Climate change and financial risks of real estate

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Climate change and the transition to a climate-neutral economy entail risks, also for financial institutions. These risks manifest themselves among other things through exposures to real estate. Both physical consequences of climate change, such as more extreme weather conditions, and stricter sustainability requirements can lead to a decrease in the value of homes and offices. This possible effect is relevant from the perspective of financial stability, if only because real estate investments and loans account for more than 25% of assets held by banks, insurers and pension funds. With the aid of a new climate stress test we assess how financial institutions may be affected by flooding in the Netherlands through real estate exposures. We also consider the consequences of the energy transition for the financial sector's real estate exposures.

Climate change and the associated energy transition entail risks for financial institutions. Global warming leads to a growing risk of extreme weather conditions and floods, which could cause considerable economic and financial damage. This is illustrated by the recent floods in the Netherlands and a number of other European countries. This also impacts financial institutions, for example through higher climate-related insurance claims, direct damage to real estate investments and higher credit risks on loans. If climate change continues, it is conceivable that the damage will threaten the stability of the financial system. In order to counter climate change, many countries have given commitments under the Paris Agreement to transition to a carbon-neutral economy. Over the decades ahead this will require considerable investments and have a major impact on some economic sectors. The uncertainty concerning the course of the transition may entail financial risks. An earlier stress test we conducted already showed that sudden, major changes in climate policy or energy technology could lead to substantial losses on asset positions of Dutch financial institutions. Other supervisory authorities and central banks, such as the ECB, are currently working on issues relating to climate change and the energy transition in order to understand these financial risks (see Box 6 'Financial risks of climate change: work in progress').

Climate-related risks to financial institutions manifest themselves to a large extent through exposures to real estate. Real estate plays an important role on financial institutions' balance sheets. Shocks in real estate markets have also traditionally been a major source of financial crises. Due to the CO_2 emissions associated with its construction and use, real estate plays an important role in the energy transition, and in the policy discussions on the shape of that transition. Buildings themselves may also be vulnerable to the consequences of extreme weather conditions and floods. It is not inconceivable, therefore, that either climate change or climate policy will cause shock adjustments in real estate markets. In this chapter we therefore focus specifically on the question of how climate-related risks affect financial institutions through their exposures to real estate. The focus on real estate provides a more in-depth analysis than our previous climate stress test, which focused on other types of assets, such as corporate loans. In addition,

the inclusion of physical risks to real estate represents a widening of the scope: our previous climate stress test focused solely on transition risks. The focus of this new analysis, as in the previous climate stress test, is primarily on implications on the asset side of the balance sheet for banks, insurers and pension funds.[14]

Real estate positions and implications of climate risks

Real estate plays an important role on financial institutions' balance sheets. Real estate exposures of almost €1,400 billion represent more than a quarter of the combined balance sheet total of Dutch banks, insurers and pension funds (Figure 20). In the case of the banking sector, loans secured on real estate make up 38% of the balance sheet. These include residential mortgages (27%), commercial real estate (4%) and corporate loans secured on real estate (6%). Insurers and pension funds also have substantial portfolios of residential mortgages and are major investors in commercial real estate. These real estate investments mainly concern foreign real estate. In the case of insurers the exposures to real estate amount to 17% of total assets. For pension funds the figure is 15%.

Real estate is increasingly exposed to the consequences of more extreme weather conditions. Over the past four decades there has been a clear upward trend in the number of natural disasters, as can be seen from EM-DAT data.[15] The most recent IPCC report also finds strong indications that extreme weather is occurring more frequently. The specific physical real estate risks, of course, depend greatly on the location of the home or office. Given that a large part of the Netherlands is below sea level, Dutch real estate is particularly vulnerable to flooding. The risk is not limited to the low-lying areas, however. Last summer parts of the south of the Netherlands were affected by heavy rainfall. Rivers burst their banks, leading to flood damage in areas such as Valkenburg aan de Geul. If climate change continues, serious floods may occur more frequently. Other physical risks to real estate in the Dutch context are storm damage and pile rot.[16] In view of the large foreign positions (see the dark blue areas in Figure 20), a wide range of other physical risks may also be relevant to Dutch financial institutions. Depending on the region in question, these may involve the threat of drought, forest fires, hurricanes or extreme rainfall. The picture presented by granular data on real estate positions abroad is even less clear than data on Dutch positions, but it is important to gain further insights into this matter. Concentration risks may arise if multiple institutions have a large exposure to a particular region.

Secondly, buildings are susceptible to transition risk, because they are responsible for a considerable proportion of greenhouse gas emissions. In 2020 the built environment – one of the five climate agreement sectors – accounted for 13% of greenhouse gas emissions in the Netherlands; worldwide the figure was almost 30% The Paris Agreement and the National Climate Agreement state that greenhouse gas emissions from buildings must be reduced to zero by 2050. Ambitious targets have also been set for 2030. In order to achieve these targets, large investments will be required in the decades ahead to increase the sustainability of buildings. In the European Union an estimated €275 billion of additional annual investment is required in the renovation of buildings up to 2030. This transition may have a major impact on the value of existing buildings.

14 For non-life insurers physical risks naturally also have possible implications in terms of liabilities. This matter has already been addressed in Chapter 2 of a previous study we published in 2017.
15 EM-DAT is a widely used database of natural disasters compiled by the Belgian Centre for Research on the Epidemiology of Disasters. The underlying data on the number of disasters per year and per country can be found at https://www.emdat.be
16 No further details of these risks are provided in this chapter. Pile rot may occur if climate change leads to more frequent periods of severe drought. The fluctuations in the groundwater level may then impact the quality of foundations in some cases. The vulnerability lies particularly in foundations based on wooden piles, which are still found frequently in various cities in the Randstad region.

Flood risk to Dutch real estate

A great deal of attention has been devoted to the economic consequences of flooding, but no system-wide analysis of the consequences for the Dutch financial sector has yet been conducted. It has previously been calculated, for example, that the flooding of the river Meuse in the mid-1990s led to a 9% fall in prices of the affected homes. It has also been calculated that sale values of homes in flood-risk areas in the Netherlands are around 1% lower. In addition to these academic studies, individual financial institutions are already analysing the flood risk to their exposures. No system-wide overview is yet available, however. Below we develop such a system-wide analysis in three steps. We consider exposures, discuss the risk channels and show that the impact in terms of damage in tail scenarios can rise substantially.

The majority of Dutch financial institutions' domestic real-estate exposures are located in parts of the country that are vulnerable to flooding. To map these exposures, we have drawn together granular data from a range of individual sources to create a dataset representing over €700 billion in domestic real estate exposures. This includes both regular data that we gather as well as data from a special survey of insurers and pension funds. The picture that emerges is that the majority of real estate is located in parts of the Netherlands that may be affected by flooding. These include both areas which are not protected by flood defence systems (outside the dikes) and parts of the Netherlands that are protected against floods.[17] These risk areas are located particularly in the Rhine basin, but also in the Meuse, Scheldt and Ems. As Figure 21 shows, relatively little real estate is in unprotected areas. The main area with a relatively large amount of real estate exposures is areas that would be flooded in the event of a failure of a primary flood defence, such as a dike. These areas cover much of the west of the country. The percentages range from 52% of total Dutch exposures, in the case of banks, to 66%, in the case of pension funds. In the case of insurers the percentage is 65%. Since location information is not yet available in all cases, these percentages will actually be even higher.

The flooding of vulnerable areas leads to building damage, which in highly exceptional cases can amount to €200 billion. The possible damage to homes and commercial real estate in a future flood can be estimated using damage functions. A damage function translates the water level in a flood into an amount of damage in euros. We base our calculations on three stress levels: low, average and extreme water level.[18] We then apply these stress levels to two types of floods: one in areas outside the dikes – where there is relatively little real estate – and one in areas protected by primary flood defences. In addition to the water level, the estimated damage to homes in this methodology also depends on the surface area. In the case of commercial real estate the estimated building damage depends mainly on the user function.[19] Commercial real estate in particular appears to be relatively vulnerable, with a damage percentage of more than 60% of the value in the case of an extreme flood affecting both protected and unprotected areas (Figure 22). For homes the damage percentage in the case of a low flood level is still limited. A moderate flood of an area outside the dikes would lead to damage percentages of less than 10%, whereas a moderate flood of a protected area would lead to damage slightly above 10%. In the case of extreme water stress the debt percentages rise substantially, particularly for homes used as collateral for bank

17 For details, see Slager, Kymo (2019). Handboek overstromingsrisico's op de kaart: Over de methode van kaartproductie.
18 For a description of this method, see Slager, Kymo, and Dennis Wagenaar (2017). "Standaardmethode 2017. Schade en slachtoffers als gevolg van overstromingen." The breakdown into three levels is based partly on Stuurgroep Water (2018). "Overstromingsrisico's in Nederland." The stress levels are associated with a rise in water levels of between 1 and 5 metres.
19 The calculations are focused purely on damage to buildings. The bill for businesses would be even higher due to loss of income resulting from non-use or less efficient use of the real estate.

mortgages. In the case of an extreme flood in a protected area banks would face a damage percentage for homes approaching 50%. Given that the majority of the real estate is in protected areas (Figure 21), the total amounts of damage in such a case would rise sharply. The estimate of €200 billion is based on damage percentages in Figure 22 in the case of an extreme flood (the bars on the far right) and the exposures of banks, insurers and pension funds in Figure 21 located in protected areas.

Such substantial flood damage would impact the position of financial institutions in various ways. These could include both increased credit risk, for mortgage lenders, and a materialisation of market risk, for investors. An important point is that flood damage is not insured in all cases in the Netherlands. The flood damage that we model here, which is in areas outside the dikes and in areas protected by primary flood defences, is currently not covered by regular insurance. It is not clear at the outset to what extent the government will cover the damage under the Reimbursement for Damage due to Disasters Act (Wet tegemoetkoming schade bij rampen – Wts). A recent survey also suggests that people living in risk areas in the Netherlands are aware of the flood risk but do not necessarily have higher financial buffers to absorb any setbacks (see Box 7 'Homeowners in flood risk areas do not have higher buffers'). If buffers are insufficient after a flood, the value of the collateral will fall. Failure to take account of this will increase the credit risks for mortgage lenders. This decrease in the collateral value may then affect banks, but also insurers and pension funds. The building damage also has financial consequences from the perspective of investors. This can be seen as a form of market risk, which is relevant particularly to insurers and pension funds having regard to their large investments in real estate.

So far, the macrofinancial impact of floods has remained limited. Researchers often draw a distinction between the direct and indirect impacts of a flood. The direct impact, in addition to the damage to buildings referred to above, also includes damage to production resources and infrastructure, as well as the number of persons injured and any loss of human life. There is also the indirect impact, which includes disruptions to production chains. The combined direct and indirect impacts lead to a decrease in economic growth after a flood. Hitherto scientists have considered that floods – as well as natural disasters more generally – in most cases lead only to a short-term economic contraction. While assessments vary, the consensus appears to be that the GDP effect could at most be a few percentage points.

The macrofinancial impact of a flood will nevertheless be greater if climate change continues unabated. In the context of climate change, however, the mild effects of natural disasters observed so far can no longer necessarily be assumed to be the basis going forward, as a recent BIS study also argues. In the event of more frequent extreme weather, the impact on buildings, production processes and society will be greater in decades ahead. A recent study by the Federal Reserve (the United States central bank) therefore estimates on the basis of a growth-at-risk analysis that climate change will make an economic recession both more likely and more serious.

In the event of a serious flood, the combination of substantial building damage and an economic downturn could therefore seriously impact the Dutch financial sector. This is borne out among other things by stress test calculations using the Cassandra model. We have made these calculations over a one-year horizon. Here again we use the six stress scenarios. The scenarios are therefore based partly on a flood in an area outside the dikes and partly on a flood in a protected area. The scenarios also differ in terms of assumptions about the levels of flooding and the extent to which economic growth falls. In the most extreme scenario we assume GDP growth that is around 10 percentage points lower due to flooding. Unemployment accordingly rises by a few percentage

points in that most extreme scenario.[20] The stress test calculations show in the first place that banks would be sufficiently capitalised to withstand flood stress situations in unprotected areas outside the systems of flood defence (Figure 23, left). The capital impact on banks remains limited even in the case of a major flood in areas outside the dikes. The assessment is that in the most extreme stress scenario the effect on the combined CET1 ratio would be around 130 basis points. This limited effect partly reflects the fact that there is relatively little real estate in unprotected areas.

If we assume higher water levels in protected areas, however, this picture deteriorates rapidly. In extreme cases the capital impact on banks may rise to more than 700 basis points within a year (Figure 23, far right-hand bar). First, the property damage would increase sharply as a result of the high water level. Second, the deterioration of the macrofinancial picture would then also weigh very heavily on the banks' profitability and increase the impact of non-performing loans. It can also be noted that the stress test does not even include the aspects of operational risk. Such a large impact on the capital ratio within a year is far greater than the impact normally revealed in stress test exercises. The probability of flooding as severe as considered above is of course still extremely small at present. At the same time, climate change may ultimately increase the likelihood of such extreme situations. The more frequent occurrence of flooding could also have a strong cumulative impact.

Transition risk

The transition to a climate-neutral built environment may also affect the value of buildings. As a result of stricter sustainability requirements and higher energy and CO_2 prices, the difference in value between insufficiently sustainable buildings and low-energy buildings will widen. This applies to commercial real estate, for which binding standards have already been set in some cases, but also to homes, where the implied standard will ultimately also shift to energy-neutral. This means that buildings with low energy efficiency may require substantial investment to meet future energy standards and the cost of using these buildings will rise due to higher energy or CO_2 prices. Partly for this reason it will also be increasingly difficult to finance these buildings.

Financial institutions have only a limited knowledge of the energy characteristics of their real estate exposures, however, making it difficult to conduct system-wide risk analyses. Our survey of insurers and pension funds referred to above shows that on average these institutions have information on the relevant energy characteristics of only one-third of their foreign real estate exposures. There are substantial differences between institutions, however. In the case of Dutch real estate, financial institutions generally have considerably more information. Insurers and pension funds know the energy labels for almost 90% of their Dutch real estate exposures. In the case of banks this percentage for commercial real estate loans in the Netherlands is 66%.[21] For foreign real estate loans the energy labels are entirely absent from the banks' reporting. Figure 24 shows the breakdown of different types of real estate exposures by energy label, for various Dutch exposures, and CO_2 intensity, for foreign real estate investments.

By 2030 an estimated 40-60% of all buildings to which Dutch financial institutions are exposed are still to be made sustainable. To ensure that all buildings are climate-neutral by 2050, the standards for greenhouse gas emissions from buildings will be

20 For further details of the calibration, see the paper by F. Caloia and D. Jansen "Flood risk and financial stability: Evidence from a stress test for the Netherlands" (forthcoming).
21 The availability of this information has been improved compared to a survey we held in 2017, which only covered domestic real estate exposures.

gradually tightened over the coming decades. The precise shape of this transition currently remains uncertain. The Climate Agreement, for example, stipulates that 1.5 million homes must be made entirely energy-neutral by 2030, but it is not clear how that will be achieved. Stricter requirements are also likely to be imposed on energy consumption by offices and other commercial real estate, but these have not yet been determined. A plausible scenario is that by 2030 the Netherlands will require a minimum B energy label for commercial real estate, while for homes a B (rented) or C (owner-occupied) label will be the implied standard.[22] In the case of foreign real estate we assume implied standards consistent with the goals of the Paris Agreement.[23] In this scenario an estimated 40% to 60% of buildings to which Dutch financial institutions are exposed do not currently meet the standards that will apply in 2030.

The investments required to achieve these sustainability efforts depend greatly on climate policy choices, but they will in any event be substantial. Although the ultimate goal – making all buildings climate-neutral – has been determined, the magnitude of the required investments remains uncertain, particularly in the post-2030 period. The required investments will depend greatly on the technological choices made and the costs of the various options over time. It is still highly uncertain, for example, whether and on what scale green gas and green hydrogen will be available to heat buildings. The technological choices will also determine who makes the investment. If a choice is made to pursue building-specific solutions such as heat pumps, investments will be borne by building owners, whereas this is generally not the case when a district heating system is constructed. The investments required for similar buildings may therefore vary widely. For many buildings, investments will have to be made in improved insulation at the very least. The cost of these investments will in principle be borne by the owner of a building. Figures from PBL Netherlands Environmental Assessment Agency show that insulating all buildings in the Netherlands would require estimated investments of between €50 billion and €110 billion.[24]

There needs to be even keener awareness of the connection between increased sustainability of buildings and risks to the financial sector. The effect of the energy transition on the value of buildings will depend not only on the existing energy characteristics but also on future policy with regard to the sustainability of buildings. An investment in sustainability can also increase the value of a building, for example because it reduces the user's costs. In the case of commercial real estate, however, owners must make a substantial investment to be able to continue letting the building, even if it is unclear to what extent this investment will also translate into higher rental income. If building owners are unable or unwilling to make the required investment, the value of the building will be negatively impacted. In the case of owner-occupied homes in particular, it is possible that homeowners will be unable or unwilling to make the required investment. This is particularly relevant since, as Figure 24 shows, owner-occupied homes still require a major sustainability effort. This makes estimating the financial risks due to required sustainability efforts a complex matter.[25]

Policy implications

Climate risks related to real estate will require ever greater attention in the light of climate change
Physical risks will become more relevant,

22 By way of comparison, the 2013 Energy Agreement included the ambition of striving for at least an A energy label for all buildings by 2030.
23 We have based this estimate on the transition paths of each country, as calculated by the Carbon Risk Real Estate Monitor.
24 This concerns the estimated investments needed to upgrade all buildings to energy label D or B, respectively.
25 An Occasional Study to be published shortly will focus more closely on the effect of increased sustainability of buildings on the financial risks to the financial sector.

particularly given the onward march of global warming, as recently outlined in the IPCC report. Transition risks may already be significant in the shorter term if it is not made clear soon which sustainability requirements will apply to homes, retail properties and offices. Clarity on prevailing policy will also lead to clarity on the required financing and increase investment appetite among owners and investors. An important factor in this regard is the breakdown of costs between building owners and the government. The potential systemic risks of physical factors underline the importance of a timely transition to a climate-neutral built environment.

Although steps are being taken, the financial sector as a whole could integrate the real estate risks of climate change even more fully. Increasing numbers of financial institutions are now devoting attention to climate change in their risk management. In some cases climate change has already been embedded by, whereas in other cases such efforts are still in their infancy. An important focal point with regard to real estate, but also in a broader sense, remains the availability of the relevant data for robust analyses. In the case of physical risks this largely concerns location data; in the case of transition risk it mainly concerns data on energy efficiency. As Figures 21 and 24 show, the picture is sometimes still incomplete even for Dutch real estate exposures. At the same, time this need for improved data should not prevent financial institutions taking steps now towards further embedding climate change in their risk management. Our climate stress test for flood risk is an example of analytical work that can already be conducted on the basis of available data.

It is important that climate risks are explicitly included in real estate valuation. This applies both to the possible consequences of climate change and to the consequences of the transition to a climate-neutral built environment. Building characteristics relevant to these risks must be taken into account in real estate valuations. Financial institutions will be better able to assess risk on that basis.

Even if the results are still uncertain, the magnitude involved underlines the importance of further work on macroprudential implications. Like the work of other central banks and supervisory authorities (see Box 6) our analyses are still subject to uncertainty. However, in line with our previous energy transition stress test, this chapter also shows that financial risks relating to climate change are systemically relevant due to their possible magnitude. In addition to follow-up analyses it is important to conduct a timely discussion on possible ways to mitigate these systemic risks. At this stage it is important that financial institutions already take account of certain pockets of risk relating to geographic locations or transition paths in their own risk management.

Box 6 Financial risks of climate change: work in progress

Central banks and supervisory authorities increasingly use scenario analyses and stress tests to gain insight into the financial risks of climate change. In April 2021, for example, the French central bank and supervisory authority presented the results of an initial stress test for financial institutions. The ECB recently published the first results of a top-down climate stress test and is currently preparing a bottom-up climate stress test for systemically important banks in 2022. The Bank of England recently introduced a climate stress test for banks and insurers, the results of which are expected in early 2022. EIOPA, the European supervisory authority for pension funds and insurers, is also considering climate issues in relation to stress tests.

Stress tests on climate are still 'work in progress'. As outlined above, a whole spectrum of potential risks are relevant to climate change. We also need to understand better how climate change will impact the economy and vice versa. Finally, the evolution of the climate in the decades ahead is extremely uncertain. It is nevertheless important to carry out this analytical work in order to gain an initial insight into relevant channels and the magnitude involved. Critical mass is important in this regard. Extensive cooperation is therefore taking place between central banks and supervisory authorities, for example as part of the Network for Greening the Financial System (NGFS).

Since the end of 2017 the NGFS has been drawing attention to the way in which both physical and transition risks can impact financial institutions' balance sheets. For example, it recently published a set of climate scenarios. The financial impact of climate change can be illustrated with increasing accuracy and consistency by using these types of scenario. We have been involved for some time in the scenario work of the NGFS and will continue to contribute on the basis of the analyses presented in this chapter.

Box 7 Homeowners in flood risk areas do not have higher buffers

Do households anticipate possible flooding? To answer this question, we commissioned a survey of the members of the DNB Household panel in the spring of 2021, i.e. before the floods in South Limburg. Over 2,400 respondents completed the questionnaire. People living in a flood risk area are clearly aware of the risk. People living in areas outside the dikes are 10 percentage points more likely to mention a flood as the primary threat in terms of environmental factors. People living in protected risk areas are 6% more likely to do so than people who do not live in risk areas. The effects are similar in the case of homeowners (second column of the table). Awareness does not automatically lead to higher financial buffers, however. When questioned, homeowners in risk areas appear to have similar buffers to those of people not living in risk areas (third column). Knowledge of insurability does not appear to be the reason for this. People living in protected risk areas are slightly less likely to say that insurers should be primarily responsible for covering **flood damage.** People living in areas outside the dikes are more likely to mention insurers. These differences are not statistically significant, however (final column).

Table: What are the views of people who live in flood risk areas?

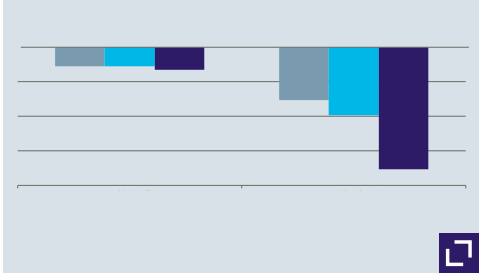
(in each case compared to people not living in a risk area)

	Sees flooding as the biggest threat	See flooding as the biggest threat	Level of financial buffer	Sees the insurer as having primary responsibility in the event of water damage
Lives in unprotected risk areas	**+10%**	+10%	-0.58	+7%
Lives in protected risk areas	**+6%**	**+7%**	-0.07	-1%
Sample	All	Only homeowners		

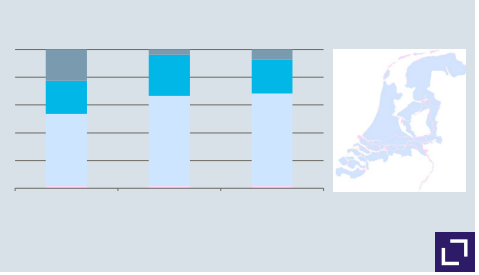
Note: With the exception of column 3, the numbers can be interpreted as the so-called marginal effect, i.e. the difference in probability of a particular outcome associated with living in a risk area. The number in the third column shows the difference in levels. Respondents could choose from seven options, numbered here from 1 to 7 on the scale. Figures in bold show that the difference is statistically significant at least at the 10% level.

Figures

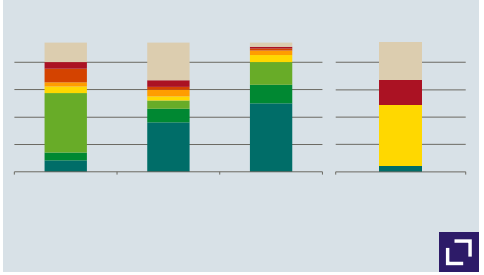
Exposures to real estate
See figure 20 →



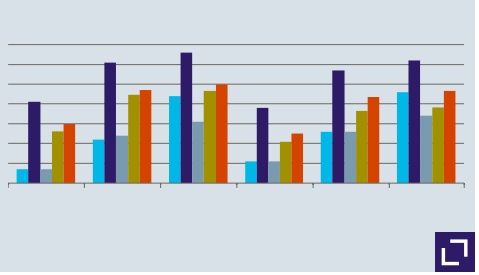
Capital impact in six flood scenarios
See figure 23 →



Flood risk and Dutch real estate
See figure 21 →



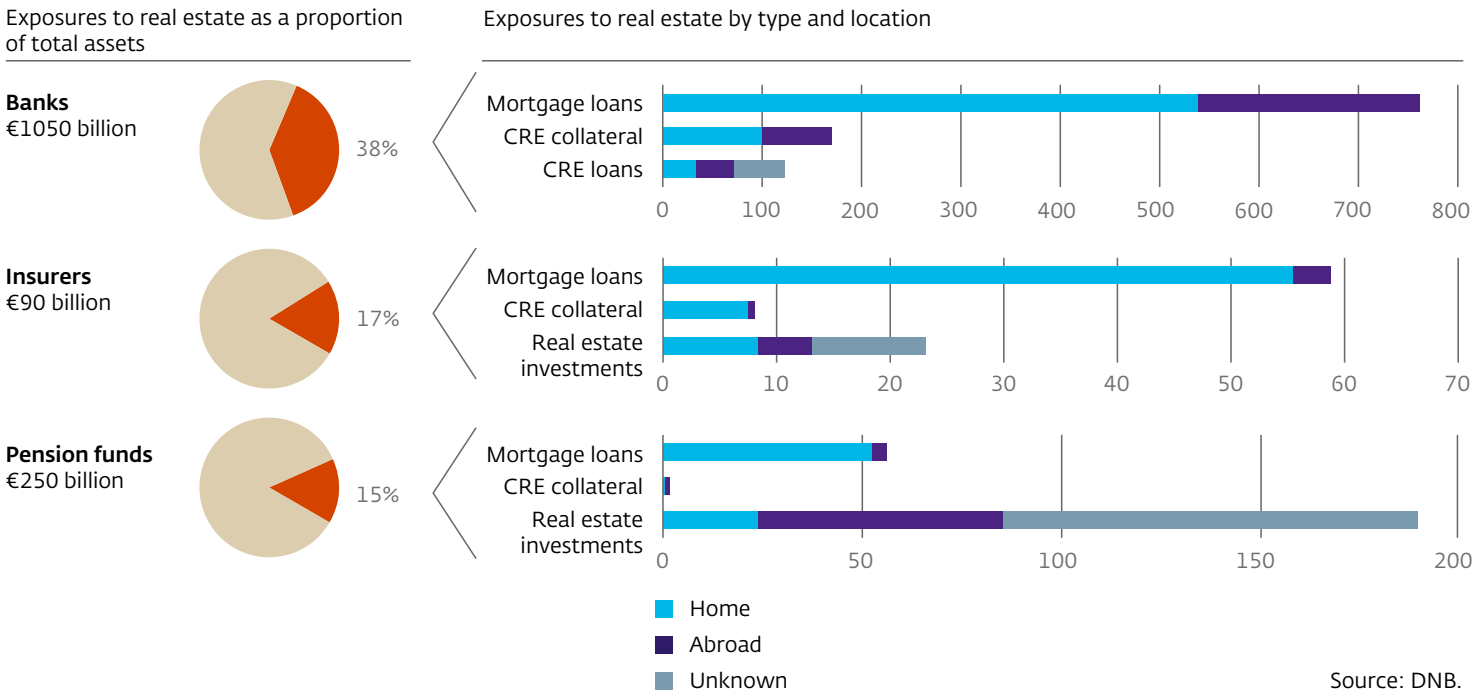
Breakdown of real estate exposures by energy label
See figure 24 →



Loss of value of real estate in six stress scenarios
See figure 22 →

Figure 20 Exposures to real estate

EUR billions

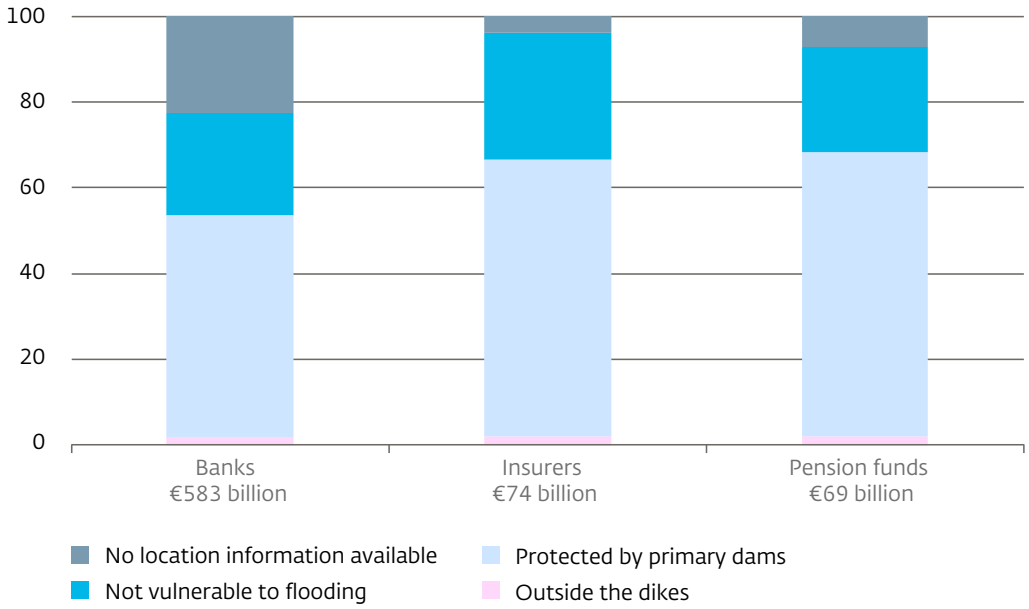


Source: DNB.

Notes: CRE collateral: loans secured on commercial real estate. CRE loans: financing of commercial real estate. Real estate investments: investments in buildings, securitisations and real estate funds and companies. The exposures for which the location of the real estate is 'unknown' concern almost exclusively foreign real estate funds.

Figure 21 Flood risk and Dutch real estate

Percentages

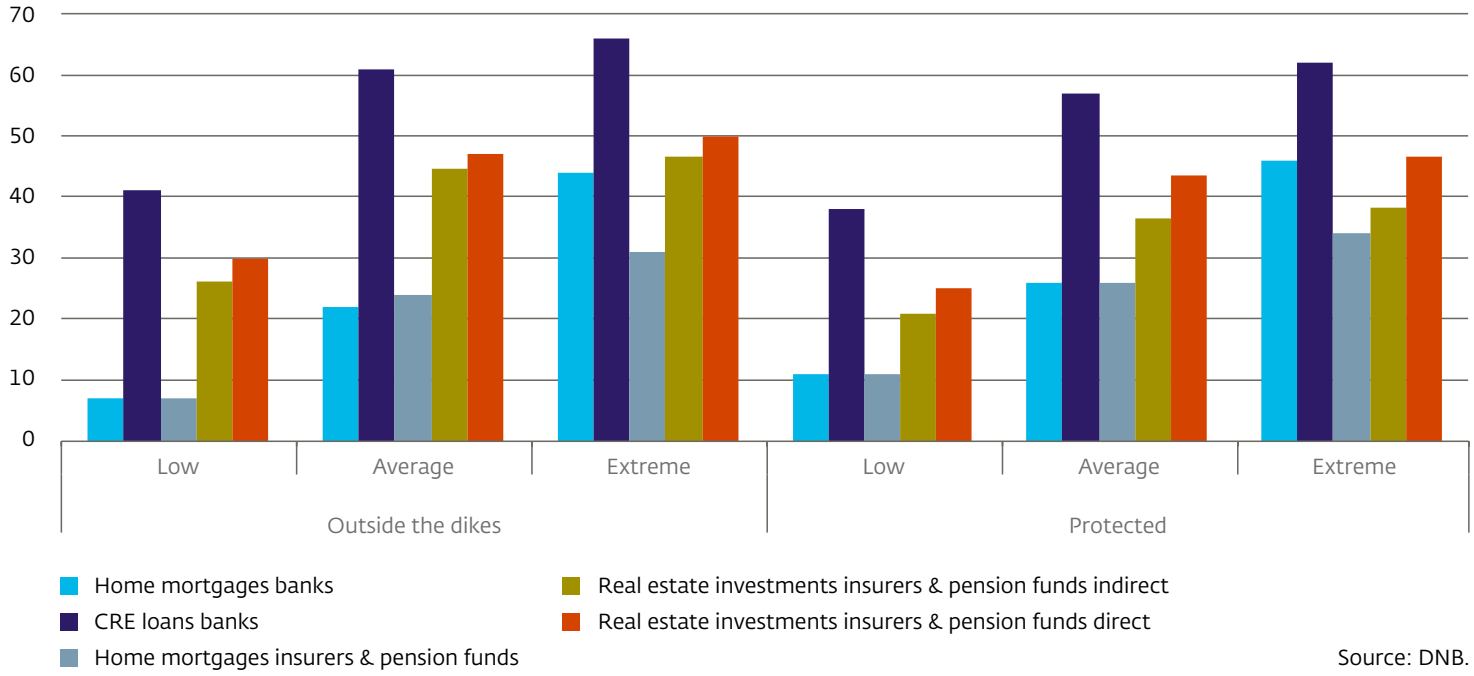


Source: DNB.

Notes: A part of the Dutch real estate exposures is missing, as DNB does not have data on the level of individual loans or buildings for this.

Figure 22 Loss of value of real estate in six stress scenarios

Percentage points

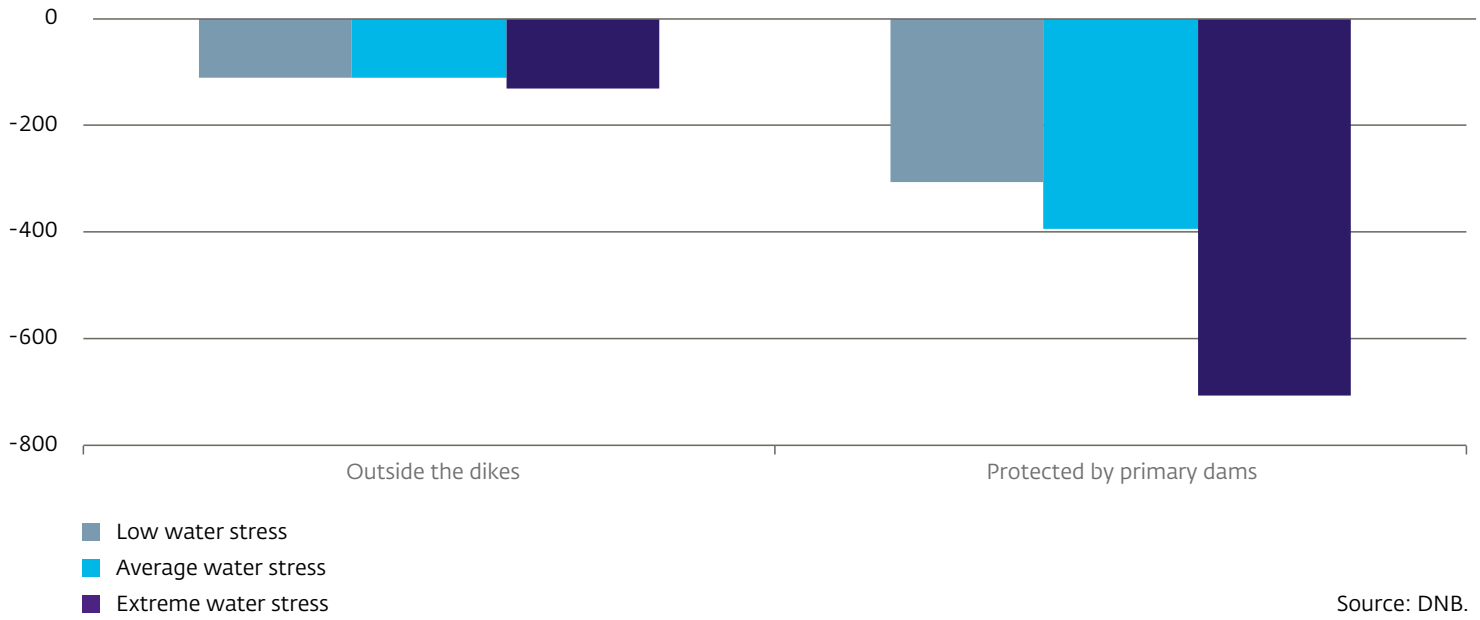


Source: DNB.

Note: Calculations by DNB based on granular data used to compile Figure 21. This shows the estimated decrease in value of real estate in percentage points for two types of flood, in each case with three levels of water stress (low, average, extreme).

Figure 23 Capital impact in six flood scenarios

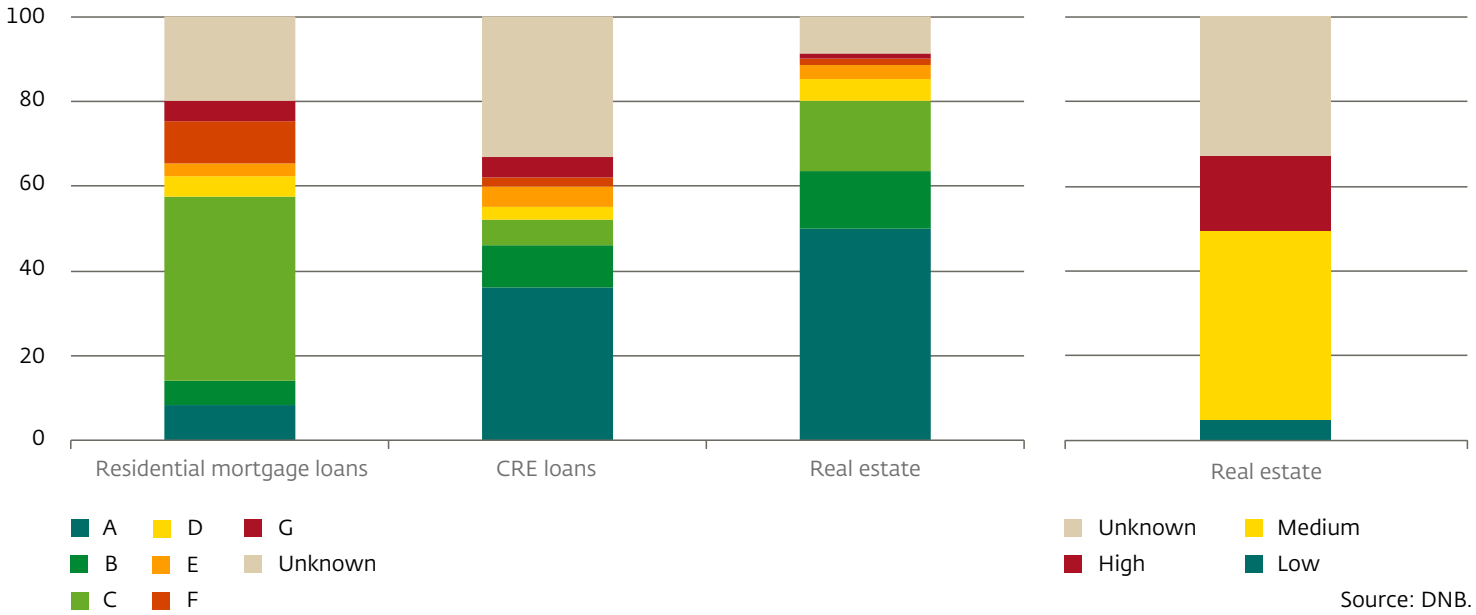
Fall in banks' CET1 ratio in basis points



Source: DNB.

Figure 24 Energy characteristics of real estate exposures

Percentages; by energy label (NL, left) and CO_2 intensity (outside NL, right)



Source: DNB.

Notes: data reported by institutions, supplemented with data from CBS and PBL for NL.