

Climate Action Programme 2021-2030

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1 Introduction

There is no doubt that the anthropogenic emissions of greenhouse gases are changing our living environment. Climate change is in our hands. We need to both work on limiting it as much as we can (mitigation), but we will also have to learn to adapt to new circumstances.

At TU Delft we are working on gaining a better understanding of climate change and climate action on an global, but also on a regional scale. Furthermore, TU Delft will harness its innovative powers to support the world-wide transition to non-fossil resources, and adaptation of the living environment to the consequences of global warming.

But our goal - a climate resilient world - cannot be achieved with innovative technologies alone. We also need deeper insights into the ethical, social and cultural aspects of climate change. How can we share the benefits and burdens in a fair way?

The problem is complex and urgent – but we have no other choice than to be optimistic and use all of our capacity to face the challenge, through our education programs and our research.

The Netherlands can and has to play an important role with the development of regional climate knowledge, adaptation and mitigation techniques. We want to take up a leading role, but also realize we can't do this on our own. That is why we are committed to regional and (inter)national cooperation, and the sharing of knowledge through open science and innovation, and to climate education.

Through the TU Delft Climate Action programme, we aim to deliver concrete Climate Action solutions based on fundamental research for the Netherlands and the world. We will focus on the following areas: Climate Science, Climate Change Mitigation, Climate Change Adaptation and Climate Governance.

We aim to make dedicated investments in joint projects for researchers from all corners of our university, for by combining insights in those Climate Action we can fill crucial gaps in our current climate action activities. Moreover, we aim to extend and strengthen our educational provision on Climate Action, focusing both on setting up professional education programmes and integrating Climate Action topics further into our current curricula.

Of course we need to practice what we preach. We have set ourselves the ambitious target that the campus must be CO₂ neutral by 2030 and we will harness all our available resources and latest research to achieve this goal, among others by using the campus as a living lab for our research.

The debate about Climate Action also extends to the political and policy domain. This debate needs to be based on facts and knowledge and needs to account for the important societal and ethical issues of responsibility and justice. We have the goal to develop a 'Climate Action Hub', with the aim to support global and national leaders, policy makers and industry in planning for and responding to climate change.

To achieve these goals we will work closely with our internal and external partners, among others the Delft Energy Initiative and its institutes (Urban Energy, Duwind, e-Refinery), TU Delft Climate Institute, GreenTU, LDE Centre for Sustainability,

Amsterdam Institute for Advanced Metropolitan Solutions, Convergence.Resilient Delta, 4TU.Resilience, International Universities Climate Alliance and IDEA league partner universities.

Focus Climate Action programme

Area	Goals
Research	<ul style="list-style-type: none"> Developing and strengthening university wide research projects on the four Climate Action themes
Education	<ul style="list-style-type: none"> Working together with internal and external stakeholders to develop professional education programmes on Climate Action topics Investigating how Climate Action can be further embedded in the curriculum
Campus	<ul style="list-style-type: none"> Developing a plan to become CO₂ Neutral in 2030
Societal impact	<ul style="list-style-type: none"> Setting up a 'Climate Action Hub' to support global leaders, policy makers and industry in planning for and responding to climate change Working together with regional partners to link fundamental research with real world application



2 Research

In the Climate Action research programme, we start from four themes we consider to be paramount for future Climate Action, namely:

- **Climate Science**
- **Climate Change Mitigation**
- **Climate Change Adaptation**
- **Climate Governance**

The TU Delft vision on Climate Action is deeply founded in preceding decades of university wide climate action research. The goal of the Climate Action research programme is to build on current strengths and identify the areas where there is a need to strengthen our capacities to keep up our (inter)national reputation as Climate Action university. We have identified eight initial research projects within which we will further develop fundamental Climate Action knowledge, which can be further tested and applied in living labs and pilot locations, before it can be brought to the market.

Theme I Climate Science

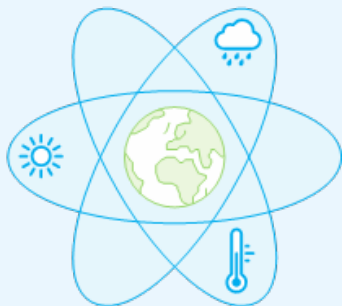
Although climate models are well capable of attributing the observed warming to increased greenhouse gases, there are still variations among different models due to uncertain feedback mechanisms in the climate system; clouds play a large role in this. Reducing this uncertainty is essential in supporting and guiding Climate Action decision making processes. It is also important to keep society in general informed with up-to-date insights into climate change. All over the campus of TU Delft, researchers work on the topic of climate science, among others by producing climate sensors, by producing models that describe our climate and ways to cope with climate change.

TU Delft Climate Institute, where much of their expertise is brought together, focuses on:

- Urban Climate
- Radiation Balance
- Ice & Sea Level Change,
- Water Cycle
- Climate Engineering

The flagship projects will add these topics:

- Scenarios of future climate change and mitigation/ adaptation measures
- Methods for safeguarding the world population against extreme climate change.



Research project



Modelling and monitoring regional climate change in The Netherlands

Challenge

Engineering solutions to the consequences of climate change mostly act on a local or regional scale. For these to be efficiently effective, knowledge of the regional climate and its future development is crucially important. What is the regional sea level rise? What is expected change of frequency of extreme weather events, such as heatwaves, precipitation, droughts, or storms? What are the underlying physical mechanisms at the regional and local scale? Future climate research will focus more on the regional aspects of climate change, based on increasingly accurate measurements and refinement of the spatial scale of the models.

Societal impact

Improved understanding of regional climate change will lead to a better definition of the boundary conditions for mitigation and adaptation measures. This will enable higher effectiveness, improved impact assessment studies and more accurate cost-benefit analyses. The Rotterdam Delta will play a key role in this flagship program, as a living lab as well as showcase. Citizen science will be one of the contributing program elements.



Research project



Solar Radiation Management

Challenge

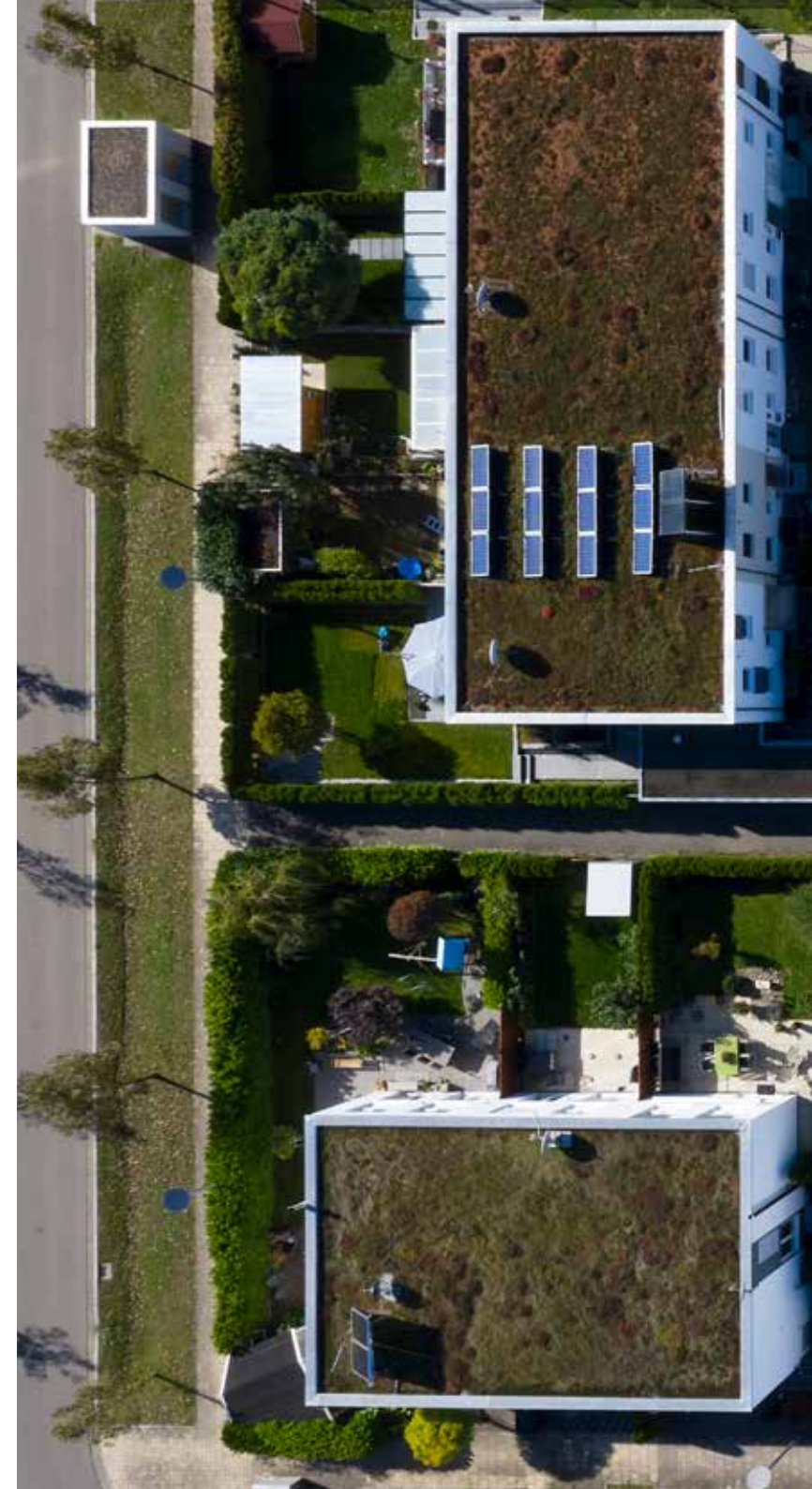
Climate engineering is not the solution to global warming, but it could help alleviate some of the severe consequences. By injecting dust particles in the stratosphere, for example, we can reflect sunlight back into space. Or we could do the same by increasing the reflective properties of cloud fields over the oceans. The development of these techniques will take many years – even decades –, but in the meantime we need to start discussions on if we even want to do this, and if so, under what conditions.

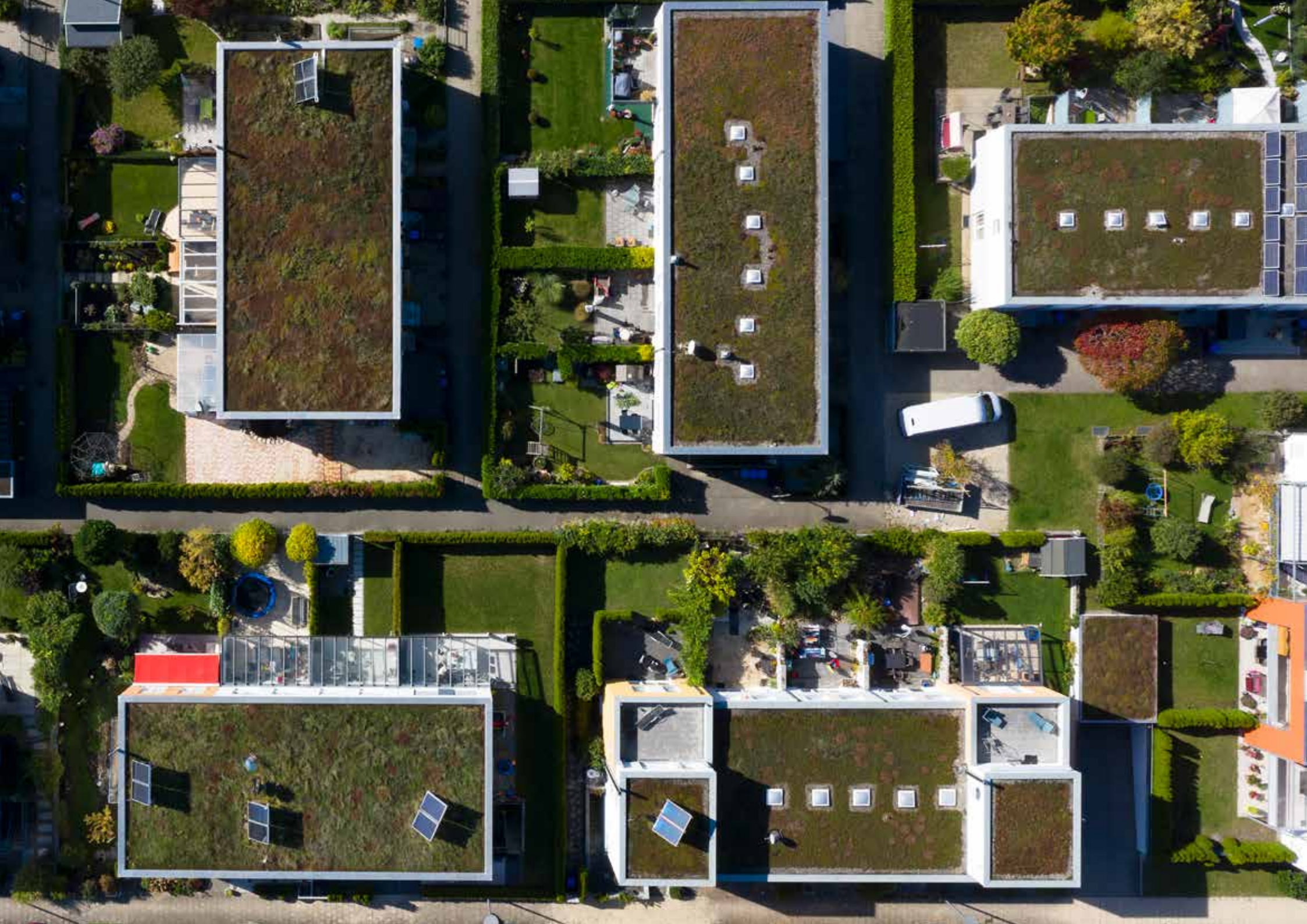
Research questions

- What is the most efficient and effective technology to inject aerosols into the stratosphere?
- What is the impact on the global temperature?
- What is the global environmental impact?
- What are the ethical implications of climate engineering?
- What is the best governance system for these technologies?

Societal impact

Societal debates about need, impact and usefulness of climate engineering, in concert with the ethical and political implications, are only fruitful when based on factual insights into the consequences and technological feasibility. This project will deliver this.





Theme II Climate Change Mitigation

In the Netherlands, the current emission of CO₂ equals approximately 164 Megaton per year, with different contributions by the sectors of energy (30%), industry (22%), road transport (18%), built environment (15%), and agriculture (5%). The remaining 10 % is of miscellaneous origin. The energy sector produces electricity for use in other sectors such as the built environment. Including the non-CO₂ greenhouse gases, the total emission amounts to 193 Megaton CO₂-equivalents per year.

The numbers above imply that every sector must take effective measures to reduce greenhouse gas emissions, ranging from short term actions for rapid emission reduction, such as efficiency measures, to the long-term development of non-fossil-based energy systems.

Such systems will comprise several energy production, conversion, distribution, and storage technologies, deployed in interconnected infrastructures and markets. Therefore, new energy market policies are needed. Ultimately, we have to move to a circular economy in which we close the water, energy, material and nutrient cycles.

At TU Delft we strongly believe that we need to develop a portfolio of innovative energy technologies for the short as well as for the long term, with radically new technologies and improvements of technologies that are already available to us.

Research areas in our portfolio are:

- Energy Technology, Chemical Technology in e-Refinery institute, DUWind, Powerweb
- Reduction of the primary demand, reuse and efficiency measures in Urban Energy
- Carbon capture, conversion and storage (partly in e-Refinery)
- Transition into a Circular Economy

We will design a research project to fill an important gap in our research portfolio: Negative Emissions. Moreover, we developed a research project focussed on broadening our knowledge in Circular Economy transitions.



Research project



Negative Emissions

Challenge

An important measure for mitigating climate change is the removal of CO₂ from the atmosphere and storage, indefinitely, at a global scale. And as we move away from fossil resources, alternative carbon sources need to be used as building blocks to many of our materials and to produce alternative high-density fuels. Carbon can be captured from where it is currently emitted, but when such point emissions disappear over time, we will also need to capture carbon from the atmosphere or from sea water.

Research questions

- What are suitable capture mechanisms?
- What is the scalability of such technologies?
- Can carbon be efficiently captured from (sea) water?
- How can CO₂ be transported and stored?

Societal impact

Technologies for capture and re-use of carbon need to be integrated into our current industrial and economic system. This requires new economic models, new carbon costing systems, and therefore has a strong link to international policy making. Reaching negative emissions requires a long-term concerted effort of global industry, government, and citizens, and our flagship will deliver technologies that support these actors in reaching negative emissions.

Research project



The transition to a circular economy

Uitdaging

In a linear economy, raw materials are extracted, created into products, and ultimately discarded into the waste stream, contributing to various greenhouse gas emissions. One solution is the circular economy where material management efficiency increased and thus carbon emissions are minimized through extending product life, recirculating materials, reducing waste, and substituting. Such a large scale socio-economic transition, however, requires significant interrelated changes from different stakeholders (industry, household, policy) in application of technology as well as in business propositions and user behaviour.

Research questions

- How should the design of technology outcomes change to implement the different cycles in a CE?
- What will persuade business and consumer markets to accept circular offerings at scale?
- What are suitable (sustainable) business and governance models for a CE?
- How can strategies and solutions for a Circular Economy be inclusive? How can citizens participate (e.g. right to repair)?

Societal impact

Strategies and solutions for a Circular Economy will have the greatest societal impact through their implementation by industry. Societal influence as well as policy will play important roles in this shift including changes in the way people and organizations consider how infrastructure, products, and services are made, used, and disposed. create these changes will require different economic incentives and behavioral patterns..



Theme III

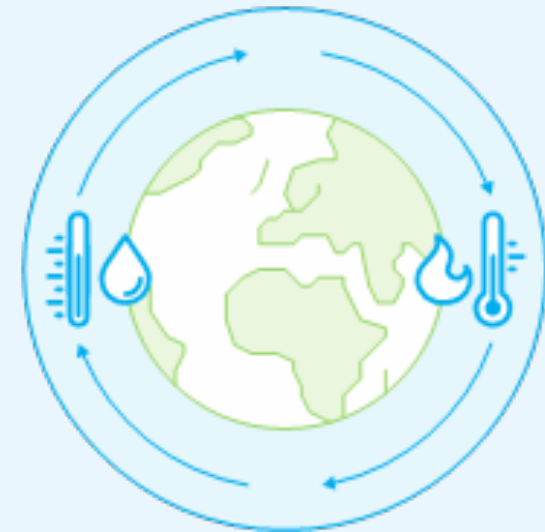
Climate Change Adaptation

Higher temperatures, droughts, sea level rise, extreme precipitation and storms: we increasingly experience the impact of climate change. Without sufficient mitigation measures, humanity and nature will increasingly be affected by climate change, so adaptation to these changes will be a dire need. Many areas in the world are already at great risk of flooding: at the coast, near rivers and in urbanised areas, due to heavy rainfall. This risk will increase in the future and it will not be evenly distributed, also strongly due to economic and population growth.

The urban heat island effect is aggravated by climate change. With European cities going well beyond 40 degrees in summer, more strategies are needed that can significantly cool the city and simultaneously support the sustainable energy transition. And with sea levels projected to rise beyond 1 metre, more severe measures might be needed, in the form of spatial planning in flood-prone areas and serious water retention strategies. In two flagship programmes we address these issues.

Societal impact

To manage climate change risks it is essential to coherently look at coastal protection, river discharge, water management, salt intrusion, urbanisation and the governance thereof. This will lead to drastic spatial planning interventions, new resilient infrastructures and nature-based adaptation techniques, as well as measures for implementation, awareness and empowerment.



Research project



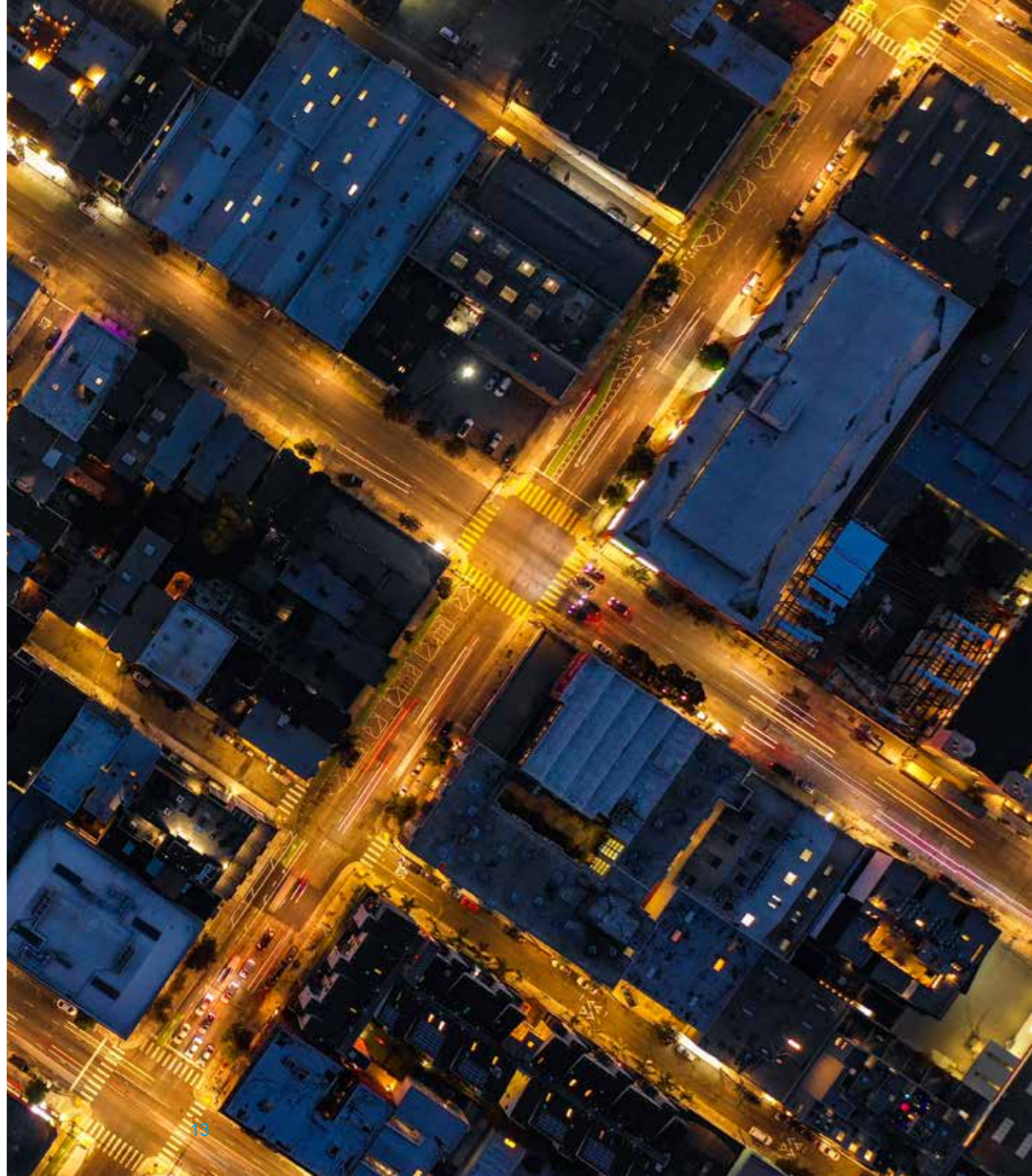
Dealing with Urban Heat

Challenge

The changing climate is ever more sensible in the city, where the Urban Heat Island (UHI) effect is aggravated by higher air temperatures and increased solar irradiation, in combination with hard surfaces, like brick, concrete and asphalt, that absorb and radiate solar heat. This effect is amplified by heat released from buildings, vehicles and – ever more so – air-conditioners or air-source heat pumps. This especially affects cities in tropical, sub-tropical and Mediterranean regions. However, even in North-Western Europe, in cities traditionally planned and designed to withstand the cold in winter, extreme summer heat has become a factor to deal with. In order to keep cities liveable in the future, urban heat will have to be mitigated in summer, using cooling techniques, the (re)use of excess heat, but also by introducing more green into our cities.

Research questions

- What are the expectations for temperatures in the city in the coming decades and what is the respective influence of global climate change, local circumstances, the UHI effect, and urban planning and design?
- Can architectural design, building technology and behaviour change help to reduce urban temperatures indoors?
- How can urban planning and design help reduce urban temperatures?
- How to generate heat mitigation roadmaps for cities, companies and citizens?



Research project



New Approaches to Water Safety

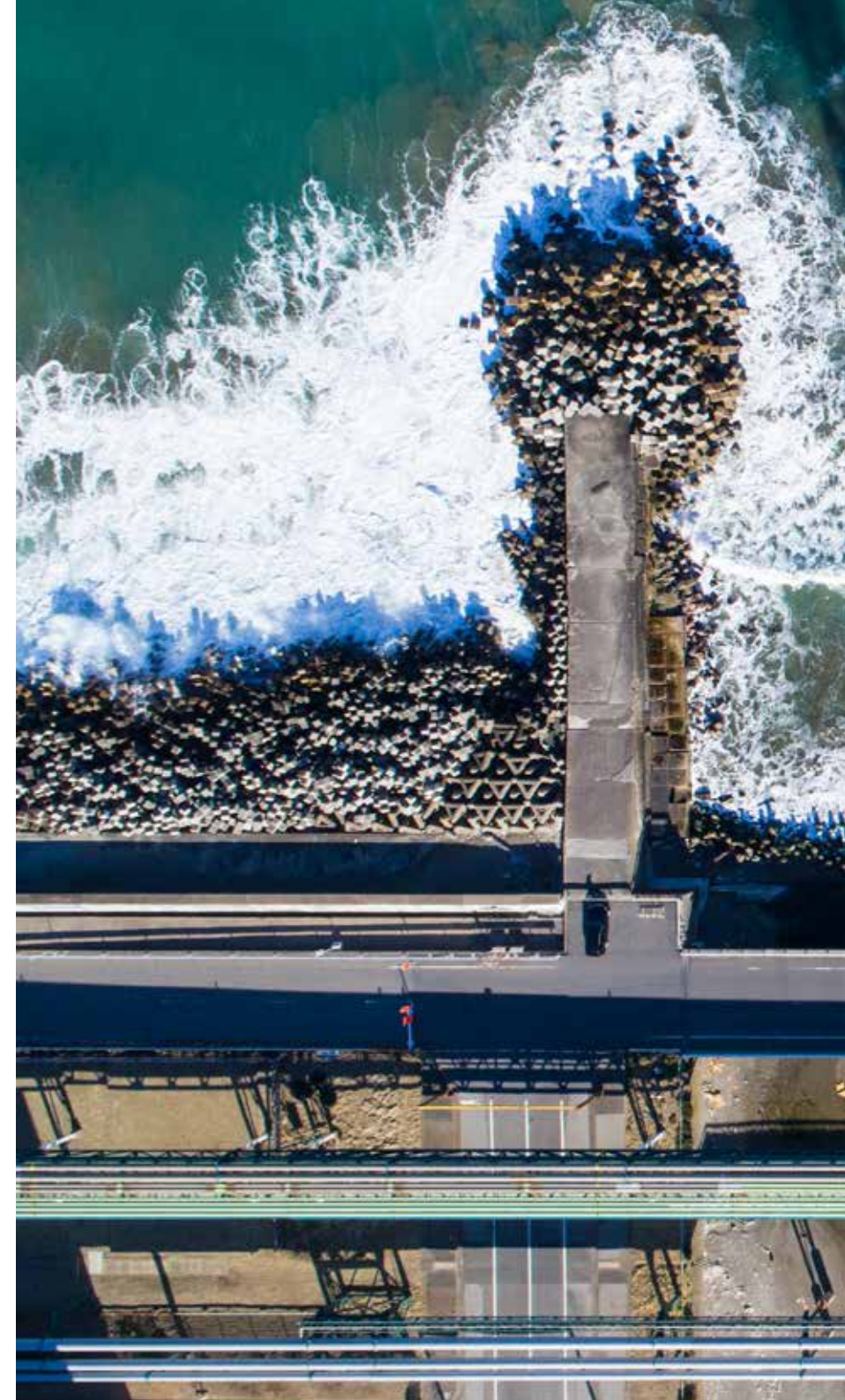
Challenge

Countries in delta regions, such as the Netherlands, face a new challenge for the coastal defence to accommodate a possible sea-level rise beyond 1 metre within a century, against the backdrop of a much larger sea level rise of several meters that might unfold in the 22nd century. Society transforming perspectives might be needed towards water safety strategies such as selective protection of valuable areas, retreat, advance or embrace. With accelerated sea level rise, new approaches to water safety will have to emerge.

The climate-adaptive city of the future will have to be smarter regarding flood protection, but also water capture, storage and usage, preferably in combination with urban nature development. This requires new approaches to urban planning and building design.

Research questions

- What is the expectation for near-future and long-term sea level rise and precipitation, and what does that mean for delta regions such as the Netherlands?
- What are novel strategies and solutions for national or regional planning, environmental design, coastal defence, flood-safe living environments and buildings that can help increase water safety?
- How can urban planning and building design help reduce the discrepancy between droughts and excessive rainfall in cities?
- Can we make a generic roadmap for countries to tackle water challenge?





Theme IV

Climate Governance

The climate challenge cannot be solved in one country or one part of the world. We need to develop technologies and solutions that can be utilised worldwide, tailored to specific local circumstances. These changes bring forth questions like what is the best technical solution for a specific context? Who will profit and who will not, and how should we deal with that? How can we make sure the energy transition is fair and inclusive? What policies do we need to make the solutions sustainable?

It requires forward-looking governance and planning, able to deal with structural uncertainties to guide government and public in making informed trade-offs between a wide range of technical, ecological, economic, ethical and social consequences.



Research project



Governing the Global Commons

Challenge

Governance of climate change is complex. A multitude of countries, each with their own interests and national circumstances, need to work together. Next to that, it is increasingly clear that climate action is not only a matter of national governments, but also of many other parties, including companies, business associations, cities and municipalities, and other sub-national governments (called non-state actors in the Paris Agreement).

Economics Nobel Prize laureate Elinor Ostrom has shown how self-organisation can work in the governance of common pool resources, a structure she calls polycentric. Could this work when dealing with climate change?

Research questions

- What are the major drivers behind non-state climate action?
- What mechanisms are present at the interaction between actions by national governments and non-state actors, for example with typical government-induced mechanisms like carbon markets?
- What is the added value of non-state action in terms of quantitative emission reduction?
- How can energy and climate models support policy making at a local scale and at a global scale?

Cross cutting theme



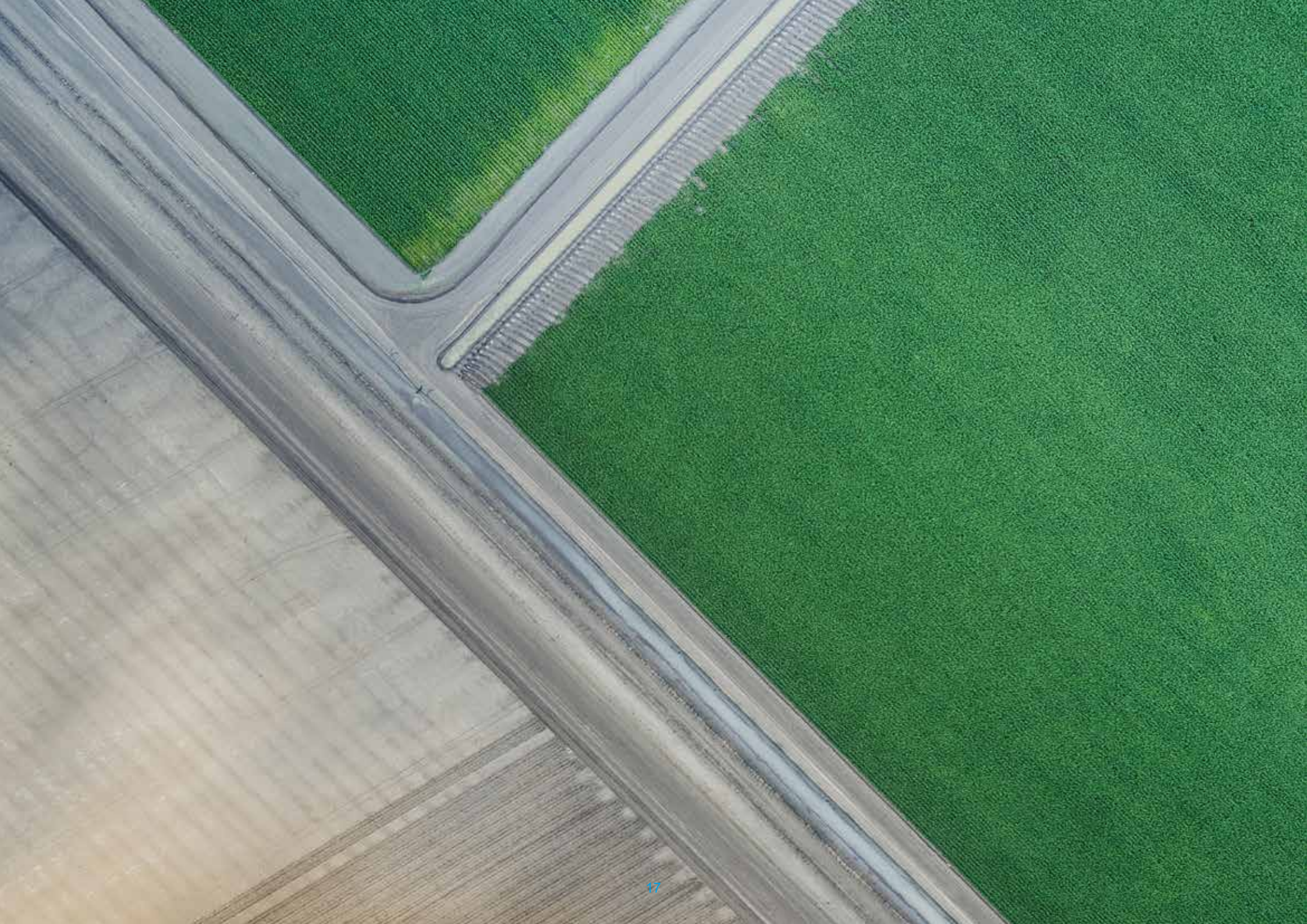
AI for Climate

Challenge

Assessment of the impact of climate action measures, as well as the development of new methods and technologies, requires accurate data. With the enormous expansion of data sources, AI is needed to explore and exploit the heterogeneous data sources at a wide range of temporal and spatial scales. Embedded in the TUD-EUR Delta Resilience program we aim to develop a digital twin of the Rotterdam delta as a tool to address fundamental questions about systemic and disruptive changes in urbanised deltas.

Research questions

- What are the optimum ways to implement AI for Climate Action?
- How to combine different data sources for impact assessments studies?
- How to make representative digital twins that can find with causal relationships within the data?





3 Education

TU Delft prepares students for solving societal challenges and educates tomorrow's responsible leaders in science, engineering and design. As Climate Action is becoming an important topic in everyday life in academic and working contexts, we see it as our responsibility to offer to our students the state-of-the-art knowledge in climate action. In 2021 the minor Climate Change Mitigation and Adaptation will start, a cooperation between the Faculties of Civil Engineering and Technology, Policy and Management. We will investigate how climate action topics can be further embedded in the curriculum, among others through Joint Interdisciplinary Projects and dedicated graduation projects/labs.

TU Delft has already developed a broad portfolio of MOOCs and professional education courses. We will invest further in professional education (lifelong learning programmes), offering a relevant portfolio in a global environment. We find that within the Climate Action themes there are ample opportunities to further extent and strengthen our professional education provision.



4 Operation of the TU Delft campus

We practice what we preach, so we integrate the Climate Action programme into the operations of the TU Delft Campus. TU Delft intends to be carbon neutral by 2030. A recent report demonstrated that, next to energy use in the buildings, food, mobility (especially air travel), waste management, water management and green on the campus all played a role in carbon emissions. Our generic goal is to make the TU Delft campus a sustainable, resilient campus in all these respects.

Initiative	Description
Sustainable catering	More plant-based and vegetarian, organic and local food.
Business travels	NS business card pilot project, policy change proposed for restricted flying and international train rides until 700 km
Waste management	Pilot projects for further waste separation on campus
GreenTU	Students are analysing the faculties and come up with proposals for improvement
Sustainable buildings	Energy-positive ECHO building under construction, new parking garage will be energy-producing and nature-inclusive
PV	Study of the potential of PV on roofs, facades and other services ongoing
Heatsystem	Ontwikkeling geothermisch warmtenet
Green on the Campus	Urban ecology measures taken in various places



5 Societal impact

Outreach and public engagement are core elements of the Climate Action programme. We aim to work closely with the general public, global leaders and policy makers in developing concrete Climate Action solutions. We aim to more actively engage in the public debate on climate change and create more opportunities for policy makers and academics to learn from each other.

We find universities should be playing a key role in advising governments on climate change and the opportunities with regards to mitigation and adaptation. Therefore, we aim to set up a Climate Action Hub at the TU Delft The Hague location. The goal of the Hub will be twofold:

- Act as a trusted source of information on Climate change/ action for policy makers (governmental relations) in the Netherlands (national/regional government)
- Promote active communication/exchange about scientific output on Climate Action topics (knowledge dissemination) with the general public and industrial relations

