[HEAT]

# Technologies for a climate-resilient future

## Why AdaptationTech solutions promise a double return on investment

A whitepaper from:

[PTI] [ERIC]

In co-operation with:

DWR eco

# About the editors

## [PT1]

PT1 is a fully independent venture capital firm that focuses on pre-seed & seed investments in transformative real asset technologies. Real assets (real estate, infrastructure and energy) are undergoing profound transformation caused by increasing scarcity of natural resources, carbon budgets, square meters and skilled labour. PT1 invests in #Futurebuilders, startups benefitting from these mega trends by serving the high economic, social and political demand through scalable solutions.

Using its proprietary AI-enabled deal flow data base, PT1 finds, funds and fosters real asset innovations. PT1 consists of a pan-European, entrepreneurial team that is supported by experienced Venture Partners with diverse backgrounds ranging from unicorn founders to industry veterans and investment experts, creating a rich pool of wisdom, track record and network.

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PT1 is part of ERIC Group, a platform that unites progressive minds making collective investments along transformational mega trends. Members include (U)HNWIs, successful entrepreneurs, forward-thinking corporate and institutional investors that aim to benefit in two dimensions from interacting with #Futurebuilders – financial ROI combined with inspiration, data and technology-access for their own transformational journeys.

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DWR eco is a leading consulting agency for market strategies, PR, communication and politics and sees itself as a strategic mission control centre for entrepreneurial growth, green technologies and clean investments in the areas of cleantech, ClimateTech and GreenTech. With an unwavering pioneering spirit and in-depth expertise, DWR eco is the go-to team in politics, the market and the public when it comes to scaling solutions for climate protection, the energy transition, clean mobility, green industry and the circular economy.

DWR eco is a long-standing pioneer in the cleantech sector and offers first-class consulting for successful market strategies, society-orientated advocacy and effective communication. To this end, DWR eco is constantly cultivating and expanding its widely ramified network, because only the authentic cooperation of many stakeholders and decision-makers can create a future worth living on our planet. With its podcast formats "Let's Talk Change" and "Deep Dive Cleantech", DWR eco reaches all key decision-makers in business, politics, media and investments.

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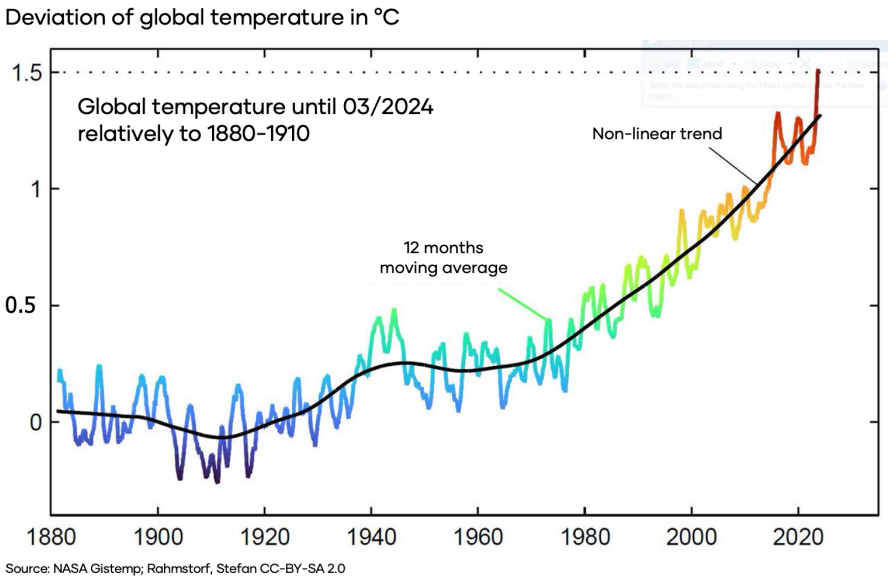
# Executive Summary

- Current situation: The 1.5-degree target (and probably also the 2-degree target) from the Paris Agreement cannot be achieved based on current efforts to reduce greenhouse gas emissions. In fact, the **1.5-degree target has already been reached in the last 12 months**.

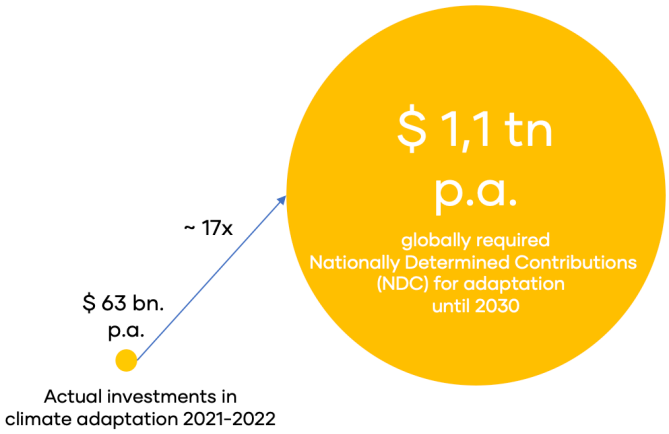
Figure 1: Global temperature is already rising by an average of 1.5 degrees in the last 12 months




Source: NASA Gistemp; Rahmstorf, Stefan CC-BY-SA 2.0

- As we are already feeling the effects today, for example, in the form of more extreme weather events, it is obvious that there is a **great need for climate change adaptation,** which will definitely become even greater as time passes.
- In addition to renaturalisation measures, there are a large number of technology-based adaptation measures, particularly in urban areas / the built world, where the majority of people live.
- These so-called **"AdaptationTech" solutions** are primarily developed by start-ups from the European entrepreneurship ecosystem, which already offer quickly scalable options with their innovative solutions to enable adaptation in the built world.
- AdaptationTech solutions include software solutions for climate data collection / climate risk analysis, disaster response & recovery systems, water management solutions, IoT solutions in the field of smart infrastructure and climate resilience FinTechs / InsureTechs.
- The **demand for these** solutions is not only **secured in the long term**, but will **continue to increase** due to climate dynamics, which will also bring a corresponding business opportunity, as adaptation to climate change will be a project for the coming decades.
- However, with a **funding gap of around EUR 1 trillion p.a.**, the climate adaptation sector is massively underfunded compared to the investments required for adaptation (see figure 2), which particularly affects adaptation tech start-ups that manage to obtain initial venture capital or public funding in the early stages, but have **difficulties obtaining the funds required for scaling in the growth stage**.

## Figure 2: Global climate adaptation finance gap per year

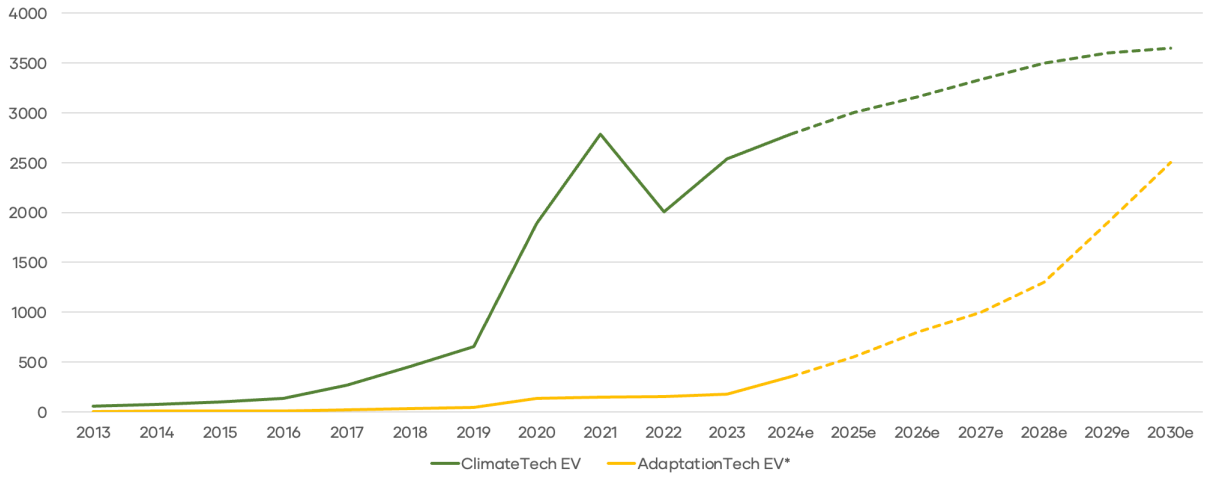



Source: CPI, GCA

- The funding gap is partly due to the **general VC weakness in the growth stage in Europe** (compared to the USA) and the fact that **AdaptationTech has so far received just little attention as an investment vertical**, especially compared to previous ClimateTech investments for climate impact mitigation.
- The **combination of secured long-term demand** and the fact that the underfunded and therefore **favourably valued investment area** has so far received little attention means that VC/PE investors have a **good long-term opportunity to invest** in a "hidden champion" vertical (analogous to e.g. early ClimateTech investments, see figure 3).

## Figure 3: AdaptationTech with massive valuation catch-up potential

Enterprise value of Climate-/AdaptationTech startups in bn. USD




Source: dealroom.co - Climate Tech Report 2023 / *own calculations

- AdaptationTech investments also offer an **excellent "double return"** due to their positive social impact. Pioneers such as Munich RE and a few VC funds such as Pale blue dot or satgana have recognised the attractiveness of that sector and have already made their first investments.
- In our opinion, the establishment of an **AdaptationTech ecosystem** (incl. VC funding) **makes particular sense in Europe,** as there is already advanced regulation and decades of research and development on energy efficiency and material science topics here - in global comparison - which offers a good breeding ground for further development.
- Due to the special characteristics of the **vertical,** we anticipate that **specialised (VC) investors,** who can support the start-ups e.g. in B2G sales to municipalities, etc., will also be needed.

# Chapter 1 - An inconvenient truth:

## Failure to meet climate targets requires considerable measures to adaptation to climate change.

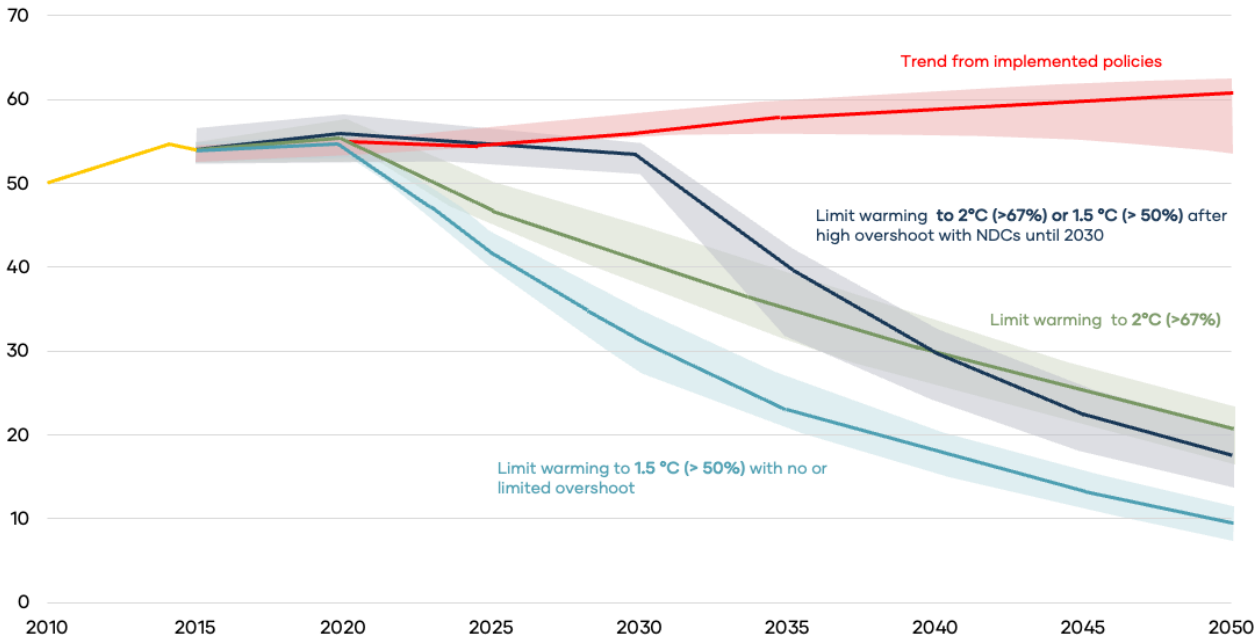
**Key Messages:**

- Very likely, the 1.5 – and probably also the 2-degree – target of the Paris Agreement will not be achieved.
- The effects of climate change vary geographically, economically and socially.
- There is already a noticeable accumulation of climate impacts today, which are accompanied by both substantial social and economic damage, e.g. through interruptions of production processes.
- Climate change mitigation and adaptation are not mutually exclusive. On the contrary, they have positive synergy effects.
- There are natural and technology-based approaches for adaptation. The latter are particularly suitable in cities/urban centres ("urban resilience").

Climate change is inevitably progressing, and it is already becoming apparent that the 1.5 degree target can no longer be met. This limit has already been exceeded in many places and global greenhouse gas (GHG) emissions have risen by almost 50% compared to pre-industrial levels.[1]

As illustrated by the various climate models based on the Representative Concentration Pathways (CPRs) defined by the Intergovernmental Panel on Climate Change (IPCC) (see Figure 5), climate change can hardly be halted by the mitigation measures currently implemented and the Nationally Determined Contributions (NDCs).

### Figure 5: Modelling of various global mitigation scenarios [2]




Source: 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.

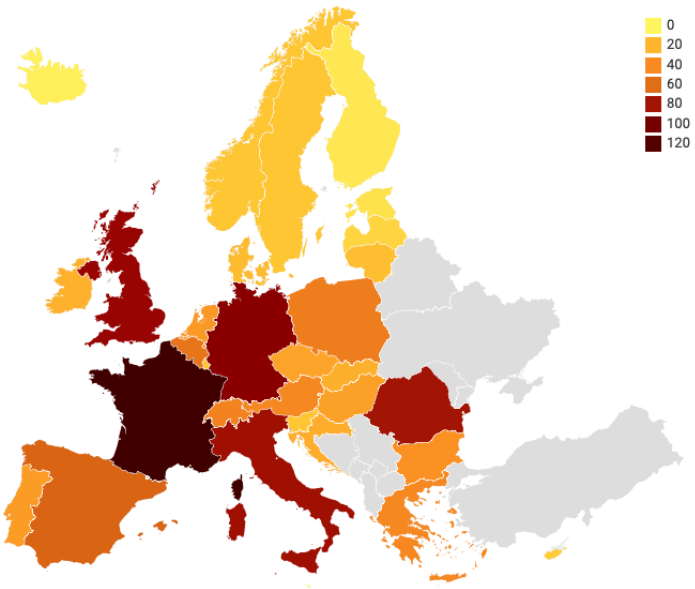
Looking at the projected status in 2030, the best-case scenario of meeting the 1.5°C target is only possible if GHG emissions are reduced by at least 43% compared to 2019. A recently published study considers such a turnaround in the climate protection course to be extremely unlikely and predicts that we would have to achieve net zero emissions by 2035 in order to increase the chance of meeting the 1.5°C target to over 50%.[3] Europe is under particular pressure to act, as average temperatures here have risen twice as fast as the global average since 1980.[4] This results in an serious need for action that cannot (or can no longer) be met by mitigation measures alone.

## 1.1. Interactions between climate and environment

The effects of climate change can be seen not only in increased global mean temperatures, but also in more frequent natural events, particularly in the form of heat and drought, as well as flooding. Germany, for example, has recorded an increase of 187% in heatwave days (≥ 30 degrees) since 1951.[5]

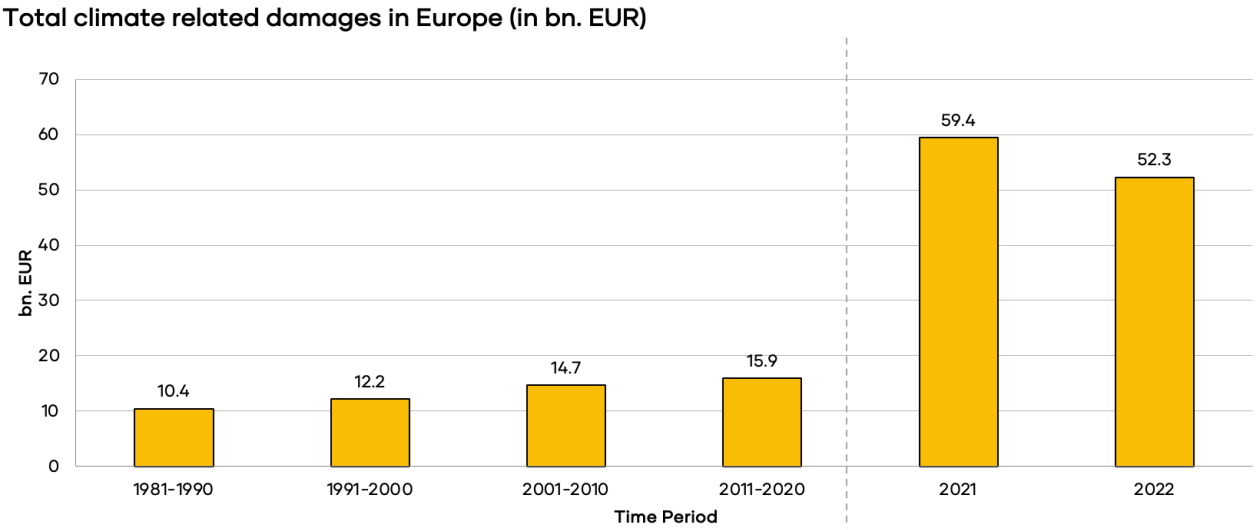
Similar trends can be observed throughout Europe and, according to forecasts by the European Environment Agency (EEA), will become even more drastic by 2100. The frequency, duration and severity of meteorological and hydrological droughts will therefore increase, particularly in Central, Southern and Eastern Europe. The probability of heavy rainfall will also increase, with Central and Eastern Europe being most affected. Both southern and northern Europe will be affected by a drastic increase in forest fires. In addition, the coastal regions of Germany, the Netherlands and Belgium will suffer from rising sea levels.[6]

Figure 6: Number of climate-related disaster events in Europe (1960-2019) [7]




However, it is not only the number of disaster events that is increasing, but also their physical and associated monetary consequences. As illustrated by the figure 8, the economic losses in the EU member states were higher in 2021 and 2022 than in the previous decades.

## Figure 7: Economic losses due to weather and climate-related extreme events in the EU Member States over time [8]




### Information Box 1:
### Types of disasters that occur more frequently as a result of climate change

| | |
|---|---|
| **Biological Events** | • Diseases<br>• Pandemics<br>• Species extinction |
| **Climatological events** | • Droughts<br>• Heat<br>• Forest fires<br>• Extreme cold |
| **Geophysical events** | • Earthquake<br>• Landslides<br>• Volcanic eruptions |
| **Hydraulic events** | • Avalanches<br>• Flooding<br>• Tsunamis |
| **Meteorological events** | • Storms (cyclones, hurricanes, typhoons, sandstorms and snowstorms)<br>• Hail<br>• Thunderstorm<br>• Tornadoes |

## 1.2. Affected systems /damage dimensions

The biggest cost drivers exist particularly in places that are already under (climate change-related) stress. Recognising these weak points is an important step towards taking appropriate adaptation measures.

### Geographical dimension

Many regions are particularly threatened by extreme weather events, water scarcity and heat due to increasing sealing and intensive changes to the landscape.[9] Extensive human intervention in the natural landscape (e.g. through river straightening, intensive agriculture, deforestation) increases vulnerability to drastically declining biodiversity and soil quality.[10]

Urban **regions**, which are particularly intensively utilised areas due to sealing and building development, are significantly affected by the impacts of climate change. Rising temperatures pose major challenges for cities and densely populated areas, as they are disproportionately affected by heat due to a lack of green spaces and insufficient air circulation, resulting in urban heat islands.[11] At the same time, cities are also particularly susceptible to flooding due to their degree of sealing.[12]

### Socio-economic dimension

The effects of climate change not only differ geographically, but also demographically. Low-income population groups as well as sick and elderly people show a significantly increased vulnerability to extreme events caused by climate change, as adaptation solutions are often not currently accessible to them, or they cannot afford them (e.g. energy-efficient, insulated housing).[13] It is therefore important that socio-economic aspects are adequately taken into account when implementing climate change adaptation measures.

### Economic dimension

Climate change has an impact on various sectors of the economy, affecting a range of systemically relevant structures and important services. The sectors can be divided into rural/nature-related resilience and urban resilience.

***Infrastructure and buildings*** are particularly significant in the area of urban resilience, as they have a long service life, are costly to construct and utilise and are essential for the functioning of societies and economies. At the same time, however, they are particularly susceptible to damage caused by changing climatic conditions or extreme weather events. However, solutions here depend heavily on the construction method and the respective location and must therefore often be at least partially individualised.[14] The accumulation of extreme weather events is also changing risk awareness and the ***need for insurance*** and the level of traditional insurance premiums, e.g. in the building sector and beyond. This can reinforce social inequalities in the long run.

Furthermore, extreme weather events caused by climate change have far-reaching effects on ***energy systems***. Stronger and more frequent heatwaves are likely to shift the balance between energy supply and demand, while further temperature rises and prolonged droughts could affect the availability of cooling water for thermal power generation in summer. This could lead to a decrease in energy supply while the demand for air conditioning and correspondingly electricity increases. In addition, the increasing frequency and intensity of extreme weather events pose a threat to the physical energy infrastructure.[15] Cities are also here in a particular focus.

The two blocks of rural or nature-related and urban resilience are both equally important and complement each other - but they bring different challenges and needs for action with them, which in turn require very different solutions.

## 1.3. Taxonomy of climate adaptation

Mitigation and adaptation are not mutually exclusive concepts, but rather have a complementary relationship with each other, as there are strong synergy effects between adaptation and mitigation strategies. The higher the temperature rise and GHG emissions, the more exponentially the costs of adaptation and resilience measures increase.[16] Conversely, effective adaptation can also contribute to decarbonisation.

Within climate adaptation, a distinction is made between two types of measures: Natural ("nature-based") and technological adaptation. Natural measures focus on protection, sustainable use or management and, as a final step, the restoration of natural and modified ecosystems. The focus of these natural measures is therefore on environmental protection and nature conservation, but if implemented successfully, they can also contribute to social challenges and increase the adaptability of communities to extreme events.[17] One example of this is the regeneration wetlands, which help to improve biodiversity and to store $CO_2$ naturally, while also serving as a buffer zone during heavy rainfall events. On the other hand, technological adaptation measures offer the opportunity to increase resilience to catastrophic events caused by climate change by recognising them at an early stage and mitigating the resulting damage or the effects caused by them.

The combination of natural and technological measures is not only possible, but essential for any adaptation strategy. Natural measures pursue long-term goals and, if implemented correctly, can not only mitigate the effects of climate change but also actively counteract it. Technological measures complement this by offering short-term solutions to minimise risks, especially considering the drastic increase in extreme weather events in Europe in recent years.

To ensure that adaptation measures - both nature-based and technology-based - work as desired, a contextualised view of the application area is crucial, taking into account regional and temporary challenges and needs, otherwise there is a risk of "maladaptation", i.e. adaptation measures that have no effect. [18]

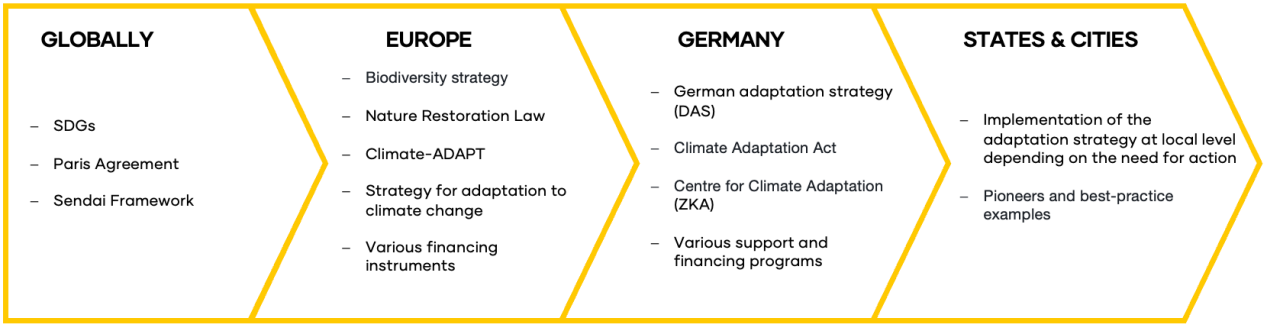
# Chapter 2 - Regulation and initiatives:

## Europe as a potential "place to be" for a climate adaptation ecosystem

**Key Messages:**

- In a global comparison (e.g. with the US, Asia), Europe has a pronounced regulatory system regarding climate change adaptation, even if it still has some room for improvement compared to the regulatory systems for climate change mitigation.
- The framework conditions that have been created already enable start-ups to establish / operate business models geared towards climate adaptation.
- Germany plays a pioneering role within the EU (e.g. with the Climate Adaptation Act), which can be a potential competitive / economical advantage.
- It can be anticipated that especially technology-based solutions will be given greater consideration by regulators in the future to leverage the scaling potential in terms of the dual promotion of the location (to improve local resilience and as an economically attractive export product).

Figure 6: Climate adaptation regulation at various political levels:




## 2.1. Global level

**Climate adaptation as part of the Sustainable Development Goals (SDGs)**

Climate adaptation plays a crucial role in the United Nations (UN) Sustainable Development Goals (SDGs), particularly in relation to the topics of cities and municipalities, as well as in the area of infrastructure and integration into national strategies and planning processes. Specific measures of the SDGs and sub-goals include:

\ *Goal 13: Climate protection measures*

- Sub-Goal 13.1: Strengthen the resilience and adaptive capacity of communities and ecosystems to climate change.
- Sub-Goal 13.2: Integration of climate change measures into national policy, strategy and planning processes to promote adaptation and strengthen the resilience of cities and infrastructure.
- Sub-Goal 13.3: Raise awareness of the need for climate adaptation and improve early warning systems.

\ *Goal 11: Sustainable cities and communities*

- Sub-Goal 11.5: Strengthen the adaptive capacity of cities to climate change by 2030, including the integration of climate adaptation measures into urban and regional planning and development.
- Sub-Goal 11.B: Increase the number of cities and settlements that develop, implement and realise integrated climate change adaptation policies and plans.

\ *Goal 9: Industry, innovation and infrastructure*

- Sub-Goal 9.1: Build resilient infrastructures by 2030 (..).

### Climate adaptation in the Paris Climate Agreement

In addition to the well-known goal of limiting global warming to well below 2 or 1.5 degrees Celsius, the agreement also sets out obligations for the signatory states to take concrete measures to adapt to climate change. A central component of the agreement is the Nationally Determined Contributions (NDCs), in which countries define their national targets and measures for adapting to and mitigating climate change. The NDCs commit countries to take specific measures to adapt to climate change based on their national circumstances and priorities. The implementation of these measures is crucial for strengthening the resilience of communities and infrastructures to the impacts of climate change.

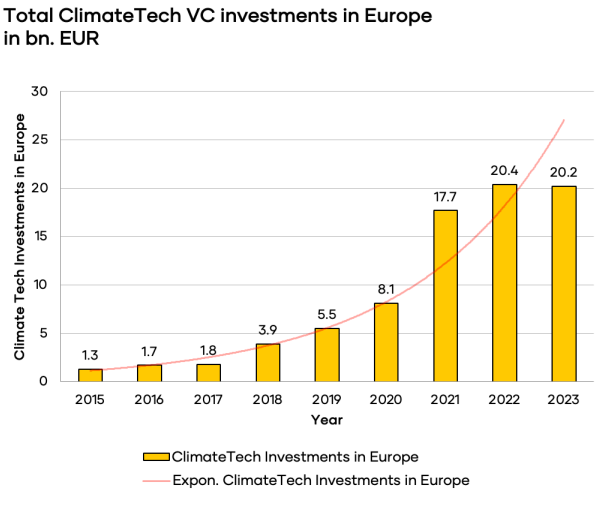
### Sendai Framework for Disaster Risk Reduction

The Sendai Framework emphasises the importance of preventive measures to reduce disaster risks and contains specific measures to strengthen resilience to natural disasters that may be exacerbated by climate change (e.g. the establishment of early warning systems and the improvement of disaster risk reduction infrastructure).

## 2.2. EU level

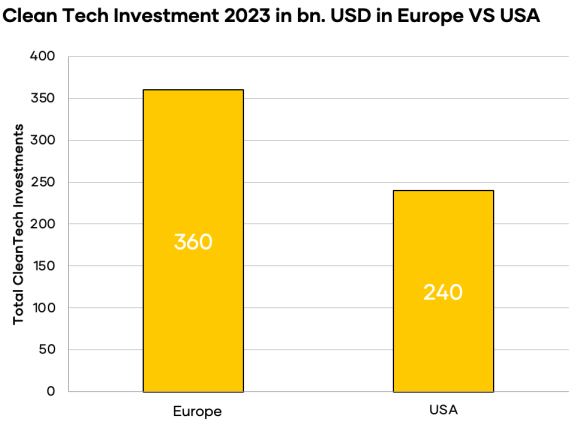
Europe and the EU are ahead of the rest of the world when it comes to climate impact adaptation regulation. This is hardly surprising, as the EU is also a leader in CleanTech investments, for example, and VC investment volumes in the ClimateTech sector have risen sharply in recent years (see Figures 8 and 9).

Figure 8




Source: dealroom.co - European Climate Tech in 2023

Figure 9




Source: Clean Investment Monitor (Rhodium Group & MIT CEEPR; EIB)

The combination of an initial regulatory framework and a generally high willingness to invest in environmental issues make the EU an ideal location for a potential ecosystem for climate adaptation and corresponding technology-based measures.

**Climate-ADAPT:**

With Climate-ADAPT (https://climate-adapt.eea.europa.eu), the EU offers a comprehensive knowledge platform on the topic of climate adaptation. It also serves as an observatory and data collection point for monitoring, analysing and preventing the effects of climate change on habitats and human health. This platform facilitates the exchange of information and co-operation between different actors in the field of climate adaptation.

**Renaturalisation measures:**

The EU has developed a range of policy instruments and strategies to tackle the challenges of climate change and biodiversity loss. The EU Biodiversity Strategy regulates natural adaptation measures such as the restoration and protection of ecosystems. The Nature Restoration Law, which is currently being negotiated, would set a binding, quantifiable target for renaturalisation measures for the first time. Specifically, effective renaturalisation is to take place on at least 20% of the EU's land and sea area by 2030.

**EU strategy for adaptation to climate change (part of the European Green Deal):**

The EU Strategy on Adaptation to Climate Change 2021 aims to ensure the adaptive capacity of all EU Member States and regions. It emphasises integrating adaptation into different policy areas and includes measures such as conducting climate risk assessments, developing and improving early warning systems and promoting climate-resilient infrastructure such as urban flood protection. Another focus is on mobilising financial resources, including support from the EU budget and the European Regional Development Fund, to support adaptation projects.

**Corporate Sustainability Reporting Directive (CSRD):**

Another example of the consideration of climate adaptation in legislation at EU level is the Corporate Sustainability Reporting Directive (CSRD). In future, this will require certain larger and capital market-oriented companies to integrate a large number of sustainability-related aspects into their management reports. Among other things, they must carry out a resilience analysis for their business model (DR E1-1) and specify regulations that affect them (DR E1-2) as well as targets relating to mitigation and adaptation (DR E1-4), which must then be quantified using appropriate metrics.

## 2.3. Germany

**German Adaptation Strategy** ("Deutsche Anpassungsstrategie", DAS)**:**

In Germany, the German Adaptation Strategy (DAS)[19], from which many fields of action for various areas can be derived, has been decisive for climate impact adaptation since 2008. In this white paper, we want to focus thematically on the area of **urban and spatial planning** or the so-called **"built world".** The relevant fields of action in this area can be found in Information Box 2. The overarching goal of technology-driven adaptation measures in these fields of action is to make cities not only more resilient, but also more liveable.

## Information Box 2:
## Fields of action for technology-based climate resilience in urban planning

| Relevant Fields of action | Early warning indicators | Measures |
|---|---|---|
| **Human health** | • Heat load | • Climate monitoring systems<br>• Greening and ventilation of heat islands<br>• (Smart) early warning systems |
| **Water** | • Groundwater pollution,<br>• High and low water,<br>• Heavy rain | • Unsealing ("sponge city")<br>• Adaptive river dams<br>• Intelligent water management systems<br>• Water consumption optimisation |
| **Construction** | • Heat load and island effects,<br>• Heavy rain & storms,<br>• Extreme cold | • Green infrastructure supported by sensor-based irrigation and/or shading systems<br>• Energy-efficient buildings<br>• Integrated sensor networks for buildings<br>• Building materials with improved resistance |
| **Energy industry** | • Weather-related interruptions & disruptions to the power supply | • Micro-grids and local solutions for energy supply (i.e. P2P systems, balcony power)<br>• Energy storage solutions |
| **Transport** | • Weather and weather-related infrastructural disruptions or failures | • Adaptive traffic control Autonomous and smart public transport systems |

The various regions and individual fields of action in Germany are affected differently by the consequences of climate change, which is why specific regional adaptation measures must be developed and implemented as part of the DAS and, in future, also as part of the Climate Adaptation Act. The greatest need for action therefore lies at state and municipal level. The Centre for Climate Adaptation ("Zentrum für Klimaanpassung", ZKA) was opened by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMUV) to support the federal states and local authorities. The ZKA plays a decisive role in networking key players and experts in climate adaptation from all areas of society at regional, state and federal level. It promotes cooperation between various partners and serves as a platform for dialogue in the field of climate adaptation.

**Climate Adaptation Act** ("Klimaanpassungsgesetz"):

Promulgated in December 2023 and expected to come into force in 2024, Germany is taking on a pioneering role in the EU with the Climate Adaptation Act. The Act references Sustainable Development Goal (SDG) 13 (see above) and for the first time provides a binding framework for the federal, state and local governments with measurable, binding targets. Among other things, binding risk prevention plans are to be drawn up for all municipalities by 2026. The law also stipulates joint nationwide funding by the federal and state governments to support the implementation of climate adaptation measures.

**Natural Climate Protection Action Programme** ("Aktionsprogramm Natürlicher Klimaschutz"):

The programme presents a comprehensive strategy that focuses on 69 measures in ten different fields of action. These measures aim to strengthen the resilience and contribution of various ecosystems to climate protection. It specifically addresses the conservation value of ecosystems such as peatlands, forests, marine and coastal regions as well

as urban settlement and transport areas. In 2023, funds totalling 590 million euros were made available for the programme from the Climate and Transformation Fund to support the implementation of these multi-layered measures. The current focus of the programme is to implement measures that have an immediate effect and are comparatively easy to implement. These measures will aim to strengthen natural adaptation strategies and thus increase resilience to the effects of climate change. In the long term, however, the programme aims to expand to technological solutions, which is already evident in the priority areas of municipalities/cities and infrastructure/transport.

## 2.4. Regulatory gaps and challenges

One possibility for optimisation in current climate policy is the strong focus on $CO_2$ mitigation. In future, greater attention should be paid to adaptation as an equally important aspect. In the case of new laws/guidelines in the area of adaptation, attention must also be paid to a fair distribution of the burden, as SMEs, for example, are disproportionately affected by the effects of climate change, e.g. through interruptions of business processes and supply chains as well as damage to property, which leads to increased costs for companies that even may jeopardise their existence. An effective and long-term climate policy must therefore take a holistic approach to combat climate change. The aim of such a holistic approach to climate adaptation must also be to not only increasingly include adaptation in legal texts, but also to explicitly promote innovation in this field, as these are quickly scalable, effective and often cost-efficient adaptation measures. In addition, more investment security should be created through clear guidelines.

# Chapter 3 - AdaptationTech explained:

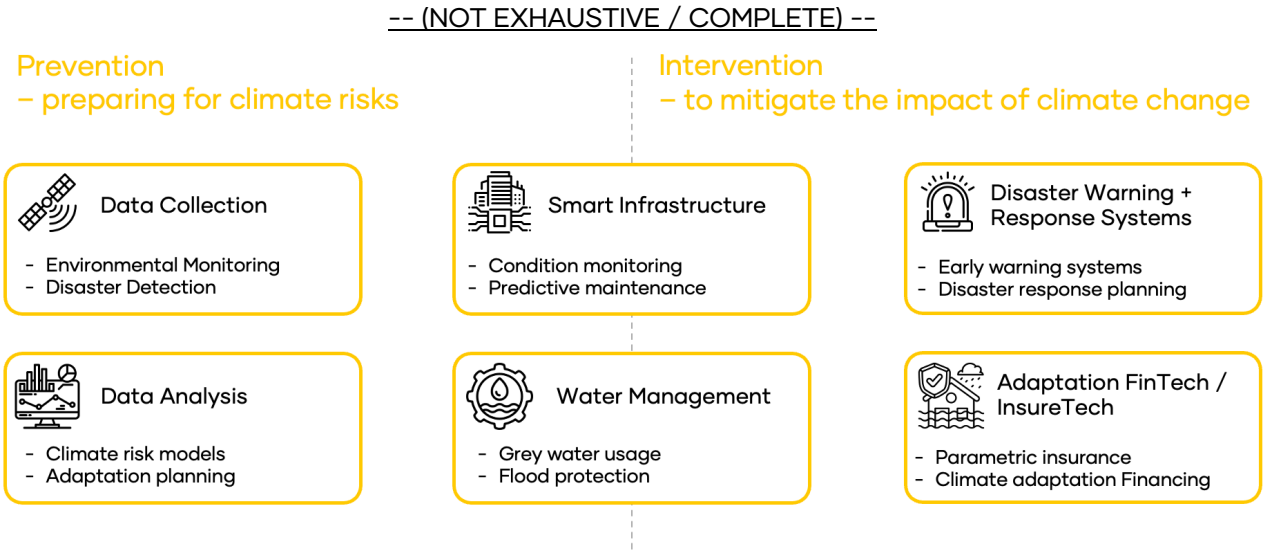
## An overview of technological solutions to increase climate resilience in urban areas.

**Key Messages:**

- AdaptationTech solutions can be categorised into the areas of prevention and intervention, as well as according to their technical complexity and the users/beneficiaries.
- However, it is essential that "basic digitalisation" is in place, particularly regarding the availability of data, on which many innovative business models can then be built.
- The greatest economic potential lies in solutions that have a high level of complexity/technology and are scalable in the private sector.
- Important AdaptationTech sectors include data collection and processing, disaster response & recovery systems, water management solutions, smart infrastructure and climate resilience FinTechs/InsureTechs.
- Key technologies such as the Internet of Things (IoT) / sensor technology and artificial intelligence (AI) are used here in particular.

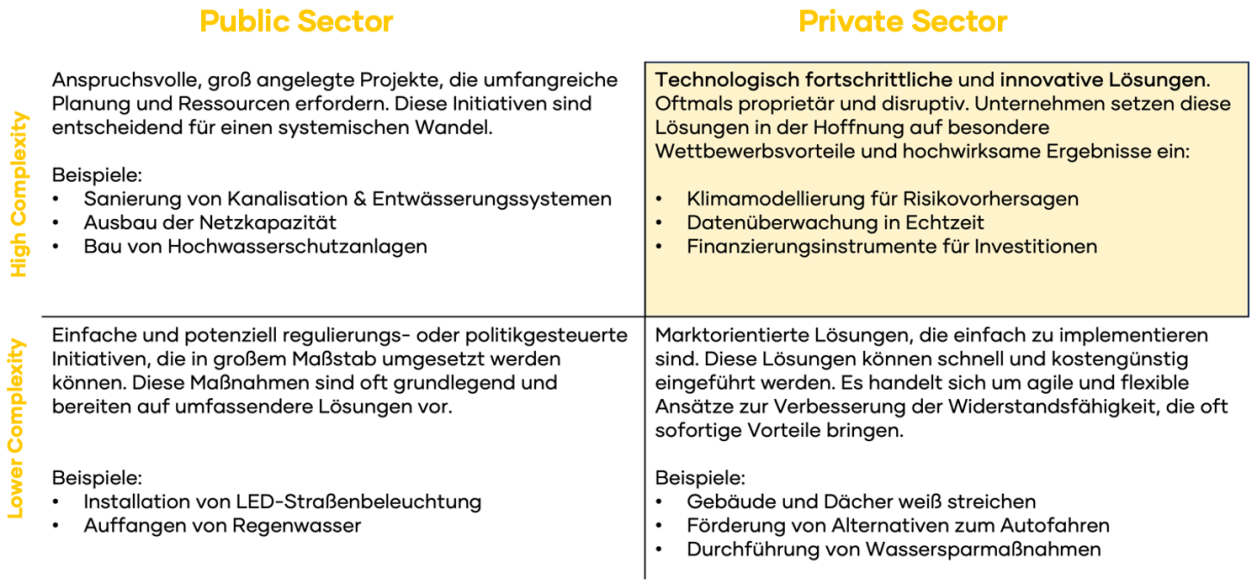
AdaptationTech, or climate resilience technologies, represent technological innovations that aim to strengthen the resilience of societies, infrastructures and ecosystems to the challenges of advancing climate change by means of innovative products / services. These technologies can be clustered as follows:

**Figure 10: Overview of AdaptationTech solutions in the Built World**




From a market perspective, AdaptationTech solutions can be categorised in terms of their technical complexity and the responsible stakeholders/customer groups. The customers come from the public sector (governments, municipalities as operators of relevant infrastructures) and the private sector (companies and individuals). This results in a four-quadrant matrix for the business orientation of AdaptionTech solutions:

Figure 11: AdaptionTech solutions by customer and technical complexity




In this [HEAT] whitepaper, we focus primarily on technical innovations in the private sector. This quadrant can be assessed as the potentially most attractive sector for startups and correspondingly venture capital investors, as the products/services in this field are based on cutting-edge technologies that represent a potential competitive advantage for the respective startup. In addition, the solutions offered are usually scalable, expandable and can be adapted to different contexts and regions as well as be established in the private sector with comparable ease. Individual technologies and associated business models are presented in more detail below:

## 3.1 Climate Resilience Data and Software

As already mentioned, software solutions are an important building block in the AdaptationTech segment, which is why this segment is also the one with the most start-ups that are active in this area or offer products.

### Data acquisition

The development of advanced software and analysis tools to assess and predict the impact of climate change on the so-called "built world" is important in order to understand climate trends and make forward-looking and scientifically sound investment decisions. Other areas in which the data is used include urban planning, disaster prevention and environmental protection.

The data on which these software solutions/data models are based comes from satellite or drone images, which are used to analyse geodata or map and analyse geographical data. For example, data on weather patterns, sea level rise and temperature changes are also collected for this purpose. The second main data source is Internet-of-Things (IoT) devices such as weather stations and environmental sensors, which collect real-time data on environmental conditions, the condition of infrastructure and disaster risks. Individual use cases in the IoT area will also be explained in more detail later. Real-time data monitoring is essential for an immediate response to climate events (floods or forest fires) and for the subsequent optimisation of resource allocation.

| Startup | Business model |
|---|---|
| **Satelite Vu** \| UK<br>www.satelitevu.com | Satelite Vu with its HotSat satellites offers high-resolution infrared/thermal images (3.5 $m^2$), which significantly exceed the previous standard in terms of granularity. Areas of application include the early detection of forest fires, but also the impact measurement of (re)naturalisation measures. Monitoring with infrared allows day and night monitoring. |
| **Albedo** \| USA<br>www.albedo.com | Provides high-quality aerial images from space using its own low-flying satellites. This forms a basis for remote monitoring of infrastructure or other assets. |
| **Iceye** \| Finland<br>www.iceye.com | ICEYE enables objective, data-driven decisions for insurance, real-time response to natural disasters and recovery planning with the world's largest SAR satellite constellation. |
| **Geosite** \| USA<br>www.geosite.io | Geosite is a comprehensive marketplace (> 1,000 data points) for geodata that offers relevant and usable data for various use cases in real time via an API. The US Air Force, for example, uses the data to coordinate rescue operations in the event of a disaster. |

## Data analysis

Software solutions to determine climate risks require sophisticated modelling and simulations to understand how different climate scenarios could impact infrastructure, real estate and urban areas. Such tools can then help policy makers, urban planners and businesses as well as investors make informed decisions about where and how to build, retrofit and invest in infrastructure to address future climate-related challenges. The use of advanced climate models that can predict climate risks leads to proactive risk management and thus enables preventive planning.

To develop these sophisticated models, the data from the aforementioned category is analysed and interpreted using machine learning and artificial intelligence, among other things. AI algorithms analyse huge data sets in order to improve the accuracy of climate forecasts, identify patterns and better assess risks. These software solutions are already very relevant in practice, as they are used for risk modelling by insurance companies and banks, among others, and help companies to meet regulatory requirements for their climate risk reporting (e.g. the Task Force on Climate-Related Financial Disclosures (TCFD), the Task Force on Nature-related Financial Disclosures (TCND) or the Corporate Sustainability Reporting Directive (CSRD)).

| Startup | Business model |
|---|---|
| **Climate-X** \| UK<br>www.climate-x.com | Climate X provides global coverage of climate risk data by combining science and econometrics to deliver (physical and transitory) climate risk analyses. The client focus is on companies in the real estate and financial services sectors. |
| **Jupiter Intelligence** \| USA<br>www.jupiterintel.com | Predictive climate risk modelling for companies. The climate analyses cover all hazard metrics and translate scientific findings into usable data. In collaboration with industry experts, the best scientific approach for analysing the physical climate risk for the respective company is determined. |

| | |
|---|---|
| **Repath** \| Germany<br>www.repath.earth | Repath offers its customers a tool that is based on climate risk models to identify a company's individual climate risks in order to identify paths to a climate-resilient future. At the same time, the tool is also designed to support the fulfilment of reporting requirements |
| **Vida** \| Germany<br>www.vida.place | With over 50 data layers, Vida aims to enable a rapid assessment of the location risks of infrastructure assets (wind/solar farms, grids, transport routes). The map-based analysis should be usable for both planning and monitoring purposes. |
| **Sust Global** \| USA<br>www.sustglobal.com | Unlike most climate risk models, Sust's AI-based tool focuses on modelling climate-related financial losses and forecasting corresponding business interruptions. The data can then be exported via API to existing workflow systems for further analysis. |
| **7 Analytics** \| Norway<br>www.7analytics.no | The planning tool from 7Analytics is designed to enable all stakeholders - from infrastructure owners to architects - to take the imminent and future effects of climate change into account when planning projects. To this end, 7A relies on hydrology, geology and data science and the risk tools derived from them. |
| **UrbanFootprint** \| USA<br>www.urbanfootpring.com | Curated data and models flow into the so-called "Decision-Making Tool", which is intended to help decision-makers make scientifically sound decisions in the field of urban planning and/or resource allocation (for example, regarding the modernisation of existing infrastructure and the transition to e-mobility). |
| **Salient Predictions** \| USA<br>www.salientpredictions.com | Salient combines novel ocean and land surface data with machine learning and climate expertise to deliver the world's most accurate sub-seasonal to seasonal weather forecasts 2 to 52 weeks in advance. |
| **ClimaLinks** \| Switzerland<br>www.salientpredictions.com | ClimaLinks offers a unique blend of Weather Relations Management (WRM) tools and Data-as-a-Service (DaaS) to transform weather data into relevant insights for businesses, including optimising weather-dependent processes. |

As observable by this list, there are already a large number of providers in the field of climate risk assessment, which often differ only slightly (e.g. focus, regionality). The accuracy of the models and the associated quality of the data will probably be decisive for the individual company's success. However, due to the aforementioned regulatory requirements for company reports in the area of climate risks, demand is expected to grow, which could further fuel competition, at least in the short term.

## 3.2 Disaster Response & Recovery Systems

In the area of early warning systems, digital communication technologies, including mobile apps, text messages and social media, can be used alongside traditional warning instruments such as sirens to warn communities immediately in time of impending natural disasters such as hurricanes, floods and forest fires.

In the event of possible flooding, advanced sensor technology and data analysis can also be used to develop intelligent warning systems for coastal areas. These systems collect real-time data on rainfall, sea levels and river flows and use predictive modelling to forecast flood events. By providing accurate and timely warnings, these systems enable coastal communities to take proactive measures to protect life and property. In addition, the data collected by these systems can be used to improve flood risk mapping and as a basis for future adaptation strategies. Sensor technology is also frequently used to detect

forest fires at an early stage and issue appropriate warnings. This technology uses gas or infrared sensors to detect changes in forests in real time, which indicate possible forest fires, allowing emergency services to be dispatched at an early stage and reducing the risk to people and property.

In addition to warning systems, geographic information systems (GIS) offer the opportunity to optimise resource allocation and quickly initiate response and recovery measures in the event of a disaster by accelerating the mapping and analysis of areas affected by a disaster. The public can also help with crisis mapping, for example by using online platforms and crowdsourced mapping tools to report and track the impact of disasters, which improves the situational awareness of the emergency services.

| Startup | Business model |
|---|---|
| ORORA<br>**OroraTech** \| Germany<br>www.ororatech.com | OroraTech is a thermal data intelligence company monitoring more than 160m ha of forest worldwide with its AI-powered nanosatellites for thermal infrared sensing. |
| DRYAD<br>**Dryad** \| Germany<br>www.dryad.net | Dryad enables ultra-early detection of forest fires and forest health and growth monitoring using solar-powered gas sensors in a large-scale IoT sensor network |
| MONAVA<br>**Monava** \| Sweden<br>www.monava.io | With its models based on satellite data, Monava aims to improve the improve the detection of avalanches, rockfalls and landslides. People in distress can thus be informed in good time about the location and type of event. |

## 3.3 Smart Infrastructure

Smart infrastructure refers to the use of technologies to increase the resilience of infrastructure. This includes, for example, the development of innovative building materials or intelligent materials that react to environmental changes, making the infrastructure better able to withstand extreme weather events. The use of IoT (especially sensors) can also be useful for infrastructure (buildings, roads, bridges, etc.), as these technologies can monitor the structural condition, predict maintenance requirements and provide real-time data on environmental changes. Data-driven decision support systems can also be used as decision-making aids to help governments and companies formulate effective climate adaptation strategies.

Another important aspect comes from the energy sector, where decentralised smart grids for renewable energies, so-called "microgrids" and storage solutions increase the resilience of the energy supply by reducing dependence on the general power grid. Digital technologies enable the creation of smart grids that improve the reliability and efficiency of energy distribution and reduce vulnerability to climate-related disruptions.

| Startup | Business model |
|---|---|
| vialytics<br>**Vialytics** \| Germany<br>www.vialytics.de | SaaS platform that enables public transport managers (municipalities) to automatically assess the condition of road infrastructure, plan effective measures based on up-to-date data and manage all maintenance tasks in a single place. |

| | |
|---|---|
| **Groundhawk** \| Finland<br>www.groundhawk.io | Groundhawk's software enables the simple and precise mapping of underground cables for telecommunications and the internet using GPS positioning in combination with AI. The documentation with geo-referenced photos of the entire trench and each network element helps with the laying of new cables and the monitoring of existing ones. |
| **Lenz Labs** \| Scotland<br>www.lenzlabs.com | Lenzlabs accelerates decision-making for logistics companies by bringing together maintenance, incident and asset information in one place. Missed maintenance work, unresolved incidents and the status of facilities are displayed on a standardised geographical map. |
| **Airpelago** \| Sweden<br>www.airpelago.com | Airpelago's software enables energy grid operators to efficiently inspect power lines. Airpelago's Drone Mission Control is a cloud-based ground station for the efficient inspection of large installations through automation and consistent data. |
| **Greenpass** \| Austria<br>www.greenpass.io | Greenpass helps planners, property developers and cities to make the best decisions at every stage of urban planning and development - and also addresses climate-related aspects in particular. The aim is to enable "climate-proof architecture". |
| **infrared.city** \| Austria<br>www.infrared.city | Infrared City's AI-based environmental/climate simulation services enable performative design and reduce the complexity of spatial planning processes, which in turn reduces financial and time expenditure. |
| **Insight Terra** \| UK<br>www.insightterra.com | Insight's platform provides IoT-based real-time geo-environmental monitoring to mitigate the impact of geohazards caused by climate change. |
| **ClimateView** \| Sweden<br>www.climateview.global | ClimateView's ClimateOS platform breaks down the activities of municipalities on the path to climate resilience into manageable sections, enabling them to quickly understand the socio-economic impacts, costs and side effects. |

## 3.4 Water Management Solutions

Water is becoming an increasingly scarce resource, and its availability is becoming more and more volatile depending on extreme weather events. Water reuse and water management are therefore playing an increasingly important role. This includes solutions that help municipalities and private households, for example, to better manage their water resources, thereby saving water and ensuring supplies during periods of drought.

Specific technologies include, for example, water recycling, methods for rainwater utilisation, flood protection structures and wastewater treatment technologies. Existing (water) infrastructure can be made "smart" through the use of IoT / sensors, which is an important basis for leak detection / water monitoring, where AI and algorithms can automatically detect unusual deviations and in water consumption and initiate automated protective measures that ultimately optimise water consumption and minimise waste. In the private and commercial sectors, replacing old, inefficient appliances and fittings with water-saving and water treatment alternatives can significantly reduce consumption.

Desalination plants that enable the utilisation of abundant seawater resources is becoming increasingly relevant, particularly in very hot and water-scarce regions. Innovative desalination technologies are significantly more energy-efficient and cost-effective than previous devices, enable profitable operations.

| Startup | Business model |
|---|---|
| **Preventio** \| Germany<br>www.preven-io.com | PreventioENGINE, which is based on machine learning, enables water damage to be predicted before it occurs and suggests suitable measures to building owners to limit the damage, thereby reducing costly miscalculations and optimising decision-making processes. |
| **Pydro** \| Germany<br>www.pydro.comw | PYDRO develops energy self-sufficient measurement and control systems for installation in water networks to make these networks "smart" and enable water suppliers to manage their networks more efficiently. PYDRO's flow meter sends data in real time without the need for a power supply or battery change. |
| **Additive Catchments** \| UK<br>www.additive.earth | Additive offers its customers IoT and AI-based software for analysing the water quality of various bodies of water in order to make data-driven investment decisions to increase climate resilience. |
| **Hydraloop** \| Netherlands<br>www.hydraloop.com | Hydraloop is developing an intelligent and affordable decentralised water recycling system in various sizes that can be used in both residential and commercial properties. This can save 25-45% water and energy. |
| **Flow Loop** \| Denmark<br>www.flow-loop.com | Flow Loop offers a plug-and-play retrofit shower that recovers used shower water from the floor of the shower, cleans it and returns it to the shower water circuit. The circulation system is said to enable homeowners to reduce their total household energy consumption by around 20% and their total water consumption by almost 30%. |
| **Field Factors** \| Netherlands<br>www.fieldfactors.com | BlueBloqs (modular, nature-based water reservoirs) can prevent flooding and drought in cities, as they can store up to 95% of the rainwater that falls on them and make it available for reuse. |
| **Natryx** \| USA<br>www.natrx.io | Natryx ExoForms can be used in place of rocks for drainage, reef restoration, erosion and storm surge applications, helping to make coastal regions in particular more climate resilient. |
| **Dutch Water Prevention** \| Netherlands<br>www.dutchwaterprevention.com | Dutch Water Prevention is a manufacturer of various innovative and decentralised flood protection systems that can be used in private, commercial and institutional environments. These include, for example, self-activating and portable systems. |
| **Membion** \| Germany<br>www.membion.com | Membion develops systems for membrane bioreactors (MBR) - water filtration for municipalities and industry, which are characterised by extremely low energy consumption, which greatly improves cost-effectiveness. In addition, the solutions are "built-to-fit", i.e. they can be integrated into existing systems. |
| **Desolenator** \| Netherlands<br>www.desolenator.com | Desolnator's SP40 is the first solar thermal desalination system to utilise a closed loop approach. These are scalable, modular systems that are suitable for use in remote locations with low water costs. |

## 3.5 Climate Resilience Fin- & InsureTech

Traditional financing instruments such as green bonds/green loans can generally finance projects to improve climate resilience. They are also attractive to many institutional investors due to their sustainability aspect. However, there are currently no financial instruments on the financial market that are exclusively geared towards financing climate resilience projects.

One service that is already established in practice, however, is climate risk insurance. Parametric insurance is particularly noteworthy. These are alternative risk solutions offered by insurance and reinsurance companies that enable companies to finance or transfer risks in a non-traditional way. The solutions revolve around a measurable index and are based on predefined triggers or payout mechanisms - without necessarily requiring a physical loss to occur. As climate-related weather risks become increasingly complex and unpredictable, the demand for such innovative parametric insurance structures is growing. Parametric insurance could become an increasingly viable option to help organisations build climate resilience and strengthen disaster preparedness and response. In addition to parametric insurance, innovative climate-based risk models are also being used in various traditional areas of actuarial science.

| Startup | Business model |
|---|---|
| FloodFlash<br>**FloodFlash** \| UK<br>www.floodflash.co | Provider of parametric flood insurance, with a fixed payout in the event of a flood, which we measure with a proprietary sensor, avoiding costs due to uncertainty. |
| DESCARTES<br>**Descartes** \| France<br>www.descartesunderwriting.com | Descartes offers data-driven risk modelling software for insurance brokers and underwriters of parametric insurance. The modelling software is based on machine learning and real-time monitoring using satellite images and IoT sensors. |
| kettle<br>**Kettle** \| USA<br>www.ourkettle.com | In the USA, Kettle offers Excess & Surplus Lines (E&S) for risks that are difficult to insure as well as parametric insurance for forest fires and hurricanes. They also offer these products as reinsurance for other insurers. |
| WeatherMind<br>**WeatherMind** \| France<br>www.weathermind.ai | WeatherMind's software enables AI-based processing of insurance claims for victims of natural disasters who have taken out parametric insurance. Thanks to the agreed triggers, fast and unbureaucratic payouts are possible. |
| RENEWRISK<br>**Renew Risk** \| UK<br>www.renew-risk.com | Renew Risk is a company that specialises in the risk modelling of renewables. Specifically, on the risk for insurance companies when underwriting the risk of offshore wind turbines and associated lines. |

Another aspect that is not considered further in this white paper, but is also important for holistic climate resilience management, is the area of "community engagement", in which the population can support the monitoring of environmental changes, e.g. through smartphone apps, and thus contribute to scientific research. Recommendations for action could also be offered here.

# Chapter 4 - AdaptationTech solutions in practice:

## Examples of established AdaptationTech business models.

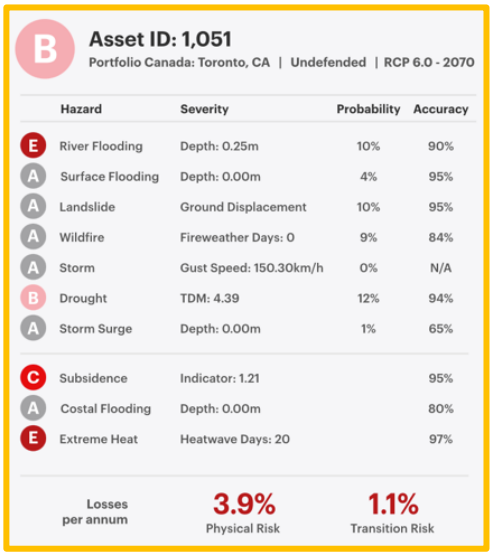
**Key Messages:**

- Already established business models are characterised by a high level of technical complexity, which is either scalable in the private sector or could alternatively be successfully marketed to municipalities in B2G sales processes.
- The start-ups have already succeeded in obtaining initial private capital from (VC) investors and/or significant support through research funding/grants.
- However, due to the structural underfunding of the sector and a general VC restriction in the growth stage, there has been a lack of further funding for scaling to date.

The solutions mentioned in the previous chapter are not only theoretical useful, but also (more or less) established in practice. A selection of these is included in the following part, where individual business models will be presented in the context of case studies.

## 4.1 Climate-X

Climate X (www.climate-x.com), based in London, was founded in 2020 by Lukky Ahmed and Kamil Kluza, who had previously worked together for many years in financial services risk management. Climate X is a leading provider of physical data and risk analytics for financial services and the property industry. With its products, Climate X enables property owners, lenders, mortgage providers, estate agents, sustainability consultants and other stakeholders to forecast the future physical risk of their property portfolio and incorporate this data into their own risk assessment engines and pricing models.

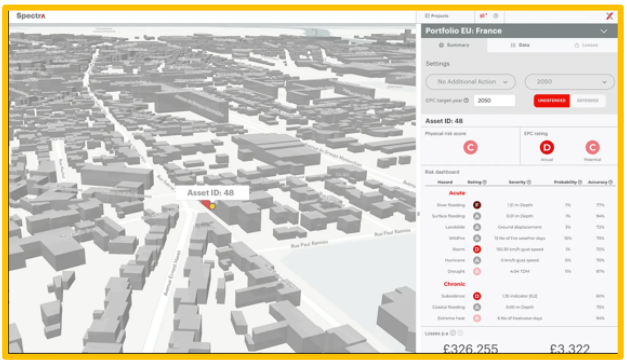



In the financial services sector, demand is currently being strongly driven by regulations forcing financial services organisations in the UK, EU and US to demonstrate their resilience in managing physical risks associated with climate change-related disruptions. The property industry is becoming increasingly sensitive to the physical risks of real estate, resulting in mispricing risks for buyers and sellers, which can be mitigated by using Climate X's software to provide climate data up to 30 years into the future. As a result, Climate X enables all decision makers to put climate action and resilience at the centre of their strategy and provide the transparency that is increasingly important for large, regulated industries to develop sustainable business models.

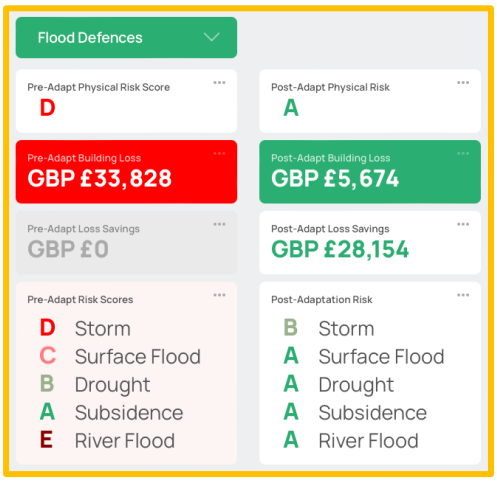
Climate X's core product, Spectra, is also described by the company as "Google Maps for climate risks". Users can enter their geographical location here to, among other things:

- Fully assess and price climate risks for new transactions and improve due diligence,
- perform portfolio valuations for existing holdings in all property categories (residential property, commercial property, infrastructure, etc.); and
- Improve climate risk disclosure for industry standards such as GRESB, CRREM, SFDR Article 8/9, TCFD reports and more.

Spectra users get easy access to specific building and site information with heat maps, can select and compare results from different pre-loaded climate scenarios / time periods and have access to data for acute vs. chronic risks, risk scores, severity metrics, probability and confidence values. The data can be easily transferred to automatically generated risk reports.




The company also offers an API that feeds Spectra data into customised platforms and models for financial services and real estate risks. Both Spectra and the Climate X API offer energy efficiency ratings, physical and transition losses and climate scenarios, among other data. Spectra and the data it contains enable users to calculate the probability and severity of weather events at asset level, sometimes decades in advance. By taking a holistic approach, customers can use their solution to assess physical risks, estimate financial losses and analyse different scenarios to make informed decisions to better prepare for weather-related events associated with climate change.

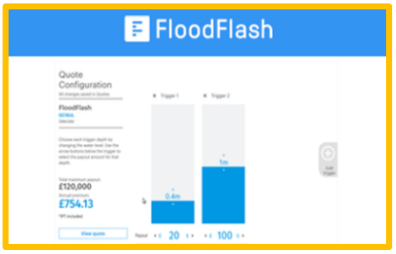



The advantages for users are obvious, as the use of Spectra saves time and facilitates collaboration between different departments / teams (e.g. finance, compliance, risk management), as the data can also be prepared differently for different teams or purposes. Spectra offers a full range of hazards for geophysical risks, including various types of floods, landslides/storms and more, which are reviewed by the Academy.

In 2024, Climate X launched a second software called Adapt, which allows users to identify adaptation opportunities up to ten times faster than is possible with traditional on-site inspections. Adapt provides its users with instant access to climate risk data at facility level and predicts the return on investment (ROI) for the planning and implementation of adaptation solutions. With just a few clicks, users can perform a full risk assessment, explore adaptation options and also download the data in a .csv file. By integrating Adapt into acquisition or due diligence processes, customers save time and resources.

## 4.2 FloodFlash

FloodFlash Ltd. was founded in London in 2017 by Adam Rimmer (CEO) and Ian Bartholomew (Chief Science Officer), where it is still headquartered today. In 2018, the eponymous product FloodFlash (https://floodflash.co) was launched on the market. Floodflash is a parametric catastrophe insurance for B2B customers in the property sector. The insurance allows tenants, landlords, asset managers and other stakeholders of properties at risk from flooding to choose what damage or amount of damage they want to cover in the event of a flood.



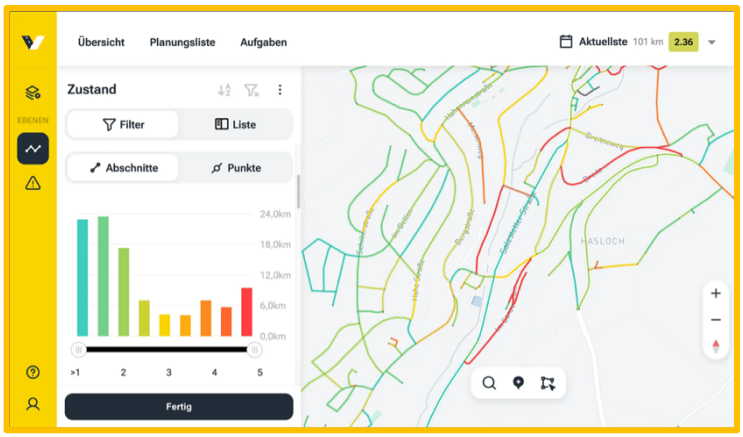

A proprietary underwriting engine calculates insurance premiums automatically and in real time at the level of individual properties/buildings, which can then be sold by the largest business customer insurance companies. The insurance policies taken out as well as sales partners/insurance brokers and other data are managed on a separate cloud-based web platform.

The height of the flood and the flooding event are checked independently of FloodFlash's own water sensor, which is installed at each customer building. installed at each customer building. Each sensor is equipped with high-precision ultrasonic depth measurement technology - similar to a car's parking sensors. They also have a mobile data connection to send up-to-date flood data to the FloodFlash control centre. The sensors are also built to last, with a battery life of up to 12 years, tamper protection and a memory chip to store data in the event of a network failure.


As a result, the use of the sensor enables a quick payout in the event of a claim, which is made after just a few checks of the sensor data. This is in stark contrast to traditional insurance policies, which often have a long and unknown claims settlement process. In addition, the parametric approach at individual property level makes it possible to insure certain buildings that are not insurable under traditional insurance policies (e.g. homeowners' insurance) or only at uneconomical conditions. Lloyds and MunichRE act as key underwriters for the relevant insurance policies with additional capacity from other reinsurance companies. In addition to the climate resilience effect, Floodflash also has a positive social impact by providing flood protection to local businesses that previously had no access to it.

## 4.3 Vialytics

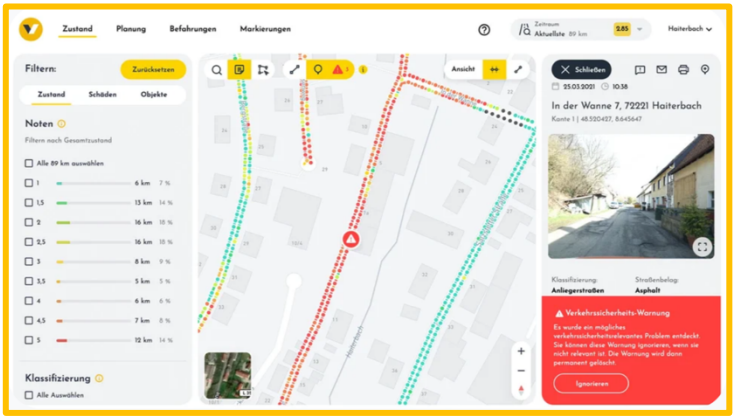
Founded in 2018 by Danilo Jovicic-Albrecht, Patrick Glaser and Achim Hoth, Vialytics (www.vialytics.de) is a leader in the emerging field of climate-resilient infrastructure management, harnessing the power of digital twins and asset tracking technology to redefine road maintenance. Vialytics utilises a sophisticated mobile application that transforms smartphones into dynamic road assessment tools. Not only does this technology create a digital twin of the road network, providing a comprehensive overview like Google Street View of road conditions, but it also introduces a strategic dimension to maintenance and asset management, providing preventative protection against climate-induced deterioration.




The creation of digital twins for critical infrastructures by Vialytics goes beyond mere monitoring; it is a proactive step towards improving the adaptability of urban environments to meet the challenges of climate change. This approach provides municipalities with actionable insights that enable the prediction of vulnerabilities and efficient use of resources to maintain the integrity of critical transport networks amid increasingly volatile weather conditions. In addition, the technology enables a sustainable model of road maintenance that emphasises preventative measures, significantly extending the life of roads and reducing the environmental impact associated with frequent repairs and renewals. To date, more than 47,000 kilometres of road network have been mapped using artificial intelligence and over 100,000 road markings have been placed using the Vialytics system.

The positive feedback from municipal users emphasises the transformative impact of Vialytics' solutions on their operations. By streamlining the process of road condition recording and asset tracking, councils can now achieve greater accuracy in maintenance planning and execution, resulting in improved road quality and public satisfaction. This shift

to a data-driven, technology-enabled approach means a significant reduction in the carbon footprint of road maintenance activities and is in line with wider environmental sustainability goals.




With a robust business model that delivers compelling value to over 300 municipalities in multiple countries, Vialytics is poised for expansive growth. Strategic expansions into new markets and further enhancements to its computer vision capabilities underscore Vialytics' commitment to innovation and sustainability. As Vialytics continues to evolve, its role in promoting climate resilience through digital infrastructure management will become increasingly indispensable, ushering in a new era in adapting cities to climate change and mitigating its effects.

One of the municipalities that uses Vialytics is the city of Menden. Here, Vialytics has been installed as standard in all waste collection vehicles. This generates image data for 98% of the road network, which can be analysed by the Vialytics AI. This helps the city of Menden to manage its infrastructure and plan its road construction measures. It saves itself the time of having to drive on the roads itself and can always work with up-to-date data, as waste collection naturally takes place at regular intervals.

## 4.4 Groundhawk

Groundhawk (www.groundhawk.io), a spin-out from Advian and co-founded in January 2023 by Janne Honkonen, Laura Tuomikoski, Christoffer Winquist and Arsi Juote, is revolutionising the management of underground utilities with its ground-breaking AI-based 3D scanning and precision positioning technology. Critical to the development of smart cities and renewable energy grids, this innovative approach enables the accurate mapping of underground cables, pipes and infrastructure, significantly reducing the risk of damage during construction work after cable installation. It streamlines the data collection process and allows existing workers to efficiently document underground utilities without the need for post-lay surveys, enabling a more sustainable construction method that minimises environmental impact and accidental damage to utilities.


The introduction of this technology is a key advance in the construction and management of urban infrastructure that is resilient to climate change. By providing real-time network overviews and highly accurate location data, Groundhawk improves the safety and sustainability of underground utility management. This system is essential for the growing demand for fibre-to-the-home (FTTH) connections and supports the urgent need for climate-resilient infrastructure development. Groundhawk already operates in five countries and is well positioned to scale and grow its business.


Groundhawk's innovation is closely linked to the climate resilience of infrastructure, providing a solution that drastically reduces the need for invasive ground surveys that can destroy soil and lead to erosion. Accurate data on underground infrastructure helps in the efficient planning and implementation of renewable energy projects, which are crucial for the transition to a low-carbon economy. In addition, the Groundhawk system prevents damage to critical utilities during extreme weather events, increasing the resilience of urban infrastructure. As cities around the world adapt to and mitigate the effects of climate change, Groundhawk's ability to accurately map and manage underground assets will become increasingly important to ensure the maintenance of services and the safety and sustainability of urban environments in the face of climate-related challenges. This is another example of the digital twin of infrastructure, and the better cities know exactly where critical infrastructure is located, the better they can ensure that it is climate-proofed.

## 4.5 PYDRO

According to studies, an average of 30% of the water treated worldwide is lost again due to leaks, at great energy and cost. Water suppliers are under daily pressure from urbanisation, water scarcity, rising energy prices and ageing water supply networks. Intelligent water infrastructures, so-called smart water networks, are an opportunity to reduce these immense losses. PYDRO (www.pydro.com) was founded in 2016 by Mulundu Sichone and Felix Müller with the aim of counteracting this loss through intelligent flow meters. Based on an ambitious bachelor's thesis, a now fully functional and multisensory flow meter was developed. The development was mainly funded by public grants such as the Horizon2020 SME Phase 1 Instrument and EIT Climate-KIC. The company slogan "water to data" is still relevant.


PYDRO is the only company to date to develop a complete system consisting of energy self-sufficient sensors and valves as well as the associated cloud-based software solution, which is designed to enable intelligent pressure regulation and pipe burst prevention. PYDRO's energy self-sufficient multi-sensors with real-time data transmission monitor drinking water pipes, thus conserving resources by reducing water and energy losses and increasing supply reliability.

The innovative approach of this project is based on the development of energy self-sufficient technologies by integrating modular and space-saving energy recovery turbines into the existing design of the measurement and control systems. PYDRO's flow meter transmits data in real time without the need for a power supply or battery replacement. Comparing the current data with historical data or the hydraulic model of the network allows the customer to localise events and leaks in real time. PYDRO also allows active water loss reduction through intelligent pressure management as well as measurement and flow analysis capabilities.

PYDRO's energy self-sufficiency offers the advantage over conventional solutions that it can also be used in locations where there is no external power supply for sensors or control valves within the water infrastructure, which was previously a frequent obstacle to the installation of these sensors. Battery-operated solutions also require frequent battery replacement as soon as data is exchanged at the required frequency or actuators need to be operated, which results in significantly higher operating costs compared to PYDRO. Subsequent connection to the public power supply network is also associated with high investment costs. In addition to selling the energy self-sufficient measurement and control system, PYDRO generates revenue through a Sensing-as-a-Service (SaaS) model, where the customer pays a data tariff per turbine system and per month for the collected sensor data and access to the software platform. In addition, PYDRO will generate further revenue through maintenance contracts and consultancy services.

# Chapter 5 - Adaptation Finance Gap:

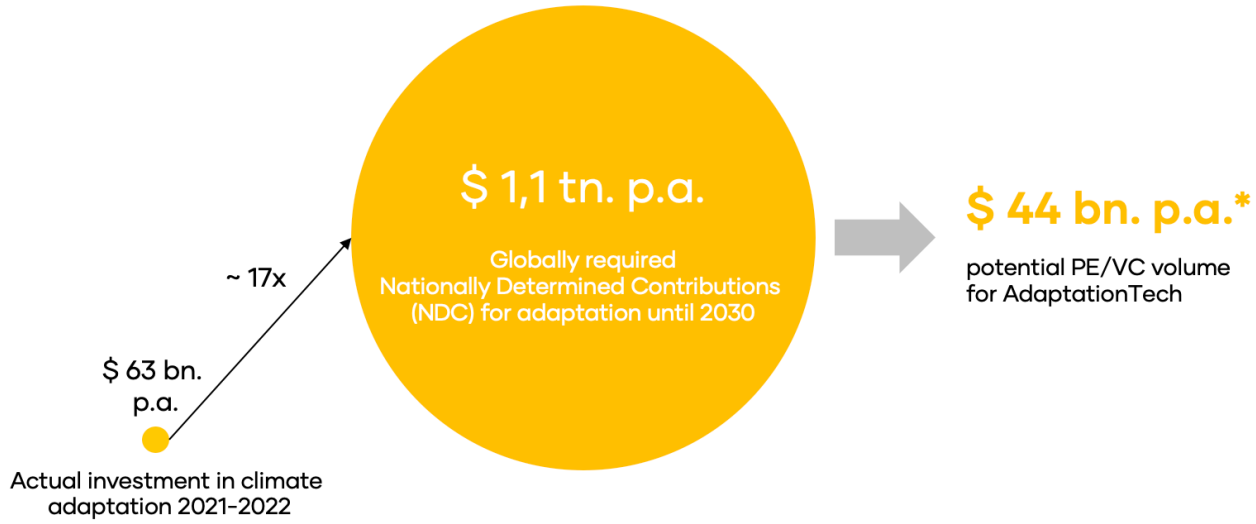
## Why current financial resources are not sufficient for adequate adaptation to climate change.

**Key Messages:**

- Public funding currently dominates the area of adaptation finance.
- Overall, there is a lack of investment totalling EUR 1 trillion p.a. worldwide for adaptation to climate change.
- Assuming that 4% would be used for innovative AdaptationTech solutions, this results in a need for EUR 44bn p.a. in venture capital.
- One reason for the significant lack of (primarily private) capital is the over-weight allocation of climate investments in climate mitigation (95%).
- The need for capital is exacerbated by a general VC funding gap in the growth stage, which makes it difficult to scale relevant AdaptationTech solutions on a large scale.

Measured against the global funding required for adaptation to climate impacts of EUR 1.1 trillion according to the Nationally Determined Contributions (NDC) from the Paris Climate Agreement (see above) and an actual volume of adaptation investments of EUR 63 billion, the global adaptation finance gap amounts to > EUR 1 bn or a factor of 17x (see Figure 12). Taking into account the ratio of ClimateTech VC investments to investments in climate change mitigation of 4%, this results in a possible VC/PE potential of EUR 44bn per year for AdaptationTech.

Figure 12: Global annual expenditure in 2021-22 and annual expenditure required for climate impact adaptation[10]




Source: CPI, GCA

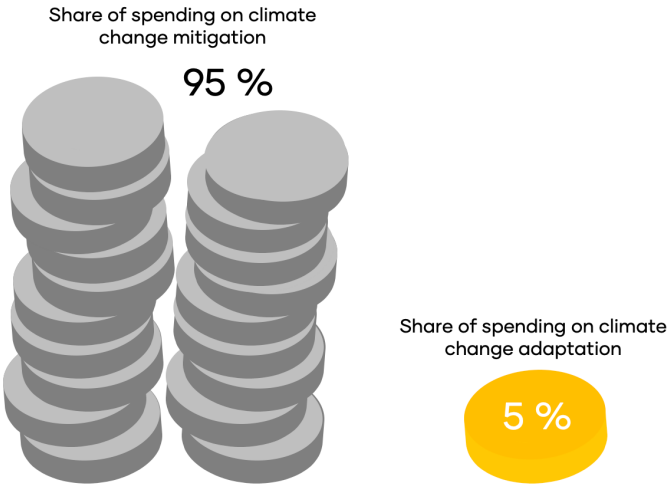
*Own calculation, based on the ratio of actual expenditure on climate change mitigation and ClimateTech investments

One of the main reasons for the overall low level of funding is the low involvement of private capital, as the majority of funding (98%) currently comes from the public sector. In Europe, this is mostly provided via funding programmes such as the *EU Regional Development Fund (ERDF)*, which supports and finances climate adaptation projects, the

European Cohesion Fund, the LIFE programme and Horizon Europe as a research and innovation programme. At national level in Germany, the immediate action programme for climate change adaptation in response to the flood disaster in the Ahr-valley in 2021 should be mentioned. This programme will provide 60 million euros by 2026 to support municipalities in adapting to extreme weather or heat waves. The programme plans to hire more than 100 local climate adaptation managers to help local authorities develop and implement customised adaptation concepts, with a focus on protection against floods and heat.

The private sector is currently only involved in a fragmented way, which seems surprising given that investments in climate adaptation have an average benefit-cost ratio of 4:1.[20] Increased cooperation between governments and the private sector is therefore crucial to drive private investment in climate adaptation and make it more attractive in order to increase global financing for climate adaptation in general. One reason for the low level of investment in climate adaptation to date is the strong preponderance of investments in mitigation, which grew by EUR 439 billion from 2021-2022 to 2019-2020 and thus increased significantly more than adaptation investments (+28% to a total of EUR 63 billion). There is therefore massive pent-up demand here. [21]

### Figure 13: Breakdown of climate investments by mitigation and adaptation




Source: Global Center on Adaptation – State and Trends in Climate Adaption Finance 2024

The second main reason for a lack of VC/PE investment in this area is due to a structural funding gap in the growth stage area in the EU and UK (compared to the US). The biggest risk for UK and European startups is that only 1 in 5 companies receive further funding from the same investors in the growth stage. This is very different in the US, where there is around eight times more capital available for start-ups in the growth stage than in the UK and Europe, where VCs focus on early-stage funding. As a result, start-ups often turn to the US markets after Series A to raise growth rounds, which often results in a drain of expertise and technology.[22]

# Chapter 6 - Seizing economic opportunities:

## Reasons for politicians and investors to recognise AdaptationTech as an attractive investment opportunity.

**Key Messages:**

- AdaptationTech is currently in a "sunrise" phase, in which the first positive signs are visible on the horizon, but there are still a few steps to go before its full potential can be realised.
- The obvious need for these solutions, which has already been pointed out, combined with a currently underdeveloped market environment, offers VC/PE investors attractive return opportunities due to (still) low company valuations.
- Enormous growth/catch-up potential (e.g. in comparison with established ClimateTech solutions for climate change mitigation) can be expected.
- The first investors, especially those with expert knowledge, have already recognised the opportunities and made investments in this new vertical.
- Policymakers are called upon to further optimise the framework conditions that have already been created in order to help exploit the potential and benefit from the positive development of the technologies through their use and possible export.

### 6.1 Political and regulatory support

In order to further drive innovation in the field of AdaptationTech, it is crucial to optimise the existing legal framework so that research, innovation and investment in this area can continue to grow without excessive bureaucracy. This includes providing efficient incentives for the use of AdaptationTech solutions and the further establishment of regulations that promote climate adaptation in general. Here, the public sector can lead by example by anchoring the consideration of climate resilience in public procurement, which would be very helpful in terms of acceptance and scaling (e.g. for infrastructure projects), as public procurement accounts for 14% of EU GDP, At national level in Germany, the topic should be anchored in the German strategy for green lead markets ("grüne Leitmärkte"), which is to be presented later in 2024. AdaptationTech start-ups should be given equal consideration to traditional adaptation measures.

From a governmental perspective, a commitment to climate change adaptation makes a lot of sense not only from an environmental perspective, but also economically, as extreme weather damage can lead to significant declines in GDP in individual countries or regions. In total, an annual loss of USD 23 trillion in global GDP is imminent if sufficient mitigation and, above all, adaptation measures to climate change are not taken; in other words, the global economy risks losing up to 18% of its GDP by 2050.[24] Annual investments of 0.6-1% of GDP in adaptation measures can not only counteract climate-related losses, but can even pay off financially.[25] In the G20 countries in particular, the OECD estimates that positive effects of climate adaptation measures on economic growth of up to +1% are possible.[26]

Germany and Europe should capitalise on the momentum and establish an AdaptionTech ecosystem due to the economic benefits highlighted and the pioneering role they currently play. Lessons learnt from the areas of e-mobility and solar should be taken into account so that adaptation technologies do not have to be sourced from abroad in the future.

## 6.2 Recommendations for action for AdaptationTech start-ups

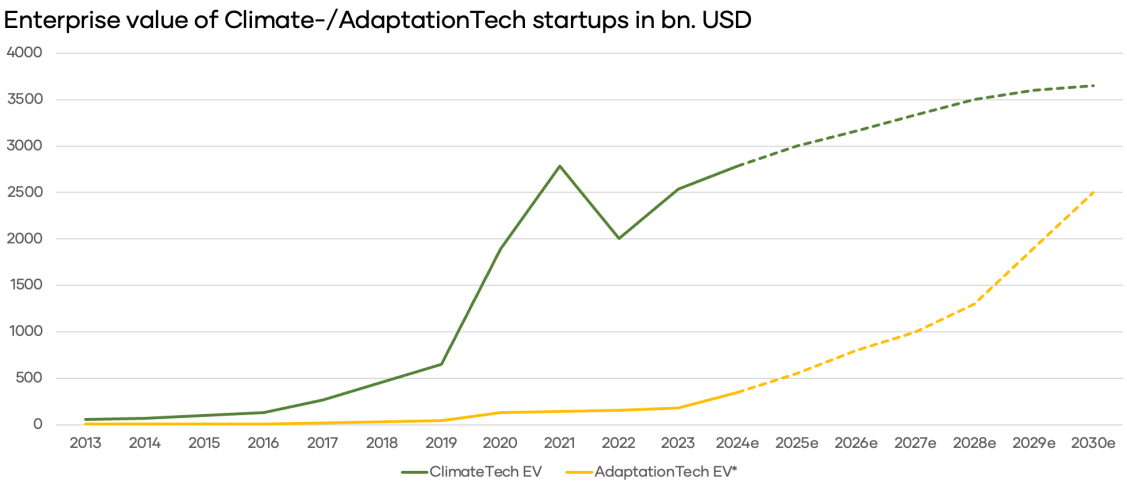
AdaptationTech start-ups play a crucial role in the development of technologies and solutions that help to counter the effects of climate change. For them, it is important to find their way in a market that is still developing. VC investors are usually more than just capital providers in the initial phase, which is why startups should make sure that investors understand the dynamics of the business model and climate adaptation in general, despite the immense capital requirements. They should also evaluate what relevant added value/experience investors can bring e.g. when scaling in the private (or public) sector. As the expected massive challenges cannot be mastered by one startup alone, it is advisable for startups to enter strategic partnerships, e.g. in the form of alliances / interest groups. This can be used, for example, to express clear positions and needs to politicians. In addition, experiences can be exchanged with competitors (or more appropriately: fellows), which ultimately helps everyone. Competitive thinking is only necessary to a limited extent here, as the market will require several providers. Furthermore, cooperation with established and financially strong production companies and corresponding pilot projects can support sales, as customers usually want to see a proof of concept before a comprehensive roll-out of the technologies.

As Chapter 3 shows, the most economically promising business models are those that can be easily scaled and placed in the private sector despite their high technical complexity. Even if pilot projects, as described, are important for initial establishment, start-ups should always aim to develop solutions that are scalable and replicable and are not overly specific or can be modified/customised, as this significantly slows down potential company growth. Ideally, the product/service can also be used in different industries and/or regions, which is associated with a larger market and correspondingly higher earnings potential. In addition to the private sector, the public sector is a major customer of AdaptationTech start-ups. Sales processes involving tenders and other public institutions can be very complex and lengthy, which is why startups should be proficient in B2G sales.

## 6.1 Recommendations for action for investors

Based on the previous findings, it can be said that investments in AdaptationTech are "double return" investments, as they are both, economically rewarding and positive for society. In addition, now is probably a good time to invest, as the topic of adaptation tech is currently attracting increased attention, which is creating a certain momentum. As start-ups in this field are often still at an early stage and private and venture capital investors are not yet "working" in the field on a large scale, this could give investors a "first mover" advantage, e.g. in the form of favourable company valuations. A historical example of the economic benefits of first movers are the company valuations of ClimateTech companies, which have grown by around 45x in the last decade (see figure 14).

### Figure 14: Catch-up potential of AdaptionTech company valuations




Source: dealroom.co - Climate Tech Report 2023 / *own calculations

We firmly believe that due to the considerable demand for AdaptationTech, a similar, if not even higher, growth potential can be expected in terms of company valuations. The first signs of this are advancing investors such as Munich Re, whose reinsurance business is particularly affected by extreme weather events and long-term climate change, which is why it has entered initial investments and partnerships with adaptation techs such as FloodFlash via its subsidiary Munich RE Ventures. It is therefore likely to be a question of time before other major investors follow suit.

Another obstacle for private investments is often the impact measurement of AdaptationTech investments, as the impact of AdaptationTech investments can be very different ("not only CO2" as with mitigation). This sometimes makes it difficult for Article 8 or Article 9 funds under the SFDR to make investments in this area. The Adaptation & Resilience Investors Collaborative (ARIC), together with the Finance Initiative of the UN Environmental Programme (UNEP), has published an approximation of how impacts in this segment can be measured in its "measurement framework for investors". [23] Due to the complexity of AdaptationTech business models, we expect that a new cohort of VCs specialising in climate impact adaptation will emerge, which, in addition to capital, can also offer added value for start-ups, for example by supporting sales to public institutions / municipalities (B2G), which is characterised by particularly long sales cycles.

In addition to VC investors who finance the start-ups, traditional asset owners should also open up to the technologies. For example, (in some cases mandatory) climate resilience readiness checks can be used to identify potential for the use of adaptation technologies in order to improve the resilience of one's own assets and thus ideally avoid the creation of stranded assets. Integrating climate resilience into the investment strategy therefore helps to minimise risks and preserve or create value in the long term. Direct investments in capital-intensive adaptation tech hardware solutions in particular could also be interesting, as these innovative assets can contribute to a positive diversification of the portfolio. Adaptation technologies therefore offer strategic potential to potentially differentiate the company from its competitors.

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