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Opportunity windows accelerate action and expand options for climate adaptation in Europe

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Abstract

Climate adaptation must be intensified globally to keep up with increasing climate change impacts. To date, adaptation is mostly driven by climate risks that need to be reduced and little by opportunities. We identify opportunity windows -i.e. favourable conditions for new or upgraded measures- by constructing an evidence-based dataset from qualitative and quantitative sources, and discuss how they can help to progress adaptation. Here we find evidence of past, present and future adaptation opportunity windows throughout Europe. Present and past triggers for opportunity windows include the implementation of European Union Directives and post-disaster recovery funds, and societal support after floods, droughts and wildfires. Future opportunities relate to aging dams and storm surge barriers. Opportunities also emerge from innovations (e.g. through pilots) which could inform new forms of adaptation. Decision-makers can operationalise and seize adaptation opportunities through adaptive pathways planning, but would need to anticipate opening and closing windows.

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Introduction

Climate adaptation efforts worldwide must increase to keep up with climate change and resulting impacts [1]. Although evidence of successful adaptation exists [2], its uptake remains too slow to reduce risks for adverse climate impacts [3], partly due to barriers like conflicting policy priorities, political unwillingness, or lack of resources [4,5].

Climate adaptation is not a one-time effort, but a process over time. Decision-makers will learn from events and anticipate (future) risks. As climate change impacts intensify, the effectiveness of adaptation strategies may fall below acceptable performance thresholds [6] (also referred to as Adaptation Tipping Points), requiring additional action. However, these additional actions may have 'soft limits', and ultimately, under extreme climate conditions, so-called 'hard limits' may be reached, with no measures left to reduce intolerable risks [7,8]. Adaptive pathways planning acknowledges adaptation thresholds and limits, and explores alternative sequences of measures under different futures [9]. In doing so, the approach helps to identify low-regret actions, generating agency and accelerating adaptation, while also allowing for further adaptation as the future unfolds [10].

Although adaptation has so-far mostly been motivated by risks and limits, the notion of adaptation opportunities has emerged as an incentive to adapt [11–14]. The 'windows of opportunity' concept, defined as 'decisions that can limit or enhance the ability to create (…) space for proactive adaptation'[12] (pp.4-5) helps to diagnose the conditions under which opportunities materialize, as for example analysed for retreat in Sweden [15]. Drivers of climate adaptation include (financial) resources, knowledge of climate risks and responses, leadership, social capital and institutional support [13]. The IPCC's 5th Assessment Report[14] identified six types of opportunities: awareness raising, capacity building, tools, policy, learning, and innovation. While opportunities have been described conceptually, to our knowledge, no studies have assessed experiences of opportunity windows that have opened and closed in the past, or may open in the future. Moreover, no approach has been proposed to operationalize adaptation opportunity windows within long-term adaptation planning.

Here, we present a collection of past, present and future adaptation opportunity windows and discuss how to operationalize opportunities through adaptive pathways planning. An evidence-based dataset was constructed to document and stratify characteristics of real-life opportunity windows and their timing from both qualitative and quantitative sources, including the GRanD dams database[16] and desk study of academic and grey literature. We focus on Europe as a pilot area to elaborate and demonstrate what opportunity windows look like in a well-studied, adaptation-rich environment, where policies are diverse but relatively well-aligned through adaptation planning [2,17–19]. We first define adaptation opportunity windows and present one typology with five classes. Next, we present 34 identified adaptation opportunities in Europe, including their classes and timelines. We conclude with recommendation for operationalising adaptation opportunity windows through adaptive pathways planning and key insights.

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Results

Typology of adaptation opportunity windows

Based on a literature review, we define an adaptation opportunity window as a period of time during which a (portfolio of) adaptation measure(s) becomes (more) feasible, affordable, and/or desirable, thus raising the potential for implementation. An adaptation opportunity window is time-bound and will ultimately close. If the measure is not implemented within this window, the opportunity is lost at that point in time; however, missing an opportunity does not necessarily imply a permanent failure to implement. Based on existing climate adaptation literature, we identify different drivers which lead to opening of an opportunity window. We then categorise the identified drivers into one opportunity window typology with five classes:

- Maintenance-driven: opens owing to planned maintenance, end-of-life, or repair of existing risk-reduction measures;
- Resource-driven: opens when the benefits of an adaptation measure outweigh its costs (expressed in a positive net-present value), or after increased availability of financial (e.g. unlocking of funds) or natural (e.g. sand) resources;
- Policy-driven: opens after policy- and/or institutional arrangements, e.g. existing (inter)national and/or local policies (also outside the domain of climate adaptation), or the adoption of climate legislation;
- Value-driven: opens after changes in societal values and/or political context (e.g. change in government) and associated adaptation preferences and support. May include changes in beliefs about nature and/or severity of climate change or in risk perception and tolerance;
- Innovation-driven: opens owing to innovations in adaptation-related technologies and their mainstreaming and upscaling, following successful (local) piloting and/or decrease in costs. Innovative decision-making approaches may also fall under this typology.

Opportunity windows can trigger and reinforce each other (Fig. 1). For example, the election of a new government, reflecting new societal values (value-driven opportunity), may result in new policies and give leaders a stronger mandate to implement measures[13,20–23] (policy-driven). New policies (e.g. tax relief schemes) in turn can unlock funding for specific adaptation measures, stimulating implementation (resource-driven). When policies involve changes in safety and/or protection levels, this may require an upgrade of existing risk reduction infrastructure[24] (maintenance-driven). An extreme weather event and consequent (near) disaster can change society's perception of risk, decrease its tolerance and/or result in the risk being perceived as excessive [13,25,26]. The public sector can catalyse private investment in climate adaptation through the provision of a stable and attractive regulatory framework [27], which may then result in rapid innovation and cheaper technologies, thus speeding up mainstreaming and upscaling, like in the case of photovoltaic technologies[28] (innovation-driven). Societal attitudes towards risk, innovation and adaptation may also influence the appraisal of emerging technologies and the speed of their mainstreaming[29] (innovation-driven). Approaching end-of-life of existing risk-reduction infrastructure may provide an opportunity for implementing new promising technologies (innovation-driven). For example, Tokyo's Arakawa River Improvement Scheme, dating back to 1910-1930, was substituted starting from 1987 with the innovative 'super-levees', levees which are gently sloped, but so wide as to avoid breakages and allow (urban) development to be planned on top of them[30–32].

Adaptation opportunity windows in Europe

We identified 34 opportunity windows in Europe for climate adaptation measures, which either opened and closed in the recent past (2000-2010; 4), remain open today (25) or can be expected to open by 2100 (5). The opportunities were identified through a combination of estimating the end-of-life and/or thresholds of functional lifetime of existing infrastructural measures and qualitative literature analysis including both academic and grey literature (see Methods section). Each adaptation opportunity window is also characterised based on their timing as either past (opened and closed in the past), present (opened in the past and remains open today), and future (expected to open in the future). Fig. 2 shows these opportunities geographically, Fig. 3 specifies the classes they belong to and Fig. 4 their timelines. Timelines of adaptation opportunity windows are described through (range of) years when an opportunity window opened and closed again (past opportunities); when it opened and, when this could be anticipated, when it can be expected to close (present opportunities); or when it is expected to open in the future (future opportunities). Where relevant, date is also included of key events which took place within the opportunity window.

Maintenance-driven opportunity windows are estimated for dams and storm surge barriers based on their operational and functional lifetime, indicating when maintenance or adjustment is needed to contain risk[33,34] (see Methods). These infrastructural measures will (soon) require (major) maintenance or reconstruction, providing an opportunity for adaptation, for example through an upgrade or replacement with new structures with increased climate resilience. 59 dams across Europe are currently past their end-of-life, the majority of which is located in the UK (15), Spain (15) and Germany (7). 23 additional dams are expected to cross their end-of-life by 2030, 69 by 2040, 52 by 2050 and 922 by 2100. The end-of-life of major storm surge barriers in Europe, such as the Thames Barrier (UK), the MOSE (Italy) and the Maeslant Barrier (NL), will also open new opportunity windows towards the end of the century, or earlier, depending on future climate conditions [6,35–38]. The end-of-life of storm surge barriers is an opportunity to upgrade them to larger and more resilient sea-walls (rather than movable barriers), or event substitute them with other adaptation strategies which go beyond traditional protect-strategies, as for example recently explored for Venice [39].

Multiple present resource-driven opportunity windows exist. In low-altitude alpine regions, opportunity windows exist for diversifying tourism in anticipation of the winter-sport tourism business threshold due to snow disappearance [40]. Opportunities for adaptation financing opened in the aftermath of the 2021 Western European floods, the 2023 Slovenia flood and multiple recent wildfires in Greece. The German national government issued a 30 billion euros reconstruction fund after the disastrous flood in Rhineland-Palatinate and North Rhine-Westphalia [41]; the Slovenian government reacted to the floods by drafting a Reconstruction Development and Financing Act and a joint task force with the EU Commission [42]; and the Greek government released compensation and relief allowances for recovery and reconstruction after the Mati and Evia Islands wildfires and issued green bonds for recovery from the Evia event [43].

Future resource-driven opportunity windows, assessed through optimal cost-benefit ratios, occur in flood risk management. Such beneficial benefit-cost ratios can open resource-driven opportunity windows and may change preferences for measures. Assuming a 3°C warming scenario by 2100, a resource-driven opportunity window is now open in Europe for implementing hybrid flood risk management combining different measures, rather than relying on individual measures [44]. The opening of an opportunity window for particular measures can be predicted by considering the dynamics of benefit-cost ratios over time. In Bergen (Norway), a window of opportunity will remain open for building inner barriers for protection against sea level rise until 2059 under RCP8.5. This timing maximises the cost-effectiveness of the barriers, providing the greatest reduction in projected flood damage costs over the 2016-2100 period [45]. Promising innovative methodologies on how to predict the opening of future resource-driven adaptation opportunity windows have been explored by assessing the cost-effectiveness of coastal protection measures and retreat in response to sea level rise in the period 2014-2100, thus indicating the optimal local protection and retreat decision based on a CBA [46,47]; and by identifying economically-optimal adaptation pathways in coastal Europe in the 2020-2150 timescale under three alternative emission scenarios [48].

Policy-driven opportunity windows in Europe relate to EU Directives, climate councils, court cases and disasters. Adaptation measures can contribute to the achievement of the policy goals outlined in the EU Water Framework Directive (WFD) and similar directives for Floods, Birds and Habitats. Timely implementation of measures may avoid penalties included in these directives, which thus determine the opportunity window. For example, more than 90% of surface waters in Belgium (Flanders), northern Germany, and the Netherlands do not meet the WFD requirements, which should be achieved by December 2027 (good status) and 2028 (phase out priority hazardous substances) [49–51]. Three (now closed) opportunity windows were also identified in relation to extreme floods, droughts and/or storms in Sweden, the UK and Italy in the early 2000s, whose impacts resulted in the opening of a policy window for climate adaptation [52]. This opportunity was leveraged in Sweden and the UK, leading to policy and institutional changes, but missed in Italy, where attempts to develop a national adaptation strategy failed (only realized in 2015) and follow-up actions failed to account for future climate impacts, thus indicating the closing of the window [52].

Value-driven opportunity windows opened after disasters like recent drought periods throughout Europe and the 2021 Western European floods because risk perception and tolerance were affected, increasing demand for and acceptability of climate adaptation measures [53,54]. Environmental activism can also open an opportunity window by influencing society's perception of what is important. FridaysForFuture's activism has been associated with bottom-up support for more proactive climate policies [22]. This was reflected in historical wins for Green Parties in the 2019 EU Parliamentary Elections and national elections in Austria, Belgium and Switzerland [22]. Conversely, the declining number of votes for Green Parties in the 2024 EU Parliamentary elections [55] may suggest that the associated value-driven opportunity window is closing.

Innovation-driven opportunity windows can open given emerging adaptation technologies. We refer to evidence of successful adaptation documented in IPCC reports as examples of innovation-driven opportunities, as these build arguments for replicating successful approaches elsewhere. One example is the Sand Engine, a sand-engineering measure making effective use of natural forces to distribute sand over time and space, thereby saving the cost of comparable human activities [56,57]. The measure was first tested on the Dutch coast (NL), and has recently been replicated in Bacton, Norfolk (UK)[58,59]. The success of the measure in the Netherlands has opened the opportunity for replication in similar shallow water environments where suppletion of sand is needed. Similarly, floating and amphibious housing is an emerging technology which allows building in flood-prone areas and within calm waters in cities [60]. Successful pilots have been documented in multiple locations in the Netherlands, Copenhagen and London, and the opportunity window remains open while further pilots and designs are tested. Additional innovative adaptation measures and technologies related to emerging opportunities include room for the river measures – creation of retention areas that can be flooded to temporarily store excess water during storm events [61]-, water desalination [62,63], transitional polders - a flood risk management strategy between double dikes [64], and biogenic-reefs of mussels or oysters for coastal protection from erosion [65]).

New innovation-driven opportunity windows may open in the Netherlands around 2033, at completion of the National Growth Fund Funds ('Groeifonds') projects. The Growth Fund is a governmental initiative for projects with potential to leverage sustainable and structural national economic growth, which provides funding for 10 years [66]. A few of these projects inform climate adaptation, such as NL2120 on the financial potential of Nature-based Solutions (NbS) [67] and Re-Ge-NL on regenerative agriculture combining food production and climate restoration [68]. Depending on the final results, these may open opportunity windows for prototyping and upscaling different NbS, land management systems, and pricing the value of nature to be mainstreamed in the Netherlands and elsewhere.

Open opportunity windows are often a legacy of drivers over past years (Fig. 4), as demonstrated by at least five of the identified opportunities. For instance, multiple droughts since the early 2000s have built enhanced risk awareness, and resulted in calls for establishing an EU Droughts Directive, a value-driven opportunity window yet to be leveraged [69]. Similarly, small-scale testing of innovative measures (e.g. floating houses) has raised confidence in their effectiveness, opening innovation-driven opportunity windows. Overall, we identify multiple (near) disasters in a relatively short time (see droughts in Europe, wildfires in Greece, and floods and storms in Sweden examples), and multiple small-scale successful pilots as key legacy drivers which can result in opening of opportunity windows. Additionally, one individual driver can result in opening up multiple opportunity windows, sometimes even at different timescales. This was for example the case after the 2021 floods in Germany, which triggered resource-, maintenance-, policy-, and value-driven opportunities, some in the immediate aftermath, others during the reconstruction phase and others in the longer term [41,53].

Opportunities have a finite window, and the possibility that these may (soon) close, and the conditions under which that might happen, should be accounted for in adaptation planning. Maintenance-driven opportunities close when the aging infrastructure is damaged to such an extent that it does not meet the safety standards anymore, and maintenance is triggered by a risk threshold rather than an opportunity. Innovation-driven opportunity windows may close when local pilots are unsuccessful, when successful measures are met with lack of acceptance, or when newer and better technologies emerge. Resource-driven opportunities can instead be expected to close when the costs exceed the benefits, or when finances are scarce. The closing of policy-driven windows may follow closing of implementation windows, finite mandate of governments, and change in policy priorities (due to external shocks, like for example the COVID-19 crisis[22]). For example, opportunity windows associated with the implementation of the WFD will close by 2027-2028, when non-complying member states will receive fines. Finally, opportunity windows that rely on public perceptions (value-driven) are governed by time-varying changes in these perceptions, such as may be experienced in the aftermath of a disaster. Individuals who have experienced flooding and/or evacuation in the past have a higher perceived flood probability, and properties in floodplains decline in price immediately after a flood [70–72]. Nevertheless, in absence of subsequent flooding events, the associated window of opportunity only remains open for a period of 4-10 years, when the effect on house pricing disappears [71,73–75].

Some opportunity classes are easier to predict than others. Maintenance-driven opportunities can easily be anticipated, as the end-of-life of infrastructure measures is well constrained and insensitive to changing climate or societal conditions. Opening of other classes of opportunity windows will generally be affected by the unfolding future, and not straightforward to position in time. Approaches developed for dealing with (deep) uncertainties, like adaptive pathways planning, may be useful to account for future opportunity windows. In the next section we propose how adaptation opportunities may be leveraged through adaptive pathways planning.

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Leveraging opportunities within their window with adaptive pathways planning

The opening of a window does not automatically lead to leveraging of the opportunity [13,52,76]. Actors responsible for climate adaptation can better exploit opportunities when they have prepared for their opening in advance. Incorporating opportunity windows within adaptive pathways planning can further facilitate their exploitation. Within adaptive pathways planning, short-term actions and long-term adaptation options are identified to develop an adaptive plan that can be implemented depending on how the future unfolds [9,77,78]. The aim is to support decision making under uncertainty and make decisions that do not lock-in investments, but allow for flexibility to change path and avoid maladaptation. A key step in the approach is the identification of multiple alternative sequences of adaptation measures (adaptation pathways), where new measures in a pathway are implemented once the limits of previous measures have been reached. The resulting pathways are visualised through a so-called pathways map, which can take different forms, like metro-maps, decision trees or bar plots [10]. The plan is complemented with monitoring to derive signals of changing conditions -such as climate change and opportunities- to determine when implementation of follow-up actions or adjustment of the plan is needed. Incorporating opportunity windows strengthens the approach to seize opportunities.

We illustrate how the opening of any of the opportunities may impact an adaptive plan based on the identified opportunity windows and comparing them to a stylised pathways map. We identified four ways in which this may happen. Fig. 5 showcases how three of the four impacts can be visualized within an adaptation pathways metro-map, showing alternative sequences of adaptation options over time. The fourth and last impact does not impact the pathways map, but rather influences the evaluation of pathways alternatives, and thereby influences the adaptive plan. An opening opportunity window can result in:

1. Advancing the implementation of a measure, so that it is implemented before the limit of existing measures is reached (anticipation of action A in Fig. 5);
2. Postponement of the previously identified limit of a measure, through improving its effectiveness despite increasing climate impacts (postponement of action C in Fig. 5);
3. Widening of the solution space, by opening it up to alternative measures or strategies (shift from action A to action E in Fig.5);
4. Changes in priority ranking of different pathway alternatives, as a result of changes in pathway evaluation.

Adaptation opportunity windows can be used for the design of the adaptive pathways plan and for the implementation of the adaptive plan. During the design stage, opportunity windows – especially those that tend to arise unexpectedly, such as post-disaster or value-driven opportunities- can be integrated through what-if scenarios to assess their potential impact on the adaptive plan. Another contribution can be to help identify whether (and when) any opportunities need to be created to ensure that adaptation objectives remain achievable in the long term, through for example the creation of policy-directives, policies, and councils (policy-driven opportunities), recovery funds (resource-driven), and innovations (innovation-driven). During the design and implementation stage of the adaptive plan, pre-identified opportunities guide what to monitor so that emerging opportunity windows can be detected and trigger the execution of prepared action plans. Incorporating opportunity scanning into the monitoring process also reduces the need to predict when opportunities will arise, a task that is complex for most opportunity classes, except maintenance-driven ones.

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Conclusions

This paper provides an inventory and typology of adaptation opportunity windows, both existing today and arising in the future in Europe. In doing so, we complement existing literature which described possible opportunities for climate adaptation [11–15]. In addition, we present how adaptation opportunities can become part of an adaptive planning cycle to facilitate the leveraging within the opportunity window. We found five classes of opportunity windows. Of the 34 opportunity windows found, 25 could help to accelerate adaptation now, four existed in the past but are now closed, and five can be leveraged in the future if anticipated.

Although some opportunities emerge, like those driven by external shocks like (near) disasters, others can be created. Governmental actors across scales are key driving forces for this, especially through the implementation of European Directives, establishment of green growth funds and creation of reconstruction/emergency funds in the aftermath of extreme events. When successful, pilots, may open innovation-driven opportunities for upscaling, replicating and mainstreaming. Moreover, the private sector -alone or through public-private collaborations- can create opportunities for new measures or provide the finance needed for leveraging of opportunities (innovation-driven opportunities).

Seizing adaptation opportunities is thus not only a reactive exercise, but also one of proactive action as part of adaptive pathways planning, which may take different forms depending on the opportunity window class. Aging infrastructure, for example, associated with both present and future maintenance-driven opportunity windows, lends itself well to being anticipated in adaptation planning, while the opening of other classes of opportunity windows can be hard to foresee, which can be overcome by continuous monitoring. Extreme events may open opportunities, especially if anticipated with plans for when they emerge. At the same time, windows opening in the follow-up of unexpected events can also be leveraged, particularly when what-if scenarios have been planned for in advance by accounting for plausible opportunities in the adaptive plan.

The 34 opportunities identified in this research are not exhaustive, and more may exist today, or open in the future. The exercise presented here showcases that evidence of adaptation opportunity windows can be found with an elementary research method, particularly when using the opportunity window classes. Future research may complement this first-order assessment with more quantitative and systematic assessments of opportunities of a specific class, or within specific spatial scales. For resource-driven opportunities, and particularly future ones, further methodological developments along the lines of [46–48] may be of use. This research only focuses on opportunities across Europe, but the concept can be applied to different regions, inspired by the examples in this paper. Some opportunities can be expected to only be relevant to a specific context, while others may be replicated across countries and scales. Disasters in one country have, for example, been found to open opportunity windows elsewhere [79]. Whether extreme events will also open policy- and particularly resource-driven opportunity windows may depend on the governance and financial capacity of the affected community. In general, when assessing present opportunity windows, we recommend first looking at aging infrastructure, existing policies and associated implementation deadlines with synergies with adaptation goals.

We argue that considering adaptation opportunity windows in adaptive pathways planning can support actors in leveraging these opportunities before their windows close and further strengthen adaptive plans though creating and monitoring opportunities. Adaptation opportunities provide agency to policy prioritization of measures for implementation (when the window is still open) and those which can be postponed until (foreseeable) future opportunity windows may open. Hereby, adaptation opportunities complement existing approaches and provide a somewhat more positive outlook to the reality of climate adaptation, which may particularly resonate under current societal discourse, advancing adaptation and widening the existing solution space for adaptation.

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Methods

This section is intended to be complemented with the information provided in Supplementary Information and in Online Datasets[80], which includes the following:

-Online Dataset 1: Full list of the identified adaptation opportunity windows, their description and analysis; list of countries in the area of study; distribution of the identified opportunities across countries; and timeline of each adaptation opportunity including (projected) year of opening of opportunity window, any events within the window and year of window closing (for past opportunity windows).

-Online Dataset 2: Full list of dams from the GranD dataset[16] and calculation of time passed since their construction date, including analysis of number and percentage of dams per opportunity type and their distribution across the area of study.

-One Supplementary information file, divided into two sections:

Supplementary Notes 1: Definition of adaptation opportunity windows, list of opportunity window classes, and associated literature

Supplementary Notes 2: Plausible impact of opportunity window typologies on a pathways map

Definition and conceptualization of adaptation opportunities

To define and conceptualize adaptation opportunity windows, we started by carrying out a literature review on the use of the term 'opportunity' in climate adaptation planning literature. We then complemented our findings with the existing definition of adaptation opportunity tipping points[11], so as to come up with an updated definition. Finally, we further explored the literature to identify main adaptation opportunity classes. Table 1 below summarizes the identified typologies and associated literature, additional detail on which aspects of the literature informed the classes is presented in Supplementary Information (Supplementary Notes 1; Supplementary Table 1).

Mapping adaptation opportunity windows in Europe

As a next step, evidence was collected on opportunity windows in Europe. This resulted in the identification of a total of 34 opportunity windows. The study area, referred in the main text generally as Europe, includes all European Union member countries, European Free Trade Association (EFTA) countries and the United Kingdom, for a total of 32 countries. The full list of considered countries is presented in Online Dataset 1[80].

Past, present and future opportunity windows were looked for. Past adaptation opportunity windows are those opportunities which opened up in the recent past, and can be considered as closed today. Past opportunities may have been taken or missed. Present adaptation opportunity windows have opened up in the (recent) past and remain open today. Future adaptation opportunity windows can be expected to open in the near- or long-term future based on the information available today.

Opportunity windows were assessed through a combination of methods, also depending on the opportunity type. The full list of adaptation opportunities, their analysis and associated references is presented in Online Dataset 1[80].

Maintenance-driven opportunities were quantitatively assessed for dams in the case study area by relating them to their (upcoming) end-of-life. A list of existing dams, their coordinates and year of construction were obtained from the GRanD database[16] (v.1.3). The database includes for the most part dams associated with reservoirs with more than 0.1km3 storage capacity, but includes a few dams for smaller reservoirs when data for them was available [16]. Dams without an indicated construction date were excluded from the list. When two construction dates were indicated for a single dam (under the column date, and alt_date), the latest of the two was taken. This resulted in the identification of 1145 dams across 28 countries. Maintenance-driven opportunity windows associated with existing dams were identified by calculating the number of years since their construction (reference year 2025), assuming an end-of-life of 100 years, which is commonly identified as the lifetime of a well-designed, well-constructed and well-maintained and monitored dam[33,34]. Dams already past their end-of-life were considered as open maintenance-driven opportunity windows, as these can soon be expected to require maintenance or (major) updates. For estimating the opening of future maintenance-driven opportunity windows, we calculated the number of dams which would pass their end-of-life by 2030, 2040, 2050 and 2100. The full list of dams from taken from the GranD dataset[16], and identified opportunities within them are listed in Online Dataset 2[80].

To broaden the scope of our assessment, we also manually added information from (grey) literature on three major storm surge barriers in Europe, namely the Thames Barrier in London (UK), MOSE barrier in Venice (Italy), and the Maeslant barrier in Rotterdam (the Netherlands). For the storm surge barriers, the opening of the associated maintenance-driven opportunity windows was determined based on approaching thresholds of functional lifetime as identified in academic literature and policy documents. The Thames barrier is currently projected to remain in use until 2070 [37,38]. The MOSE was originally constructed with an intended design life of a 100 years, which would ensure its operability until around 2120. Nevertheless, climate change and associated SLR was not accounted for in the initial design, and the threshold of the barrier could thus be reached earlier due to increase of number and length of closures [35,39]. Assuming no changes in the current closure threshold (110cm), the number of closures would increase to an unsustainable amount by 2050-2060. When instead assuming an increase in the closure threshold to 130cm, more time could be gained, with more than 20 closures per year only expected in the 2080s-2090s under RCP2.6 and or 2070s-2080s under RCP 8.5 [35]. It is not expected that the threshold of the Maeslant barrier will be reached in the foreseeable future, but continuous increase in the number of needed closures may lead to a threshold related to limited access to the Rotterdam harbour or to a reduction of the barrier's operational life-time. Assuming a limit of one opening per year, the threshold may be reached by 2100 under the Dutch Delta Scenarios, or even around 2075 under IPCC projections with accelerated SLR [6,36].

Policy-, value-, resource- and innovation-driven opportunities were all assessed qualitatively, by collecting evidence of each typology through both academic and grey literature. Evidence was initially looked for with prompts related to the definitions of each opportunity typology, followed by snowballing methods. Academic literature and policy documents were also analysed which related to the follow-up of recent extreme climate events throughout Europe, namely the 2021 Western European Floods, 2023 Slovenia floods, multiple recent wildfires in Greece (2007, 2018, 2021, 2023), and drought events throughout Europe in the 2018-2022 period. For innovation-driven opportunities, evidence of successful examples of adaptation which could be replicated elsewhere were collected from the IPCC Water Chapter [81], in the section on benefits and effectiveness of water-related adaptations, their limits and trade-offs.

Analysis of adaptation opportunity windows

For each identified adaptation opportunity, comparable information was collected to facilitate analysis and comparisons. In addition to a short description, each opportunity was analysed based on: opportunity class, timing, year when window opened and closed (when relevant), impact of the opportunity window on a pathway, spatial scale, and location.

In terms of opportunity class, each identified opportunity was classified as either maintenance-, value-, policy-, resource-, and/or innovation driven, with multiple selections possible. The timing of each opportunity window was classified as either past, present or future. Additionally, past (closed) opportunity windows were also differentiated based on whether these have been taken or missed. The timing was further specified by indicating relevant year(s) when a window opened and closed. These refer to either the (range of) years when an opportunity window opened and closed again (in case of past opportunities); when it opened (present opportunities) and, if this can be anticipated, when this can be expected to close; or when it is expected to open in the future (future opportunity windows). When relevant, information (and date) was also added of key events which took place (and often reinforced, or where further evidence of) within the opportunity window. The impact that each opportunity windows would have on an existing pathway is expressed for each opportunity window as either anticipating implementation, postponing of adaptation tipping point, broadening of the solution space, and/or changing pathways ranking, with multiple selections possible (see results section of the main text for further explanation). This information was filled in based on expert judgement from the authors team and associated experience with adaptation pathways. Additional explanation on the reasoning behind the answers and identified patterns across opportunity window typologies are provided in Supplementary Notes 2. Spatial scale was characterized as either local, regional, national (one or multiple countries), Europe and/or global, and it refers to the geographical area from which the opportunity windows originate.

Limitations and future research

This research identifies opportunity windows in past, present and future of different typologies across Europe. We also indicate how identifying opportunities in the adaptive pathways planning cycle can help leverage these and advance climate adaptation. Still, two main limitations should be discussed, particularly about the exhaustiveness of the opportunity list and their leveragability.

In this research we identify a total of 34 adaptation opportunities across Europe. This number should not be understood as exhaustive, and many more adaptation opportunity windows may have existed and closed in the past, may be open today and may be anticipated and open in the future. Our research is instead intended as a first-order assessment of adaptation opportunities across five classes, so to showcase the broad range of opportunity examples which can be pointed at and leveraged in Europe. Future research may then complement our work by more extensively and systematically map adaptation opportunities from specific classes and or in individual (sub-)national scales. The quantitative assessment of adaptation opportunities in particular could be further expanded on in future research. For example, similar assessment could be carried out as the one presented here for aging dams to other structural measures, as long as data on construction dates is available. For quantitative assessment (and anticipation of timing of) future opportunities, quantitative methodologies such as [46–48] could be further explored, so to more systematically assess resource-driven opportunities. Finally, although this research focused on Europe, the adaptation opportunities concept can easily be applied elsewhere, and we welcome future assessments outside of the European context. Future research may then explore which adaptation opportunity classes are consistent across contexts, and which are instead particularly context-bound.

The leveragability of identified adaptation opportunities should also be further explored. In this research, we propose to embed the adaptation opportunity windows within adaptive pathways planning, so to facilitate the exploitation of open opportunity widows by including these in long-term planning, and by continuously scanning for new opening windows through monitoring. By definition, the existence of an open adaptation opportunity implies that a (portfolio) of measure(s) has become (more) feasible, affordable, and/or desirable. Although this raises the potential for implementation, particularly when the potential opening of the window had been anticipated, this may not always be enough, as multiple things need to be right for measures to be implemented [82] In some cases, 'just' the opening of an innovation-driven opportunity window may then not be sufficient to trigger implementation, for example due to shortcomings in terms of acceptability of new measures (no value-driven opportunity) or political stagnation (no policy-driven opportunity). Those opportunities belonging to multiple classes at the same time, such as post-disaster recovery from the 2021 floods, or the replication of Room for the River projects (Fig. 3, bottom-right map), may be more easily leveraged than others, as they reflect an overall-suitable environment for adaptation implementation. Future research may further explore which combinations of adaption opportunities may be most suitable for implementation, and how decision-makers may deal with shortcomings when the context may not be optimal, but action is nonetheless required.

Data availability statement

All data and calculations are presented either in Supplementary Material 1, or the two Online Datasets. The two online datasets are publicly available in Figshare can be accessed through the following link: https://doi.org/10.6084/m9.figshare.31249858 Part of this research incorporates data from the GRanD database (http://globaldamwatch.org/) which is © Global Water System Project (2011).

Reference list

1. Calvin, K. *et al. IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (Eds.)]. IPCC, Geneva, Switzerland.* (2023) doi:10.59327/IPCC/AR6-9789291691647.

2. IPCC. Europe. in *Climate Change 2022 – Impacts, Adaptation and Vulnerability* 1817–1928 (Cambridge University Press, 2023). doi:10.1017/9781009325844.015.

3. United Nations Environment Programme. *Adaptation Gap Report 2024: Come Hell and High Water - As Fires and Floods Hit the Poor Hardest, It Is Time for the World to Step up Adaptation Actions*. (2024).

4. Birchall, S. J., Bonnett, N. & Kehler, S. The influence of governance structure on local resilience: Enabling and constraining factors for climate change adaptation in practice. *Urban Clim.* **47**, 101348 (2023).

5. Malekpour, S. & Newig, J. Putting adaptive planning into practice: A meta-analysis of current applications. *Cities* **106**, 102866 (2020).

6. Kwadijk, J. C. J. *et al.* Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. *WIREs Climate Change* **1**, 729–740 (2010).

7. IPCC. Glossary. in *Climate Change 2022 – Impacts, Adaptation and Vulnerability* 2897–2930 (Cambridge University Press, 2023). doi:10.1017/9781009325844.029.

8. Dow, K. *et al.* Limits to adaptation. *Nat. Clim. Chang.* **3**, 305–307 (2013).

9. Haasnoot, M., Kwakkel, J. H., Walker, W. E. & ter Maat, J. Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change* **23**, 485–498 (2013).

10. Haasnoot, M., Di Fant, V., Kwakkel, J. & Lawrence, J. Lessons from a decade of adaptive pathways studies for climate adaptation. *Global Environmental Change* **88**, 102907 (2024).

11. Haasnoot, M. *et al.* Generic adaptation pathways for coastal archetypes under uncertain sea-level rise. *Environ. Res. Commun.* **1**, 071006 (2019).

12. Brown, K., Naylor, L. A. & Quinn, T. Making space for proactive adaptation of rapidly changing coasts: A windows of opportunity approach. *Sustainability (Switzerland)* **9**, (2017).

13. Brullo, T., Barnett, J., Waters, E. & Boulter, S. The enablers of adaptation: A systematic review. *npj Climate Action 2024 3:1* **3**, 1–8 (2024).

14. IPCC. Adaptation opportunities, constraints, and limits. in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects.* 899–943 (Cambridge University Press , Cambridge , 2014).

15. Göransson, G., Van Well, L., Bendz, D., Hedfors, J. & Danielsson, P. Opportunities for planned retreat and flexible land use in Sweden: Local, regional and national governance perspectives. *Clim. Risk Manag.* **41**, 100530 (2023).

16. Lehner, B. *et al.* High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. *Front. Ecol. Environ.* **9**, 494–502 (2011).

17. Magnan, A. K. *et al.* Status of global coastal adaptation. *Nat. Clim. Chang.* **13**, 1213–1221 (2023).

18. Reckien, D. *et al.* How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *J. Clean. Prod.* **191**, 207–219 (2018).

19. McEvoy, S., Haasnoot, M. & Biesbroek, R. How are European countries planning for sea level rise? *Ocean Coast. Manag.* **203**, 105512 (2021).

20. Soroka, S. N. & Christopher Wlezien. *Degrees of Democracy: Politics, Public Opinion, and Policy.* (Cambridge University Press, 2010).

21. Wlezien, C. The public as thermostat: dynamics of preferences for spending. *Am. J. Pol. Sci.* 981–1000 (1995).

22. Winkelmann, R. *et al.* Social tipping processes towards climate action: A conceptual framework. *Ecological Economics* **192**, 107242 (2022).

23. Solecki, W., Orlove, B. & Bolgert, A. The Role of Catalysts in the Climate Adaptation Process. *WIREs Climate Change* **16**, (2025).

24. van der Most, H., Tánczos, I., de Bruijn, K. & Wagenaar, D. New, risk-based standards for flood protection in the Netherlands. in *6th International Conference on Flood Risk Management* (Sao Paulo , 2014).

25. Rosenzweig, C. & Solecki, W. Hurricane Sandy and adaptation pathways in New York: Lessons from a first-responder city. *Global Environmental Change* **28**, 395–408 (2014).

26. Patterson, J. J. More than planning: Diversity and drivers of institutional adaptation under climate change in 96 major cities. *Global Environmental Change* **68**, 102279 (2021).

27. Pauw, W. P., Kempa, L., Moslener, U., Grüning, C. & Çevik, C. A focus on market imperfections can help governments to mobilize private investments in adaptation. *Clim. Dev.* **14**, 91–97 (2022).

28. Ding, H., Zhou, D. Q., Liu, G. Q. & Zhou, P. Cost reduction or electricity penetration: Government R&D-induced PV development and future policy schemes. *Renewable and Sustainable Energy Reviews* **124**, 109752 (2020).

29. Fritz, L., Baum, C. M., Brutschin, E., Low, S. & Sovacool, B. K. Climate beliefs, climate technologies and transformation pathways: Contextualizing public perceptions in 22 countries. *Global Environmental Change* **87**, 102880 (2024).

30. Zhang, Y., Shen, Z. & Lin, Y. The Construction of Water-Sensitive Urban Design in the Context of Japan. *IOP Conf. Ser. Earth Environ. Sci.* **691**, 012015 (2021).

31. Nakamara, H., Shiozaki, Y. & Kato, T. Super levees along the Arakawa River in Tokyo: Evaluation from the viewpoint of spatial planning in a low-lying area. in *International Conference on Flood Resilience: Experiences in Asia and Europe (ICFR2013)* (2013).

32. McKean, C. A. Tokyo Building Enormous “Super-Levees” to Hold Back Its River. *Next City* (2013).

33. Wieland, M. & Mueller, R. Dam safety, emergency action plans and water alarm systems-Martin Wieland and Rudolf Mueller discuss the integral safety concept for large dams. *International water power dam construction* **61**, 34 (2009).

34. Perera, D., Smakhtin, V., Williams, S., North, T. & Curry, A. *Ageing Water Storage Infrastructure: An Emerging Global Risk*. https://seprem.es/articulos_f/Debate_Riesgo/Ageing-Water-Storage-Infrastructure-AnEmerging-Global-Risk_web-version.pdf (2021).

35. Giupponi, C. *et al.* Boon and burden: economic performance and future perspectives of the Venice flood protection system. *Reg. Environ. Change* **24**, 44 (2024).

36. Haasnoot, M. *et al.* Adaptation to uncertain sea-level rise; how uncertainty in Antarctic mass-loss impacts the coastal adaptation strategy of the Netherlands. *Environmental Research Letters* **15**, 034007 (2020).

37. Hall, J. W., Harvey, H. & Manning, L. J. Adaptation thresholds and pathways for tidal flood risk management in London. *Clim. Risk Manag.* **24**, 42–58 (2019).

38. Penning-Rowsell, E. C., Haigh, N., Lavery, S. & McFadden, L. A threatened world city: the benefits of protecting London from the sea. *Natural Hazards* **66**, 1383–1404 (2013).

39. Lionello, P. *et al.* Pathways for adaptation of Venice and its lagoon to sea-level rise. Preprint at https://doi.org/10.21203/rs.3.rs-7420349/v1 (2025).

40. van Ginkel, K. C. H. *et al.* Climate change induced socio-economic tipping points: review and stakeholder consultation for policy relevant research. *Environmental Research Letters* **15**, 023001 (2020).

41. Birkmann, J. *et al.* Strengthening resilience in reconstruction after extreme events – Insights from flood affected communities in Germany. *International Journal of Disaster Risk Reduction* **96**, 103965 (2023).

42. Umek, G. European Water Summit - Transnational water security . Preprint at https://www.vlaamsewaterweg.be/sites/default/files/download/ppt_water_summit.pdf (2024).

43. OECD. *Taming Wildfires in the Context of Climate Change: The Case of Greece* . https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/06/taming-wildfires-in-the-context-of-climate-change-the-case-of-greece_754f2c60/cfb797a7-en.pdf (2024).

44. Dottori, F., Mentaschi, L., Bianchi, A., Alfieri, L. & Feyen, L. Cost-effective adaptation strategies to rising river flood risk in Europe. *Nat. Clim. Chang.* **13**, 196–202 (2023).

45. Thorarinsdottir, T. L., Guttorp, P., Drews, M., Kaspersen, P. S. & de Bruin, K. Sea level adaptation decisions under uncertainty. *Water Resour. Res.* **53**, 8147–8163 (2017).

46. Lincke, D. & Hinkel, J. Coastal Migration due to 21st Century Sea-Level Rise. *Earths Future* **9**, (2021).

47. Lincke, D. & Hinkel, J. Economically robust protection against 21st century sea-level rise. *Global Environmental Change* **51**, 67–73 (2018).

48. Völz, V. *et al.* The economically optimal mix and timing of coastal adaptation in Europe to 2150. Preprint at https://doi.org/10.21203/rs.3.rs-6314787/v1 (2025).

49. ClientEarth. *Key Deadlines under the Water Framework Directive* . https://www.clientearth.org/media/br0pedp4/clientearth-legal-paper_key-deadlines-under-the-wfd.pdf (2023).

50. European Commission. Water Framework Directive . https://environment.ec.europa.eu/topics/water/water-framework-directive_en.

51. European Environmental Agency. Ecological status of surface waters in Europe. https://www.eea.europa.eu/en/analysis/indicators/ecological-status-of-surface-waters?activeAccordion= (2021).

52. Keskitalo, E. C. H., Westerhoff, L. & Juhola, S. Agenda-setting on the environment: the development of climate change adaptation as an issue in European states. *Environmental Policy and Governance* **22**, 381–394 (2012).

53. Garside, S. & Zhai, H. If not now, when? Climate disaster and the Green vote following the 2021 Germany floods. *Research & Politics* **9**, (2022).

54. Biella, R. *et al.* The 2022 drought needs to be a turning point for European drought risk management. *Natural Hazards and Earth System Sciences* **25**, 4475–4501 (2025).

55. European Parliament. Comparative Tool. https://results.elections.europa.eu/en/tools/comparative-tool/.

56. Brière, C., Janssen, S. K. H., Oost, A. P., Taal, M. & Tonnon, P. K. Usability of the climate-resilient nature-based sand motor pilot, The Netherlands. *J. Coast. Conserv.* **22**, 491–502 (2018).

57. Stive, M. *et al.* The Sand Engine: a solution for vulnerable deltas in the 21st century? in (7th International Conference Coastal Dynamics 2013 Conference paper, Arcachon, France, 2013).

58. Lorenzoni, I., Day, S. A., Mahony, M., Tolhurst, T. J. & Bark, R. H. Innovation in coastal governance: management and expectations of the UK's first sandscaping scheme. *Reg. Environ. Change* **24**, 101 (2024).

59. North Norfolk District Council. Bacton to Walcott Coastal Management . https://www.north-norfolk.gov.uk/sandscaping.

60. Penning-Rowsell, E. Floating architecture in the landscape: climate change adaptation ideas, opportunities and challenges. *Landsc. Res.* **45**, 395–411 (2020).

61. Zevenbergen, C., Rijke, J., van Herk, S. & Bloemen, P. Room for the River: a stepping stone in Adaptive Delta Management . *International Journal of Water Governance* 121–140 (2015).

62. Morote, Á., Rico, A. & Moltó, E. Critical review of desalination in Spain: a resource for the future? *Geographical Research* **55**, 412–423 (2017).

63. Navarro, T. Water reuse and desalination in Spain – challenges and opportunities. *Journal of Water Reuse and Desalination* **8**, 153–168 (2018).

64. Weisscher, S. A. H., Baar, A. W., van Belzen, J., Bouma, T. J. & Kleinhans, M. G. Transitional polders along estuaries: Driving land-level rise and reducing flood propagation. *Nature-Based Solutions* **2**, 100022 (2022).

65. Islam, M. *et al.* Inducing mussel beds, based on an aquaculture long-line system, as nature-based solutions: Effects on seabed dynamics and benthic communities. *Nature-Based Solutions* **6**, 100142 (2024).

66. Rijksoverheid. Doel Nationaal Groeifonds. https://www.nationaalgroeifonds.nl/doel-nationaal-groeifonds.

67. NL2120. Elevating Nature-based Solutions . https://www.nl2120.nl/.

68. ReGeNL. Naar een rendabele regeneratieve landbouw . https://regenl.nl/.

69. Biella, R. *et al.* The 2022 Drought Needs to be a Turning Point for European Drought Risk Management. Preprint at https://doi.org/10.5194/egusphere-2024-2069 (2024).

70. Botzen, W. J. W., Aerts, J. C. J. H. & van den Bergh, J. C. J. M. Dependence of flood risk perceptions on socioeconomic and objective risk factors. *Water Resour. Res.* **45**, (2009).

71. Mutlu, A., Roy, D. & Filatova, T. Capitalized value of evolving flood risks discount and nature-based solution premiums on property prices. *Ecological Economics* **205**, 107682 (2023).

72. Niu, D., Eichholtz, P. & Kok, N. Overstromingsinformatie verandert koopgedrag van woningeigenaren. *ESB* **109**, 272–275 (2024).

73. Bin, O. & Landry, C. E. Changes in implicit flood risk premiums: Empirical evidence from the housing market. *J. Environ. Econ. Manage.* **65**, 361–376 (2013).

74. Atreya, A. & Ferreira, S. Seeing is Believing? Evidence from Property Prices in Inundated Areas. *Risk Analysis* **35**, 828–848 (2015).

75. Atreya, A., Ferreira, S. & Kriesel, W. Forgetting the Flood? An Analysis of the Flood Risk Discount over Time. *Land Econ.* **89**, 577–596 (2013).

76. Eisenack, K. *et al.* Explaining and overcoming barriers to climate change adaptation. *Nature Climate Change 2014 4:10* **4**, 867–872 (2014).

77. Werners, S. E., Wise, R. M., Butler, J. R. A., Totin, E. & Vincent, K. Adaptation pathways: A review of approaches and a learning framework. *Environ. Sci. Policy* **116**, 266–275 (2021).

78. Lawrence, J. *et al.* Dynamic adaptive pathways planning for adaptation: lessons learned from a decade of practice in Aotearoa New Zealand. *Journal of Integrative Environmental Sciences* **22**, (2025).

79. Bloemen, P., Reeder, T., Zevenbergen, C., Rijke, J. & Kingsborough, A. Lessons learned from applying adaptation pathways in flood risk management and challenges for the further development of this approach. https://doi.org/10.1007/s11027-017-9773-9 (2018) doi:10.1007/s11027-017-9773-9.

80. Valeria Di Fant *et al.* Opportunity windows accelerate action and expand options for climate adaptation in Europe_Online datasets. *Figshare* Preprint at https://doi.org/https://doi.org/10.6084/m9.figshare.31249858 (2026).

81. IPCC. Water. in *Climate Change 2022 – Impacts, Adaptation and Vulnerability* 551–712 (Cambridge University Press, 2023). doi:10.1017/9781009325844.006.

82. IPCC. Climate Resilient Development Pathways. in *Climate Change 2022 – Impacts, Adaptation and Vulnerability* 2655–2808 (Cambridge University Press, 2023). doi:10.1017/9781009325844.027.

83. Gersonius, B. *et al.* Developing the evidence base for mainstreaming adaptation of stormwater systems to climate change. *Water Res.* **46**, 6824–6835 (2012).

84. van de Ven, F. H. M., Gersonius, B., de Graaf, R., Luijendijk, E. & Zevenbergen, C. Creating water robust urban environments in the <scp>N</scp> etherlands: linking spatial planning, design and asset management using a three-step approach. *J. Flood Risk Manag.* **4**, 273–280 (2011).

85. Koukoui, N., Gersonius, B., Schot, P. P. & van Herk, S. Adaptation tipping points and opportunities for urban flood risk management. *Journal of Water and Climate Change* **6**, 695–710 (2015).

86. Fairbrother, M. Public opinion about climate policies: A review and call for more studies of what people want. *PLOS Climate* **1**, e0000030 (2022).

87. Bliuc, A.-M. *et al.* Public division about climate change rooted in conflicting socio-political identities. *Nat. Clim. Chang.* **5**, 226–229 (2015).

88. Bremer, J. & Linnenluecke, M. K. Determinants of the perceived importance of organisational adaptation to climate change in the Australian energy industry. *Australian Journal of Management* **42**, 502–521 (2017).

89. Mendizabal, M. *et al.* Triggers of change to achieve sustainable, resilient, and adaptive cities. *City and Environment Interactions* **12**, 100071 (2021).

90. Kopp, R. E., Shwom, R. L., Wagner, G. & Yuan, J. Tipping elements and climate–economic shocks: Pathways toward integrated assessment. *Earths Future* **4**, 346–372 (2016).

91. Kingdon, J. A. *Agendas, Alternatives and Public Policies* . (Little, Brown and Company, Boston , 1984).

92. Béland, D. & Howlett, M. The Role and Impact of the Multiple-Streams Approach in Comparative Policy Analysis. *Journal of Comparative Policy Analysis: Research and Practice* **18**, 221–227 (2016).

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Figure 1: Mutual interactions between adaptation opportunity classes. Mutual interactions between adaptation opportunity classes (in green) and effects of external drivers (in this case a (near) disaster; in light-blue) on the evolution of opportunities.

Figure 2: Identified adaptation opportunity windows across Europe. Distribution of adaptation opportunities across Europe. The colour of the countries indicates the number of identified opportunity windows there, as indicated by the legend in the top-right corner. Each circle represents one opportunity identified, and the colour of the circle the class of each opportunity: grey = maintenance-driven, light-green = resource-driven, light-blue = value-driven, dark-blue = policy-driven, brown = innovation-driven, dark green = multi-class. The numbers within the circles refer to the opportunity number as listed in Online Dataset 1 and consistent with the numbers in Figures 3 and 4.

Figure 3: Adaptation opportunities per class. Distribution of identified adaptation opportunities per class. The numbers within the circles refer to the opportunity number as listed in Online Dataset 1 and consistent with the numbers in Figures 2 and 4. Symbols next to the numbers indicate timing of opportunities and whether they relate to a specific location or the whole country area, as specified in the legend in the bottom-left corner.

Figure 4: Timeline of identified adaptation opportunity windows. List of identified opportunity windows and associated timelines, including when the window opened/will open, key events within the window and/or when the window has closed or is expected to close. Colours and numbers represent specific identified opportunity and their classes, are showcased in the legend and text below the graph and are consistent with Figures 2 and 3.

Figure 5: Impacts of adaptation opportunity windows on a stylized pathways map. Visualisation of an adaptation pathways metro-map for a stylised case and potential impacts of an opening adaptation opportunity window. The pathways map should be read from left to right. Actions (or adaptation measures) are listed on the left, and the coloured lines indicate with a measure may be implemented and for how long (length of the line). Transfer points indicate moments when or situations under which one action in a pathway is followed by the next one. The brackets indicate the opening and closing of an adaptation opportunity window, and the arrows indicate what happens to the adaptive plan when a certain window is open. Impact type 4 (changes in priority ranking) is not included in the figure, as this only changes the evaluation of the pathway and the adaptive plan.

Table 1: List of adaptation opportunity window classes and associated literature.

Opportunity window class	References
Maintenance-driven	11,41,83–85
Resource-driven	13,14
Value-driven	13,14,86–90
Policy-driven	13,14,23,26,52,91,92
Innovation-driven	11,13,14

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Competing interests

The authors declare no competing interests.

Author Contributions

VDF, MH, HM and BvdH conceptualised the study. VDF and AKP carried out the data collection and analysis. VDF, HM, AKP, KdB, BvdH and MH all contributed to interpretation of results, and both writing and editing of the manuscript.

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Editorial summary:
Practical openings for climate adaptation may emerge or be created in Europe when funding becomes available, policies shift, public concern rises, infrastructure reaches its limits, or new technologies mature, according to a study identifying 34 opportunities across the region.

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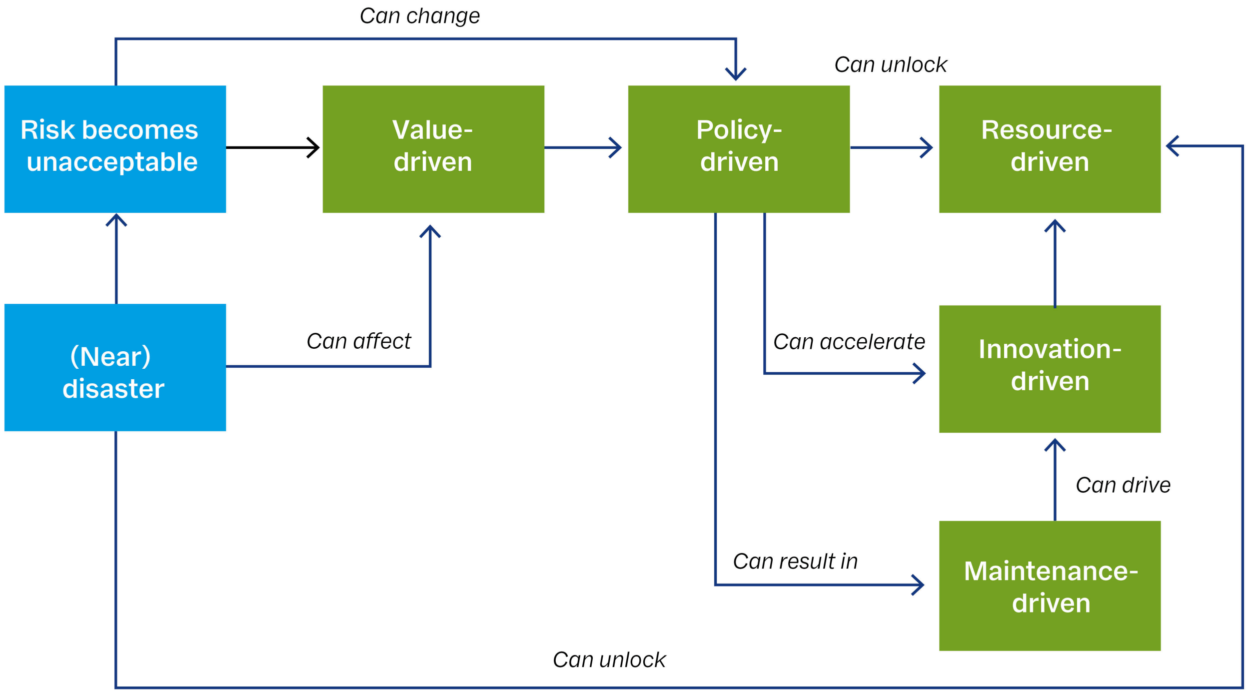
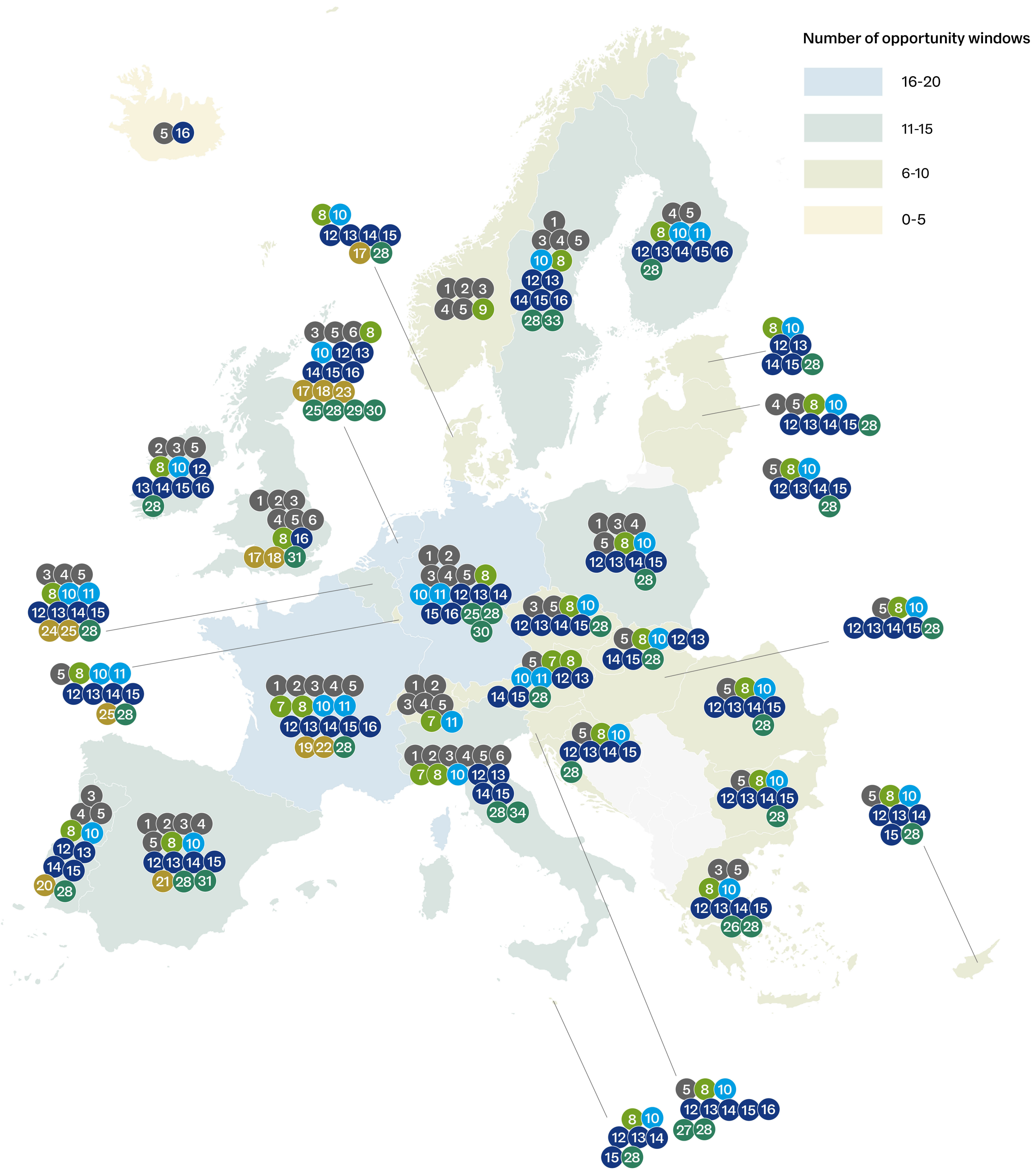
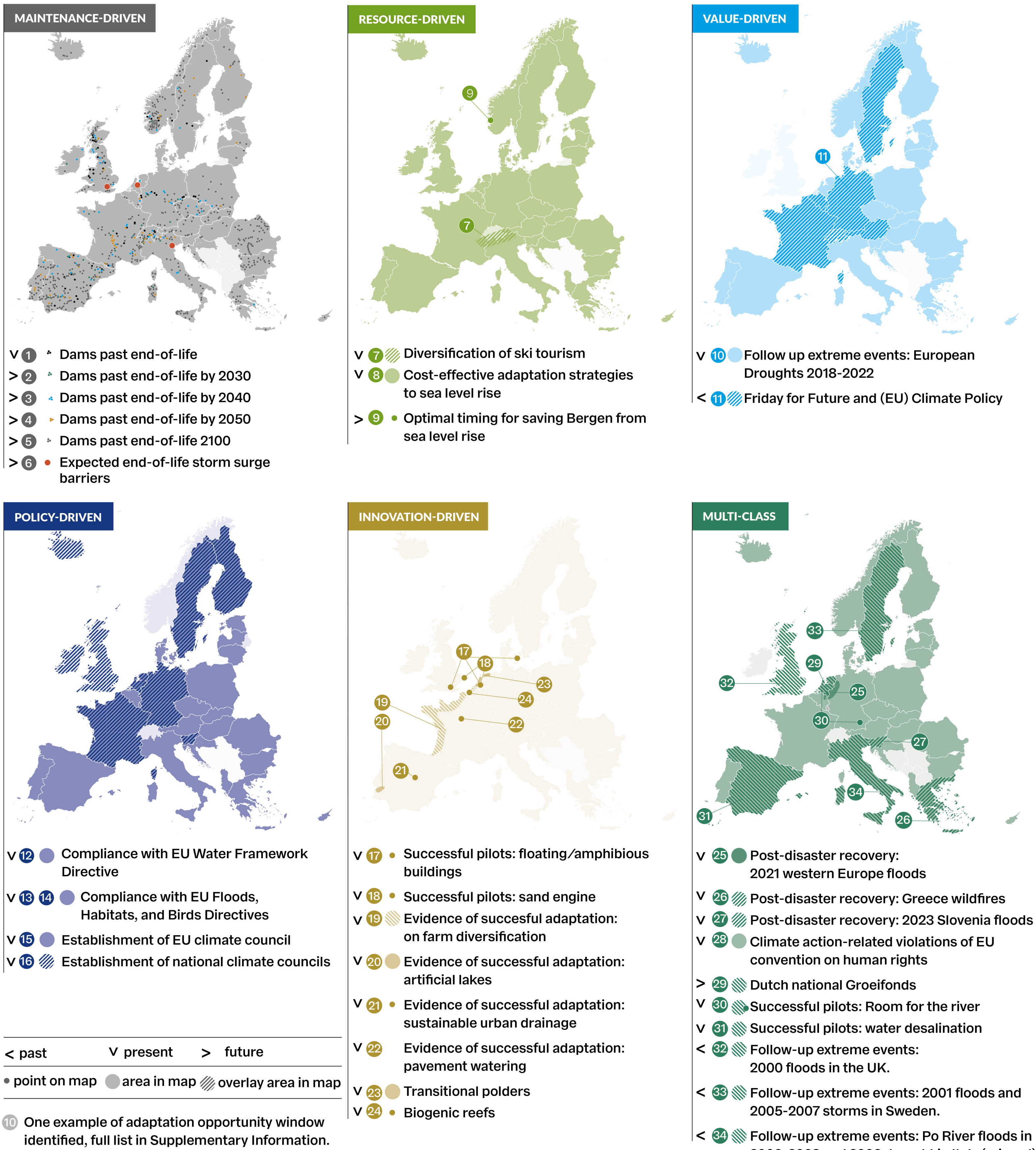

Can change
Can unlock
Risk becomes unacceptable
Value-driven
Policy-driven
Resource-driven
Can affect
Can accelerate
(Near) disaster
Innovation-driven
Can drive
Can result in
Maintenance-driven
Can unlock


Number of opportunity windows
16-20
11-15
6-10
0-5


MAINTENANCE-DRIVEN
V 1 Dams past end-of-life
> 2 Dams past end-of-life by 2030
> 3 Dams past end-of-life by 2040
> 4 Dams past end-of-life by 2050
> 5 Dams past end-of-life 2100
> 6 Expected end-of-life storm surge barriers
RESOURCE-DRIVEN
9
7
V 7 Diversification of ski tourism
V 8 Cost-effective adaptation strategies to sea level rise
> 9 Optimal timing for saving Bergen from sea level rise
VALUE-DRIVEN
11
V 10 Follow up extreme events: European Droughts 2018-2022
< 11 Friday for Future and (EU) Climate Policy
POLICY-DRIVEN
V 12 Compliance with EU Water Framework Directive
V 13 14 Compliance with EU Floods, Habitats, and Birds Directives
V 15 Establishment of EU climate council
V 16 Establishment of national climate councils
INNOVATION-DRIVEN
17
18
23
24
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21
V 17 Successful pilots: floating/amphibious buildings
V 18 Successful pilots: sand engine
V 19 Evidence of succesful adaptation: on farm diversification
V 20 Evidence of successful adaptation: artificial lakes
V 21 Evidence of successful adaptation: sustainable urban drainage
V 22 Evidence of successful adaptation: pavement watering
V 23 Transitional polders
V 24 Biogenic reefs
MULTI-CLASS
33
29
32
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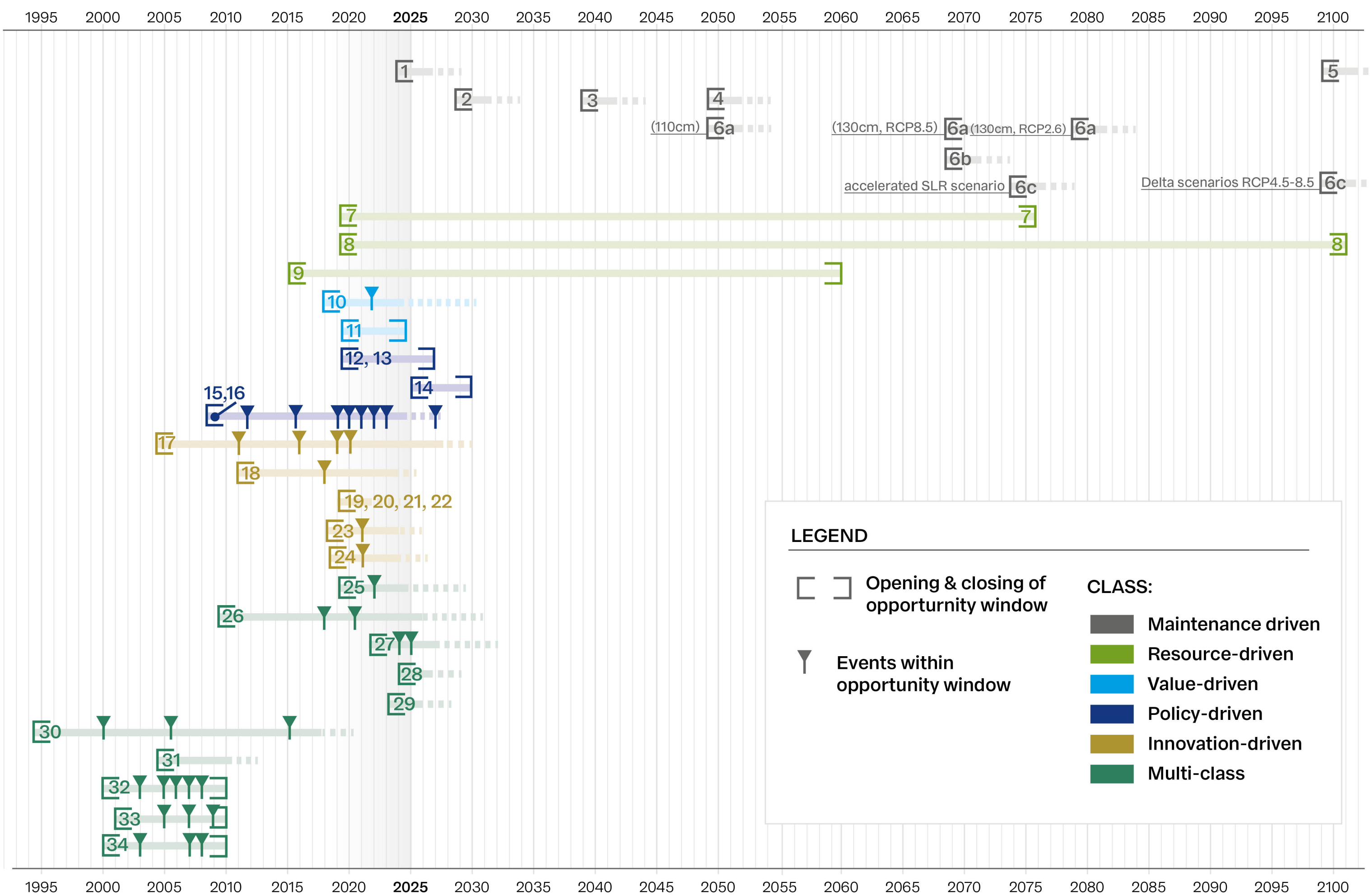
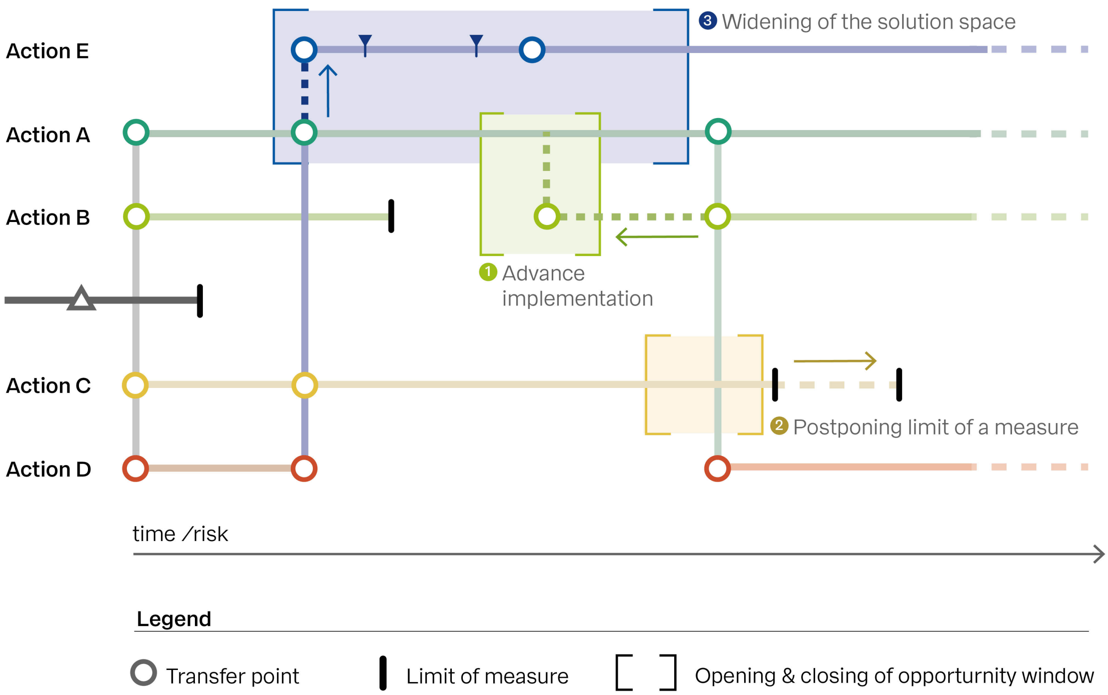
31
26
V 25 Post-disaster recovery: 2021 western Europe floods
V 26 Post-disaster recovery: Greece wildfires
V 27 Post-disaster recovery: 2023 Slovenia floods
V 28 Climate action-related violations of EU convention on human rights
> 29 Dutch national Groeifonds
V 30 Successful pilots: Room for the river
V 31 Successful pilots: water desalination
< 32 Follow-up extreme events: 2000 floods in the UK.
< 33 Follow-up extreme events: 2001 floods and 2005-2007 storms in Sweden.
< 34 Follow-up extreme events: Po River floods in 2000-2008 and 2003 drought in Italy (missed).
< past
V present
> future
point on map
area in map
overlay area in map
10 One example of adaptation opportunity window identified, full list in Supplementary Information.



1 Dams past end-of-life
2 Dams past end-of-life by 2030
3 Dams past end-of-life by 2040
4 Dams past end-of-life by 2050
5 Dams past end-of-life by 2100
6a Expected end-of-life MOSE (Venice), under different scenarios
6b Expected end-of-life Thames Barrier (London)
6c Expected end-of-life Maeslant Barrier (Rotterdan), under different scenarios
7 Diversification of ski tourism
8 Cost-effective adaptation strategies to sea level rise
9 Optimal timing for saving Bergen from sea level rise
10 Follow-up extreme events: Droughts
11 Fridays for Future and (EU) climate policy
12 Compliance with EU WFD
13 Compliance with EU Floods Directive
14 Compliance with EU Habitats & Birds Directives
15 Establishment of EU climate council
16 Establishment of national climate councils
17 Successful pilots: floating/amphibious buildings
18 Successful pilots: sand engine
19 Evidence of succesful adaptation: on farm diversification
20 Evidence of successful adaptation: artificial lakes
21 Evidence of successful adaptation: sustainable urban drainage
22 Evidence of successful adaptation: pavement watering
23 Transitional polders
24 Biogenic reefs
25 Post-disaster recovery: 2021 western Europe floods
26 Post-disaster recovery: Greece wildfires
27 Post-disaster recovery: 2023 Slovenia floods
28 Climate action-related violations of EU convention on human rights
29 Dutch national Groeifonds
30 Successful pilots: room for the river
31 Successful pilots: Water desalization
32 Follow-up extreme events: 2000 floods in the UK
33 Follow-up extreme events: 2001 floods and 2005-2007 storms in Sweden
34 Follow-up extreme events: Po River floods in 2000-2008 and 2003 drought in Italy (missed)



Action E
Action A
Action B
Action C
Action D
3 Widening of the solution space
1 Advance implementation
2 Postponing limit of a measure
time /risk
Legend
Transfer point
Limit of measure
Opening & closing of opporturnity window