for insurance, but its message could be stronger, highlighting the need for efficient insurance markets. Ensuring competitive market access to insurance providers that satisfy all the financial requirements and efforts to ensure complete information is key to competitive risk pricing. Despite these efforts, some insurance for residual risks may be unaffordable for private individuals and firms. Subsidies can reduce the cost of insurance, but they distort private behavior by shifting the cost of risk from private to public budgets. Without appropriate countermeasures —such as upgraded and enforced building codes or land use restrictions—subsidies induce a sub-optimal aggregate risk level. Although the distributional impact of this outcome may be desirable, the efficiency cost should be carefully assessed.

57. Present financing of flood protection is based on cost-sharing and mutuality principles but without strong institutional constraints mutuality may lead to inefficient risk taking. We welcome the Recommendation 2 of the Deltacommission 2008 to grant permits to new development in low-lying flood-prone areas based on cost-benefit analysis in a fiscally responsible way, so that protection costs fall on the beneficiaries rather than on other administrative levels (Deltacommissie, 2008, p. 12).

Adaptation to Increased Risks from Coastal and River Flooding

58. The Netherlands is exposed to both coastal and river flooding but is considered prepared to deal with these challenges because of its long-term flood risk management practices. Around 55 percent of the country is susceptible to flooding. 26 percent is below sea-level and 29 percent is susceptible to river flooding.[53] More than half of the population and two-thirds of economic activity can be potentially affected by coastal and river floods (OECD, 2014). However, the

[53] Source: PBL, available at https://www.pbl.nl/correctie-formulering-over-overstromingsrisico .

country is uniquely prepared to deal with these challenges. Flood hazards are effectively and efficiently reduced to tolerable risk levels thanks to strong institutions, financial resources, centuries of experience, and strong cooperation between all levels of government. The existential threat from floods has shaped institutions and the very core of Dutch society.

Box 2. The Delta Programme

Following the disastrous floods in the south-western part of the Netherlands in 1953, a Delta commission was established to improve the system of flood defenses with a vast program of construction and land management – the Delta Works.

The continuous monitoring, maintenance, and upgrade of existing protection as well as the management of freshwater supply is managed by the central government, provincial and municipal authorities through the Delta Programme, overseen by a dedicated government official, the Delta Commissioner.

The Delta Programme is embedded in the legal framework and administrative functions of the central government, water authorities, and provincial and municipal authorities. The Delta Programme receives funding from the Ministry of Infrastructure and Water Management, and it is in conjunction with investment projects funded by other authorities.[1/] Its areas of investment include resilient infrastructure, including dike upgrading, and improved water discharge and storage facilities.

The total estimated annual budget of the Delta Programme is on average EUR 1.5 billion between 2023 and 2036, 55 percent of which are dedicated to new investment and the rest for maintenance, upkeep, and management, according to The Delta Fund.[2/]

The Netherlands' effort to contain risks from flooding has multiple building blocks and follows a holistic and adaptive approach to management decision making under uncertainty. Adaptation actions are planned in both mid- and long-term horizons. The major building blocks are flood protection, coastline preservation, river water management, and sustainable freshwater supply.

[1/]The Delta Programme 2023 states that water authorities expect to invest on average EUR 2 billion per year, of which EUR 915 million on flood defenses. For 2021, the Delta Programme estimated that the national government, water authorities, provincial and municipal authorities and drinking water companies together have spent EUR 1.7 billion on flood defenses, sewage purification, water systems, water quality, and sustainable freshwater supply.
[2/]Sources: the Delta Programme https://www.government.nl/topics/delta-programme/delta-programme-flood-safety-freshwater-and-spatial-adaptation (access: Feb.2023)

59. **The planned level of protection is adequate to deal with expected flood risks at least until 2050 but the country needs to plan carefully to upgrade the protection to address the evolving risks from climate change.** A sophisticated level of governance and substantial investments have contributed to the highest standards of protection for a low-lying delta country like the Netherlands and to the adequate management of freshwater resources (Box 2). However, key investments and planning are needed to upgrade the defense system by 2050 to ensure that the minimal levels of protection are extended to the whole population, to deal with continued soil subsidence, and to face increasing risks from climate change. Addressing observed trends in sea-level rise (SLR), as well as pluvial and riverine flood risks, requires additional measures. If planned

upgrades are delayed, flood damages in urban areas until 2050 can increase to between EUR 33 bln and 87 bln with continuation of present climate trends, and to between EUR 55 bln and EUR 124 bln if climate change intensifies (The Delta programme, 2021; p.18).

60. Sea-level rise (SLR) and intensification of conditions that can lead to pluvial and riverine floods should be closely monitored. Faster than expected SLR can potentially lead to more flooding, saltwater intrusion, coastal deterioration, and loss of habitats than what predicted. While the current protection strategy is expected to minimize these losses, the risks keep evolving. If the SLR trend intensifies, more drastic and costly interventions would likely to be required. While the difference between high and low SLR scenarios is projected to be small until 2050 (KNMI'14 estimates range between 15 and 30 centimeters in a moderate warming scenario and between 20 to 40 centimeters in a fast-warming scenario)[54], in the second half of the century high warming scenarios diverge substantially from observed trends (KNMI'14 projects 30 to 60 cm in the moderate scenario and between 45 and 75 cm in the fast-warming scenario in 2085). Extreme scenarios with SLR of 100 centimeters or more cannot be excluded if melting of Greenland and Antarctica will be faster than predicted. While the country is well-prepared to address SLR as the current trend continues up till 2050, an acceleration of sea-level rise in the second part of the century requires contingency plans.

61. The long-standing tradition of using cost-benefit analysis (CBA) for flood risk management and water governance should be continued and possibly reinforced. This tradition started in 1954 with the pioneering work cost-benefit analysis of the Delta Works by Tinbergen (1954) and continues to this day (CPB, 2017). Standard good practice in CBA should be applied consistently across studies:

- A range of policy/investment alternatives should be assessed against each other, including the no incremental protection case (business-as-usual).
- The cost of adapting to rising sea levels under a range of SLR scenarios should be calculated against a counterfactual with no SLR.
- Whenever possible, regional interdependencies (positive and negative spillovers) should be considered and different combinations of protection options in different parts of the country should be assessed.
- Non-market impacts should be monetized using the best-available evidence while being cognizant of inherent uncertainties. Loss of life should be monetized using the Value of Statistical Life, consistently with national CBA standards. Disutility losses in case of relocation should also be monetized.

[54] With respect to the period 1986–2005. Source: KNMI'14, p. 49. SLR in the moderate warming scenario is similar to what estimated by the SSP2–4.5 scenario and SLR in the fast-warming scenario is similar to what estimated with the SSP5–8.5 scenario by the IPCC (Fox-Kemper and others (2021, Table 9.9).

- The flood protection strategy envisioned until 2050 is based on implementing the Local Individual Risk (LIR) (the probability per year to die at a certain location due to flooding, taking into account evacuation possibilities) defined in part by a motion of parliament and in part using CBA (van der Most et al 2014). CBA can contribute to assess if the application of this standard across the country is efficient and could be used to determine the optimal local safety standard.

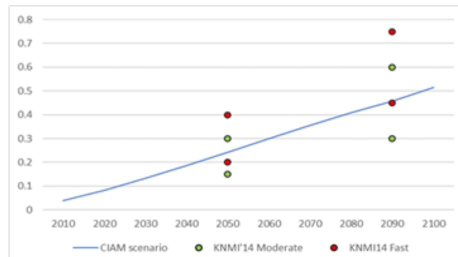
62. Utilizing the CIAM model (Diaz, 2016–Box 3), IMF staff conducted a stylized CBA of alternative protection strategies. The model-based estimation suggests that implementing an efficient protection strategy can significantly reduce the overall protection costs while minimizing the residual damage. This finding aligns with national studies. Model output allows comparing the full protection (zero permanent inundation in any part of the country) and the "optimal" protection strategies (where the total costs of SLR are minimized, including the protection costs, residual damage, and the non-market value loss of wetlands due to the protection). The "optimal" protection level entails slightly elevated risks of inundation but much lower total costs than the full protection. The numerical findings of the model should however be taken with caution since it potentially underestimates climate change damages by excluding the risks of riverine flood and potentially overestimates adaptation costs since it assumes no protection against SLR in the baseline scenario (no protection scenario). Nevertheless, the model allows comparing trade-offs between costs and benefits of protection under alternative protection strategies. More accurate national models should allow similar CBAs to facilitate efficient protection strategies.

Box 3. A Stylized Cost-Benefit Analysis of SLR Using CIAM from 2050 to 2079

The Coastal Impact and Adaptation Model (CIAM) is a global optimization model for cost-benefit analysis of adaptation to SLR (Diaz, 2016). The coastline of the Netherlands is divided in 128 segments of varying length. To estimate costs and benefits of alternative protection strategies, the model uses segment-specific information on protection costs, geographic features, population density, and level of economic activity and capital. The model does not consider increased risks from river floods. See Annex I for details of the model.

This exercise uses the median increase of local sea-level in the Netherlands for the RCP 4.5 scenario in Kopp et al (2014). SLR in this scenario falls within the range of the KNMI'14 scenario for moderate warming. This exercise uses also the 5th and the 95th percentiles of the distribution of SLR for the RPC 4.5 scenario to illustrate uncertainty.

Sea-Level Rise in CIAM Analysis and in KNMI' 14 Scenarios
(meters)



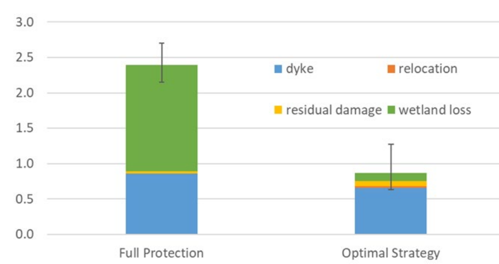
Source: CIAM scenario corresponds to the 50th percentile of local sea-level rise projections in Kopp et al. (2014), measured in meters with respect to 2000. KNMI'14 scenarios of sea-level rise for Moderate and Fast warming scenarios from KNMI (2014), measured with respect to 1985–2005.

Two adaptation strategies are simulated: protection (by building dikes, flood barriers, reinforcing coastal dunes, etc.) and retreat (by progressively relocating population and assets). Utilizing the model, IMF staff estimates suggest that full protection, which although eliminates the permanent inundation risks from sea level rise entails higher total costs, whereas a policy combination of protection and retreat is the most cost-effective.

In the full protection scenario, the model indicates that EUR 862 million are needed annually between 2050 and 2079 to eliminate contemporaneous and future inundation risks from SLR, or a total of EUR 25.9 billion. This strategy is cost-effective because damages from inaction are estimated to be much higher.

In the optimal protection scenario, accepting inundation in some areas leads to lower investment needs in protection and to lower losses of ecosystem services. Pro-active land use management minimizes costs to the population and loss of infrastructure. This strategy allows to reduce investment needs in protection to EUR 656 million annually, or EUR 19.7 billion in total. Land and capital losses due to inundation are kept at a modest level, around at EUR 2.31 billion cumulatively during the same period.

Annual Adaptation Cost to Sea-level Rise and Residual Damages with Alternative Strategies, 2050–2079
(Billion EUR/year)



Sources: IMF staff calculation, utilizing modeling tool from the Coastal Impact and Adaptation Model (Diaz, 2016).
Notes: the bar chart shows the breakdown costs of SLR, taking the median level of local SLR under RCP 4.5 rom Kopp et al (2014). The confidence interval shows costs using the 5th and 95th percentiles of SLR.

Due to the coarse nature of the model, and to large uncertainties in costs of protection and avoided damages, these scenarios should not be interpreted as exact estimates of investment needs. However, they clearly indicate that protection is highly effective at reducing potential damages from SLR, and that comparing alternatives that entail different mixes of protection and planned inundation while including monetary and non-monetary costs and benefits is an essential component of CBA.

D. Summary of Policy Recommendations

Mitigation

- Replace temporary energy tax reductions and price freezes in response to the energy price surge with further targeted assistance, unrelated to energy consumption
- Convert the CO_2 levy for industry into a feebate
- Convert the CO_2 levy for power into a feebate and harmonize emissions prices across the power and industry schemes
- Consider integrating a CO_2 charge into residential natural gas prices aligned with CO_2 prices in the EU ETS combined with compensation for vulnerable households, unrelated to energy consumption
- Consider a target rate of at least 8 cents per kilometer for the planned transportation tax on driving to align it with estimates of congestion costs
- Promote local congestion pricing pilot schemes with a long-term view to linking kilometer-based fees to congestion
- Complement the shift to kilometer-based taxation in transport with incentives for a market-driven transition to pay-as-you-drive auto insurance
- Link the air travel departure tax to a proxy for CO_2 emissions per passenger trip

Adaptation

The Netherlands represents a good practice for climate change adaptation, particularly to sea-level rise. The estimates of climate change impacts on the Dutch economy are likely to be modest by mid-century, although subject to high uncertainty. The country has put in place a comprehensive legislative and policy framework for adaptation, implemented through a coordination mechanism at national and subnational level.

- Climate adaptation could be further strengthened by holistically integrating it into long-term planning frameworks of the government.
- Government action could further focus on adaptation with large positive externalities, removing barriers to private adaptation, and dealing with equity issues.
- The National Adaptation Plan could also benefit from highlighting the cost of market distortions for adaptation.

Annex I. The Coastal Impacts and Adaptation Model[1]

1. **The Coastal Impact and Adaptation Model (CIAM) is a global optimization model for cost-benefit analysis of adaptation to SLR (Diaz, 2016).** The model starts from coastal characteristics on 12,000 coastal segments covering the entire global coastline from the Dynamic Integrated Vulnerability Assessment model (DIVA), a tool to assess the biophysical and socioeconomic impacts of SLR. The DIVA tool estimates the SLR impacts by considering coastal erosion, coastal flooding, wetland change and saltwater intrusion (DIVA Modeling Framework). For each coastal segment, CIAM develops economic, population, and SLR scenarios. The SLR scenarios are from Kopp et al (2014). On top of SLR, the model considers the expected value of storm surges to include rare but potentially high-impact events.

2. **Using costs of alternative coastal protections, CIAM determines costs and benefits of alternative adaptation strategies (including no adaptation) for each coastal segment.** The efficient level of coastal protection is selected by maximizing the net present value of each strategy. Protection can be full – excluding any inundation also under extreme storm surges – or can be partial – accepting storm costs.

3. **The model can be used to develop insights on different costs from SLR and different protection strategies (Table A1) in each coastal segment or at different level of aggregation.** This SIP aggregates all coastal segments in the Netherlands.

Annex I. Table 1. The Netherlands: Cost Specification in the CIAM

Category	Explanation of the Costs	Measurement of Cost [1]
Protection Cost	Constructing and maintaining protection (generalized as sea walls) to shield the land behind the sea walls from the SLR-caused inundation	A function of the coastline length, the height of the sea walls, and the value of the land occupied by the sea walls
Retreat Cost	Relocation of population and assets from the affected areas, including the forced emigration and the planned retreat	The cost of relocating population and mobile capital in the incremental area of retreat, as well as the cost of demolishing the immobile capital
Inundation Cost	The loss of land and assets due to the SLR-caused inundation	The cost is based on the extent of land endowment lost and the associated value of the land and the capital stock

[1]Measurement of the cost per period. The model optimizes the adaptation strategies over 20 periods

[1] The detailed description of the model can be found in Diaz (2016) and the documentation of the model (https://github.com/delavane/CIAM/blob/master/CIAM%20Documentation.pdf)

Annex I. Table 1. The Netherlands: Cost Specification in the CIAM (Concluded)

Category	Explanation of the Costs	Measurement of Cost [2]
Wetland Cost	The loss of wetland due to the inability to migrate inland naturally, constrained by the rate of SLR and the lack of space	The wetland losses take two forms, (1) the total service value of the wetland occupied by the sea walls; (2) the service value of the wetland lost related to the rate of SLR
Flood Cost	The damage to population and asset due to extreme surge	The expected damage associated with the risk of the extreme surge. The likelihood of the extreme events follows the generalized extreme value distribution by using the local surge frequency data from the DIVA tool, while the total land affected by the extreme surge depends on the elevation exposed to a given flood water height.

[2]Measurement of the cost per period. The model optimizes the adaptation strategies over 20 periods

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