



The Randstad Co-location

Information about the partners which make up the Dutch co-location

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Introduction

The Dutch co-location is centred within the triangle formed by the three academic partners Utrecht University, Delft University of Technology, and Wageningen University. The co-location also includes knowledge institutes which accelerate the transfer of scientific knowledge towards practice (TNO, Deltares, and Wageningen UR/ DLO Foundation), and governmental partners (Province of Utrecht and the region Rotterdam-Rijnmond). The co-location centre is closely associated with public-private partnership programmes including 'Knowledge for Climate,' which focuses on urban deltas, and 'B-Basic,' focusing on new bio-based production concepts for industry. Governmental partners will stimulate growth by co-investing and/or as lead implementation customers. Stadshavens Rotterdam and the Province of Utrecht are two specific pilot areas in which many Climate-KIC projects can be tested.

The Dutch consortium has world leading expertise in climate mitigation and adaptation. The consortium's expertise is focused on interdisciplinary research into adaptation in urban deltas, low-carbon energy systems including bio-renewables and CCS, water management, agriculture and land use. In addition it has significant research facilities and pilot areas in which innovation projects concerning water risks and low-carbon cities can be tested with scalable pilots. There are strong links with a host of private partners ranging from SMEs and consultancy firms to large multinationals such as DSM and Shell.

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The partners which make up the Randstad co-location and an indication of their interests are summarized in table 1.

Partner	Main area's of interests				
	Assessing climate change and managing its drivers	Transitioning to resilient, low-carbon cities	Adaptive water management	Zero carbon production systems	Strategic roadmaps
Delft University of Technology	•	•	•	•	•
Deltares	•	•	•		•
Province of Utrecht		•	•		•
Stadshavens Rotterdam		•	•		
TNO	•	•	•	•	•
University of Utrecht	•	•	•	•	•
Wageningen University and Research Centre	•	•	•	•	•

Delft University of Technology (TU Delft)

In the past 165 years, TU Delft has developed into a globally renowned University in the technological sciences which currently has an academic staff of 2800 people and more than 15000 students. The world population will grow significantly in the coming decades, the quest for greater economic prosperity will continue worldwide and have a large impact on the natural resources of our planet. Major technological breakthroughs will be essential in order to satisfy people's basic needs. TU Delft is highly motivated to address this challenge and to contribute significantly to the development of responsible solutions to urgent societal problems in the Netherlands and the rest of the world. To this end, TU Delft sets itself to develop new, ground-breaking insights that will pave the way for the urgently needed technological breakthroughs (knowledge as a product). A key part of this vision is to realise world-level multidisciplinary research and design with a view to sustainability. The faculties and unique large-scale technological research facilities at TU Delft will play a key role in realising this vision. TU Delft disseminates its knowledge by training highly qualified knowledge workers and by stimulating the application of research results (knowledge as capital). Its programmes are internationally attractive. One of the driving aims behind the vision is to attract and utilise a variegated pool of talent. Education and research, both important prerequisites for knowledge valorisation, are interwoven and harmonised. Research at TU Delft is organized in four 'Delft Research Initiatives' (DRI's) which are given in the following table.

<p>Delft Health initiative</p> <p>Prof.dr.ir. L.J. van Vliet</p> <p>L.J.vanVliet@tudelft.nl +31 (0)15 27 87989</p> <p>Site: http://www.tudelft.nl/live/pagina.jsp?id=b338c70a-f96c-4ca2-bff0-07b01e891465&lang=en</p>	<p>Delft Environment Initiative</p> <p>Prof.dr.ir. N.C. (Nick) van de Giesen</p> <p>N.C.vandeGiesen@tudelft.nl, +31 (0)15 27 87180/+31 (0)15 27 81646 environment@tudelft.nl</p> <p>www.environment.tudelft.nl</p>
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Programme: Assessing climate change and managing its drivers

TU Delft Programme coordination:

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Monitoring the environment

It is important to be able to make reliable statements about ‘the climate’ and to determine accurately whether human interventions work or not. TU Delft develops the essential methods, sensing techniques and models to accurately define our environment.

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Solutions for the CO₂ problem

In the short term, our growing energy requirement cannot be met fully through renewable sources such as solar or wind power. Underground storage of CO₂ can offer a temporary solution. TU Delft is seeking integrated solutions in every step of that process, from catchment and transportation to the storage itself, including the accompanying societal issues.

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Combined Laboratories for Environmental Research (CLEAR)

Many environmental issues relate to gas and fluid flows through soil, water and air. TU Delft has many leading laboratories that study such flow mechanics, from the micro to the macro level. Within the Delft Environment Initiative, this research will be brought under one heading, making CLEAR the biggest academic environmental research institute in Europe.

Coordinator: prof.dr.ir. J. (Jerry) Westerweel, Fluid Mechanics,
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Underground CO₂ Capture and Storage (CCS)

In order to stabilize the world’s atmospheric CO₂ concentration, serious reductions in carbon dioxide emissions are a necessity. TU Delft researchers are looking into the possibilities of useful underground CO₂ storage.

<http://www.citg.tudelft.nl/live/pagina.jsp?id=0d2be545-73b0-42d8-bb3b-ebe69b21c7ec&lang=en>

Seismic Observatory for Imaging and Monitoring (LOFAR)

Seismic surveying has always been rather expensive. LOFAR will give TU Delft researchers the chance to get images of the subsurface in a completely new way and monitor subsurface changes using time-lapse seismic.

<http://www.citg.tudelft.nl/live/pagina.jsp?id=c03afa0a-0861-4fc9-86ec-c13a9ab34dae&lang=en>

EUCLIPSE is an European Union funded research programme. This aims to reduce the ambiguities present in current climate models by shedding more light on the role played by clouds in climate change. Delft University of Technology (The Netherlands; TU Delft) and the Royal Netherlands Meteorological Institute (KNMI) are participants in this European programme.

<http://www.tnw.tudelft.nl/live/pagina.jsp?id=2fc11906-4ecb-481d-97ea-9c91ebf0aa77&lang=en>

Programme: Adaptive Water Management

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Sustainable delta technology

The availability of natural resources and transport possibilities make river deltas attractive residential population lives in these dynamic environments. But deltas are also vulnerable. How can we maintain the advantages of living and working in these low-lying areas, without endangering the safety of the residents and investments in changing circumstances?

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Urbanisation in Delta area

Deltas are attractive areas for settlement due to their fertile soil and the strategic linkage of different networks for water and land transportation. This is why deltas throughout the world are so densely populated. At the same time, however, there is a constant danger of flooding and ecosystem destruction. TU Delft is working at home and abroad to create an attractive, safe living environment for delta areas where urban quality of life can be combined with economic development, safety and nature.

Coordinator: Professor [Han Meyer](#) of the [Faculty of Architecture](#) Chair of Urban Design V.J.Meyer@tudelft.nl tel: +31 (0)15 27 85963

FilterXpert: monitoring the operation of sand filters online

Virtually all Dutch water companies use sand filters in their water purification facilities. The filters capture dirt and remove dissolved substances such as iron and

manganese. They also mediate the conversion of ammonia.

<http://www.citg.tudelft.nl/live/pagina.jsp?id=d70cc9da-e99a-462e-9d4b-2da341603e83&lang=en>

Urban Riverfronts: flood protection and more

In Dutch river cities current flood protection is often insufficient. TU Delft is researching ways to improve flood protection in urban areas by creating multifunctional and adaptable flood defenses.

<http://www.citg.tudelft.nl/live/pagina.jsp?id=70ab9d26-f415-4051-ab59-16d5972f3f86&lang=en>

Building with Nature

'Building with Nature' is the name of a programme aimed at building up a body of scientifically based knowledge, expertise, resources and design concepts for the sustainable management of coastal, delta and riverine regions. TU Delft takes a multidisciplinary approach to this programme. <http://www.ecoshape.nl/home>

Programme: Zero Carbon Production Systems

TU Delft Programme coordination:

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How can biomass be used sustainably?

Biomass, such as plant waste, offers an enormous potential as a green alternative for fossil fuels for example for the aviation and shipping industry and freight transport.

It also serves well as raw material for the chemical and materials industry. The biomass as such is, however, not always ready to use and it is only truly sustainable when it is not in competition with the production of food.

The use of green (bio-based) raw materials for the chemical, materials and energy industry can only be sustainable if there is a good balance between ecological, humanitarian and economic goals. Biotechnology can help to apply non edible plant waste effectively as a basis for biofuels.

Making raw materials available

To be able to use biomass, such as plant waste, as a green raw material, micro-organisms need to be able to digest the energy sources (sugars) present in the material.

These organisms are not always able to do that naturally. Research is aimed at adapting the properties of these organisms, such as baker's yeast, in such a way that they will also be able to digest sugars that do not come naturally to them.

From nutrient to final product

To be able to apply micro-organisms as 'live factories', it is essential to meticulously design, regulate and optimise the entire production process from nutrient to final product. Only then a small number of nutrients can be turned into a broad range of bioproducts. For example biofuels such as bioethanol and biobutanol, biochemicals

and biomaterials, such as bioplastics. To enable the implementation of the production process, researchers look into how it can be upscaled from the lab to an industrial environment.

Waste as raw material

Soil and water contamination are often caused by the accumulation of non degradable fossil materials. Research is conducted into the process micro-organisms apply to turn this waste into valuable products, such as bioplastics, that are biodegradable. Another area of study focuses on how micro-organisms can use waste streams to strengthen the soil, for example in dikes or foundations.

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Some sample projects & programs:

B-Basic is a consortium of universities, research institutions and industry. The programme focuses on the development of new bio-based production concepts for the chemical (and energy) industry which are rooted in the current explosive increase in fundamental insights in molecular biology through the genomics revolution, combined with advanced bioprocess technology and existing chemical knowledge.

<http://www.b-basic.nl/index.html>

Clean Tech Delta is a New Green Deal: a collaboration of trade and industry, education and government to stimulate innovation and clean technology and then implement it. Innovation and clean technology in the Delft-Rotterdam region is creating sustainable solutions which can be applied at both regional and international levels. <http://www.cleantechdelta.com/eng/>

Programme: Transitioning to resilient, low-carbon cities

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Electrical transport

The future of transport is electric. Why? Because electric motors are far more efficient than internal combustion engines. An electric vehicle only uses half the amount of fuel that is needed for a conventional vehicle with an internal combustion engine. Electric cars will become progressively more sustainable as the sustainability of electric power generation is improved. TU Delft is researching:

- accumulators and batteries
- the charging infrastructure for electric cars
- the electricity grid

- the transition to electric transport (vehicle, infrastructure, integration into the grid)

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The Zero Emission era

What ingredients are needed to create a clean, quiet and safe transport system? Thirty per cent of all CO2 emissions in the Netherlands arise from road transport. Aviation and international shipping have not yet been included in this calculation. In any event, the aircraft, ships and cars of the future must either drastically economize on fossil fuels or switch to alternatives. The time lag between the initial conception of new technologies and their large-scale implementation can, however, be as much as 40-70 years. Researchers at TU Delft are now working on a Zero-Nuisance Aircraft, with attention no longer focused on just one aspect of the aircraft (as in the past) but simultaneously on several aspects, such as the use of materials, design (aerodynamics), more efficient engines and alternative energy sources. Thanks to this approach, the burden placed on the environment, on local residents and on passengers at every level will in future be reduced to a minimum.

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Harbor of the future

What will the port of the future look like?

A transport hub such as the port of Rotterdam requires efficient deployment of technology and transport in order to prevent new logistical problems. The port of the future will quickly and painlessly get to grips with handling and transporting both old materials and goods and new ones (such as biomass and LNG).

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Metropolitan Parks

Are metropolitan parks the answer to urbanisation

Metropolitan parks must improve the quality of life in the densely populated Randstad conurbation. These parks offer the inhabitants and visitors to the region an attractive leisure environment. At the same time the parks give a metropolitan area structure and significance and they can help to safeguard the region against climate change. In this way metropolitan parks can serve to protect cultural heritage and ecosystems. Living, working and leisure will go hand in hand in the Randstad of the future.

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Efficient traffic flows

How can we provide reliable information on the most efficient, safest, fastest and cleanest transport method at a certain time?

Every day, large volumes of people and goods make their way from, to and within the cities of the Randstad: commuters, business travellers, day trippers and also building materials, fuels and consumer products. This creates traffic: cars, trains, barges and bicycles. Sudden hold-ups, caused by accidents, weather conditions or engineering works, can block the flow of traffic altogether, leading to uncertainty over journey

times, increased costs and environmental pollution. This must change. In the future, anyone who wishes to travel will have access to a seamless, multi-modal transport system. At any given time, up-to-date information will be available about which form of transport is most efficient, reliable, safe, fast and clean at that particular moment.

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Urban Environment

What makes a house, a district or a city sustainable and climate proof? It is vital for the future that we design and use our urban areas in economically and environmentally sound ways. Together with Rotterdam municipal authority, TU Delft is seeking concrete ways to develop climate proof cities.

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Some sample projects & programs:

Next generation infrastructures

Infrastructures, such as roads, rail roads, waterways, waterworks, gas and electricity grids and telecommunications connections, play a crucial role in society. Although most infrastructures started off as separate networks, nowadays most of them are interconnected. Telephone calls are made through cable, and who knows one day the gas grid will be used for the transport of hydrogen. It is not just this technical entanglement that makes infrastructures complex

<http://www.tudelft.nl/live/pagina.jsp?id=819ac274-3feb-461f-9ab8-d9be7ee6f20b&lang=en>

D-INCERT. TU Delft is the initiator of this national platform involving research/educational institutions and companies which aims to acquire and share knowledge and understanding of electric transport with a view to accelerating learning, exploiting economic opportunities and supporting the development of clean and sustainable transport. <http://www.d-incert.nl/>

Deltares

Deltares is a leading research institute for water and subsurface issues with its base in the Netherlands. Throughout the world, our advanced expertise enables safe, clean and sustainable living in deltas, coastal areas and river basins. With this goal in mind, we develop knowledge, innovative products and services, pool our knowledge with others, and make the results available. We advise governments and the private sector, and use our expertise to make sound and independent assessments of the physical condition of deltas, coastal areas and river basins.

This range of roles can be seen in our work throughout the world. Our work picks up where others leave off, often in the exploratory stages of a project, with independent advice using the latest advances. In this respect we collaborate intensively with universities, research institutes as well as the private sector. We extend our knowledge base in government research programmes and contract research for contractors and the engineering sector. In the process, we encourage innovations, and speed up the pathway making new advances available for application in practice.

Economic developments, rapid urbanization and envisaged impacts of climate change provide huge challenges and opportunities for innovative concepts and approaches. Deltares supplies answers by combining knowledge and technical expertise in water and subsurface management issues with an understanding of political, administrative and economic governance processes. This interdisciplinary approach, our independent position, and our role as an authority with a reputation for integrity mean we can get pro-actively involved in public debate, implementing our strategic principle: 'Enabling Delta Life'.

Our expertise

Water and the subsurface involve not only technological issues, but also natural processes, spatial planning and administrative and legal processes. We apply our understanding of those processes in an integrated way, improving the quality of life in deltas, coastal areas and river basins. The integrated approach allows us to come up with innovative solutions. In the Netherlands, it is known as 'delta technology'.

Deltares

- employs 900 water and subsurface experts
 - is a non-profit organisation with an annual turnover of €100 million
 - has 75% of its work in Europe, and 25% elsewhere in the world
 - www.deltares.nl
-

With regard to the programmes of KIC-Climate, our interests are: Assessing and Managing Climate Drivers, Resilient and Low-Carbon cities, Adaptive Water Management, Low Carbon Production Systems.

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Programme: Assessing climate change and managing its drivers

Deltares has an extensive track-record in assessing the impacts of climate change on the hydrological cycle. It collaborates intensively with the Netherlands Meteorological Institute on coupling hydrological models to the climate change scenarios envisaged, among others in the Dutch Knowledge for Climate research programme. It thus provides a sound basis for policy advice and further analysis of possible mitigation and adaptation measures, for which the so called 'tipping point analyses' provides a useful framework. The same type of hydrological models is being used in various river basins and deltas around the world. Here, a framework of analysis is available within the established IWRM and ICZM approaches, while for global assessments the Netherlands Environment Assessment Agency's instruments such as IMAGE are being upgraded with the Deltares hydrological modules. Through the International Groundwater Resources Assessment Center – IGRAC section within Deltares we provide world wide assessments of groundwater aquifers. Socio-economic and enabling governance aspects are being addressed also by Deltares. Deltares further collaborates with private sector parties to explore, develop and implement innovative approaches stemming from the rapid developments in the IT environment, such as the use of newly developed processors which may firmly enhance the availability and analysis of on-line data. This is in favour of the operational functioning of real time early warning systems and rapid assessments, and thus an asset for every day as well as disaster management decision making.

Deltares participates in the EU funded SCENES project: Water Scenarios for Europe and Neighbouring States. This project develops and analyses a set of comprehensive scenarios of Europe's freshwater futures up to 2025. It covers all of Greater Europe reaching to the Caucasus and Ural Mountains, and including the Mediterranean rim countries of north Africa and the near East.

The scenarios provide a reference point for long term strategic planning of European water resource development, alert policymakers and stakeholders about emerging problems, and allow river basin managers to test regional and local water plans against uncertainties and surprises. The SCENES project delivers combined qualitative and quantitative scenarios.

SCENES is planned as a 4-year Integrated Project with a total budget of 10.1 million EUR, of which 7 million EUR is contributed by the EU.

<http://www.environment.fi/default.asp?contentid=269510&lan=EN>

Deltares has a specific interest in assessing and managing extreme events, and finding innovative concepts and approaches not only from an integrative water management or technological perspective, but also by strongly emphasizing the innovation cyclic processes involving knowledge and research institutes, the private sector as well as relevant government entities. Deltares has extensive experience in working in communities successfully addressing the innovation paradox.

KIC-Climate contact person for this programme:

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Programme: Transitioning to resilient and low-carbon cities

For sustainable development we have to reduce the environmental footprint of urban developments. Urban areas are highly parasitic. Their existence depends on a sufficient supply of e.g. water, energy, food, building material and a sufficient capacity to drain stormwater and waste water, garbage, heat and other wastes to its surroundings. Moreover the world faces rapid urbanization, in particular in deltas and river flood plains, making impacts worse. In addition, urban areas are slow in adapting to new technological, economical, climatological, demographical and social development. This makes cities and their residents vulnerable. On the other hand, residents continuously try to improve the quality of their living environment and industry tries to optimize their production processes. To support and realize all these objectives we have to transition to adaptable, resilient cities with low (carbon) emission levels.

Vulnerability assessment

Quantifying the vulnerability of urban areas is a first step in the transition process. Vulnerability depends on the risk of exposure to extreme conditions, the damage sensitivity and the in time adaptability of the existing buildings, infrastructure and organization. Climate change will influence the exposure to flooding, droughts, heat stress and land subsidence. Exposing vulnerable buildings and infrastructure to these extreme conditions could result in socially and economically unacceptable damage.

Climate resilient urban development / redevelopment

Developments in climate, technology, economy and other fields require the urban system to be flexible and robust. Adaptation of land use, soil, water system, buildings and infrastructure as well as non-structural measures can be made to reduce the sensitivity and damage of extreme conditions. And next to the structural capacity of the urban system to avoid damage we can strengthen the coping capacity, the recovery capacity and the adaptive capacity of the urban system. All structural measures require attention during the phases of planning, design, construction and operation & maintenance. This requires a transition in urban development and urban renewal.

Robust urban water systems

More heavy rainfall is expected to occur due to climate change and urbanization of regions. In order to be able to cope with these severe rainstorms we have to increase drainage capacities and/or the on-site storage capacity in our urban drainage systems. This requires larger drains, pumping stations and extra storage capacity in our urban surface waters. And extra storage means extra land for storage, in a city that is short of space. Alternative could be the use of local retention measures such as green roofs, infiltration trenches, infiltration swales and other sustainable urban drainage systems (SUDS). Question is: How much and how many do we need to be effective? Deltares works on urban drainage design including SUDS and groundwater level management, urban flooding simulations and flood hazard mapping. The effect of

urban groundwater extractions on land subsidence, drainage systems and flooding risk is evaluated and translated into relevant urban drainage and water supply policies. Such urban water plans are common in the Netherlands but hardly known abroad, so far.

And how about the effect of these systems on the water quality, during wet and dry spells? Eutrophication of urban waters is a risk that is to be controlled. Creating a good and robust chemical and ecological water quality sustains the functions that urban water can serve, such as water recreation and water supply, in addition to supporting a healthy aquatic ecological water system.

Stormwater utilization

For good reasons we invested a lot in a perfect drinking water supply. Public health is at stake. However, for low end purposes such as irrigation, fire fighting, cleaning and toilet flushing collected stormwater or polished treatment plant effluent could provide a valuable water resource as well. This would reduce the need for drinking water imports and the environmental impact of these imports, without deteriorating public health. Stormwater runoff, local groundwater, surface water and subsurface drainage water can be used as a source as well.

Water for heating and cooling

A very significant part of the energy consumption of urban areas is used for heating and cooling. Water can be used efficiently and effectively both as a heat source and for cooling. Urban surface water, rivers and lakes are effective solar collectors in summer. This heat can be harvested and stored, e.g. in aquifer thermal energy storage systems, using the local groundwater as a storage medium. The collected heat is used in winter for thermal energy supply to houses and buildings, while the same system is used in summer to cool these. Moreover, water can be used effectively to cool buildings, houses and roads by evaporation. Wet pavements, blue and green roofs, green walls, and other methods of direct and indirect evaporative cooling substantially reduce conventional energy consumption by traditional air conditioners.

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Programme: Adaptive water management

Climate change will bring profound changes to the way water is perceived and managed, both within Europe and globally. Changing weather patterns and rising sea levels will lead to more pronounced droughts in some areas and floods in others. Reliable water provision to existing urban and rural environments will be increasingly difficult. Improving human welfare against this backdrop represents both a challenge to science, technology, and policy as well as a major set of commercial opportunities. Climate change may have a significant impact in the medium to long term. Decisions that are obvious under present conditions may become questionable if conditions change. Our research includes the assessment of future hydrological boundary conditions, the vulnerability of natural and man-made systems for climate change, as well as the response of society and policymaking to climate change. Questions range from “how to deal with increasing sea levels and incidental floods?”; to “how to deal with the decrease in availability of good quality water, associated with higher temperatures and droughts?” We are involved in the development of robust management strategies and adaptation paths, taking advantage of new opportunities and avoiding damage to human and natural services.

Integrated approach

Deltares covers a variety of disciplines: technical disciplines like geo-engineering, geology, ecology, hydrology and hydrodynamics; integrated disciplines like coastal zone- and river basin management and policy analysis. We work in multidisciplinary teams to assess vulnerability to climate change, design solution strategies, determine cost-benefits and to advise policy makers on how to cope with the uncertainty associated with climate change. We develop our knowledge base in government research programmes and contract research (for municipalities, provinces, regional water authorities and the engineering sector), teaming up with universities and other research institutions along the way. In the process, we encourage innovation and contribute to its application in practice.

Flood & Drought Risk Management

Flood risk management aims at reducing loss of life, distress and economic damage caused by floods. It requires a proper (and quantitative) understanding of the characteristics and consequences of a flood event. Deltares helps to map out flood risks, advises on measures to mitigate those risks and to assess the possible impacts if a flood should occur. Drought risk management aims at maintaining or improving the capability of a region to cope with droughts. It includes drought preparedness planning, monitoring and early warning, as well as guidance on appropriate responses by implementing measures. Often transition to a new water scarcity policy approach is required since traditional paths are no longer sustainable under expected consequences of climate change. Deltares performs policy analysis including socio-economic and environmental impact assessments. We identify and evaluate promising measures and strategies to reduce risks and develop policy instruments in close consultation with stakeholders.

Flood Control 2015

In this program government and industry work together to develop new technologies leading to better decisions to be taken in combating flood risks. In recent years, tremendous technological developments occurred in information collection and dissemination of information. Monitoring systems, sensor networks, earth observation

and simulation techniques make forecasting stronger. There are opportunities to substantially increase water security by gathering more current information and better commitment to timely warnings. The programme focuses on observing, measuring, inspecting and forecasting. Thus, unsafe situations can be identified timely.

The purpose of this innovation programme is to achieve major technological improvements in the operational flood protection by developing knowledge that allows easier and improved management of acute flood risks. There will be optimal usage of existing knowledge and systems.

The project consortium consists of partners from government, knowledge institutes and the private sector.

<http://www.floodcontrol2015.nl/lang-en/home>

Adaptation strategies and innovative solutions

Time horizons for climate change are distant and the benefits are often not directly visible. Therefore, adaptation to climate change is far from trivial. We advise authorities on the design of strategies and have the tools to evaluate different options. Issues we consider are: how to deal with uncertainty (choosing robust, resilient and flexible/ adaptive strategies); costs and benefits of the measures, (expressed not only in money, but also in potential benefits for other sectors). We look at the technical skill required for implementation, as well as potential barriers.

In our innovation programmes, we develop promising measures (e.g. Deltadikes, Megaterpen, climate buffers etc.) and in business cases we bring them further to implementation.

Building with Nature

With over 80% of the world's large population centres in vulnerable coastal, delta and river areas, the construction challenge in these areas is extraordinary. Trade and industry require new ports and infrastructure, citizens require housing, rivers require space to flood, and all will have to be protected from and harmonised with nature and the effects of climate change and sea-level rise.

The challenge demands many talents; research and technology; effort and experience; planning and finance; ambition and sympathy. Input is essential from all stakeholders; from owners, residents and policymakers to designers, contractors and project administrators. Ecological and economic interests have to be responsibly balanced. We are faced with the need to learn to build with nature, so that the natural and human world can sustainably co-exist.

The Dutch national programme Building with Nature targets discovering and developing all the know-how and expertise required to allow this to happen. To create state-of-the-art models for ecodynamic design. To permit the aims to be realised. Society will benefit in many ways: from improvements to administrative and policy-making processes, development of new business opportunities, establishing new positions in technological and scientific excellence, to provision of new and innovative design tools and consolidation of skills.

The project consortium EcoShape is a consortium of Dutch specialists with a rich history of solving coastal infrastructural challenges in the Netherlands and abroad. As custodians of this knowledge inheritance of past land reclamation, sea and river defences, dike building, dredging and protecting nature, EcoShape will provide its knowledge resources for the benefit of sustainable coastal development - anywhere in the world it may be needed. The consortium members will be contributing a total of approximately EUR 13 million over a five-year period. The Dutch Ministry of

Transport, Public Works and Water Management will provide another EUR 13 million in co-financing, made available from the Balkenende Government's innovation fund.

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Programme: Zero carbon production systems

Oxidation of peat land appears to be a considerable source of greenhouse gas emissions. Improper water management of peat lands is currently responsible for a substantial volume of the global greenhouse gas emissions. We advise on adaptations in water management to reduce these emissions. Deltares has extensive experience on this issue, particularly in SE Asia. In this area, our support is highly appreciated by multinationals, governmental and non-governmental organizations.

Deltares has gained experience in developing smart@soils and biogrouting and biocementation processes for in-situ stabilization of weak soils, levees, etc. These may contribute to lower the energy intensive production of traditional and modern construction materials.

For this programme Deltares will align with other partners in the Dutch node (TU Delft, TNO, Wageningen UR, ..)

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Programme: Strategic Roadmaps

Deltares is keen to provide inputs to this strategic roadmaps programme. Jointly with an arena of stakeholders, including government, knowledge institutes and private sector platforms, Deltares develops its own strategic roadmaps for both research and market oriented activities for a number of thematic areas, among which are adaptation to climate change, safety against flooding, urban development, and others.

Furthermore, Deltares carries out wide-ranging strategic studies for various clients under short, medium and long term scenarios. We translate policy questions into

solutions within both a management and a political context. Herewith we make extensive use of disciplines like economics and spatial planning, and also social factors and the environment are being considered. For our integrated studies we use a wide scale of tested techniques and methods, such as trend and uncertainty analyses and the perspectives method. Our future scenarios help managers and decision makers to develop a picture of the possible future in various sectors of water and soil management. We highlight uncertainties and make risks predictable. Our expertise thus contributes to sound decision making by our clients.

A specific feature of strategic planning refers to the innovation cycle. However, there are no standard methods to bring an innovation successfully into the phase of actual implementation. Tailor-made approaches are essential. An innovation process consists of three basic steps: from idea to development, from development to pilot, and from pilot to application. Depending on the role of the client – for example a water resource manager, inventor or participant in the market– we help to guide this process in order to reach a breakthrough.

Deltares has experiences in identifying the probability of success for innovations in the soil, road and hydraulics-sectors. Some examples are innovative asymmetric blocks on a dike, or new techniques for soil stabilization, so that erosion can be prevented. The field of influence that dictates the implementation's chance of success consists of: social requirement (demand), technology (supply) and implementation in practice (realisation). Our research is related to these factors

Our multi-disciplinary teams' experience is an important factor in the introduction or adoption of an invention. Scientists, but also public administrators and economists may take part in a solution for the various sectors. Deltares combines high quality technologies, cost-benefit analysis to define appropriate scales of development and implementation, risk assessments, environmental impact assessments, and feasibility studies under relevant rules and regulations.

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Province of Utrecht

Introduction

The Province of Utrecht www.provincie-utrecht.nl is a Dutch region, that has the highest growth of GDP per capita in North-West Europe. It is a road and railway junction in the heart of the Netherlands, and also an ecological junction, confronted with a wide range of consequences from climate change. We have chosen to reduce the CO2 emissions within the borders of our jurisdiction to zero in 2040, and will also be totally resilient by then. We do this together with our strategic partners, with which we develop roadmaps, assisted by top advisor of the European Commission Jeremy Rifkin. Since presence of heavy industry is very low, our main targets are buildings (offices as well as houses, new as well as existing buildings, including monuments) and transport. Drivers of our economy are our knowledge institutes in the field of earth and sustainability, consultancy firms, gaming industry, building and transport companies, financial institutions. Within the Climate KIC, we offer the whole of the province as an experimental area for climate innovations. Next to that we are interested in the Strategic Road Maps and technology pull as lead customers, if possible together with others. With regard to the programmes, our interests are: Strategic roadmaps, Transitioning to resilient, low-carbon cities, Adaptive water management, and Assessing climate change and managing its drivers. Our strategy is available at the top right hand corner of:

<http://www.utrecht2040.nl/Dossier/Default.aspx>

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Strategic Road Maps

As a regional government with high ambitions, and in the process of developing our own roadmap together with our strategic partners and Jeremy Rifkin, we are looking forward to cooperating on this point. Issues that are of specific interest to us are legal and financial arrangements to maximize our own role with regard to subsidies/taxes/revolving funds, and enabling or restricting activities through law, covenants etc. Examples of ongoing projects which are of interest for KIC:

1. Revolving fund (20 mln euro): making it easier for organizations and businesses to invest in energy efficiency or renewable energy for their own operations, by giving guarantee to the bank that provides the loan, that the money will be paid back in time.
Web link, at the moment only in Dutch, translation will be available shortly:
<http://www.provincie-utrecht.nl/prvutr/internet/milieu.nsf/all/Klimaat%20Energie%20op%20Orde?opendocument>
2. “Energetic Utrecht”(18,5 mln euro): subsidy for house or business owners to insulate their buildings. Up to 25% of investment costs is refunded.
Web link, at the moment only in Dutch, translation will be available shortly:
<http://www.provincie-utrecht.nl/prvutr/internet/milieu.nsf/all/EnergiekUtrecht?opendocument>
3. Plans to have strict regulations on energy efficiency of buildings in the future.

No web link available at the moment.

4. Road map to a climate neutral Province in 2040 and Interreg project Third Industrial Revolution

Currently we are developing our own roadmap together with our strategic partners and Jeremy Rifkin and wish to start an Interreg project with European regions that want to work along the lines of the Third Industrial Revolution, as introduced by Jeremy Rifkin.

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Programme: Assessing climate change and managing its drivers

1. Mapping the effects of climate change; how exactly is climate change going to effect soil and water systems in our region, f.i. when it comes to our drinking water supply? Web link, at the moment only in Dutch, translation will be available shortly: <http://www.provincie-utrecht.nl/prvutr/internet/milieu.nsf/all/klimaat%20klimaateffectkaarten?openDocument>

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Programme: Adaptive water management

The Netherlands is a low lying country and our Province has several different water systems (lakes, rivers and ground water surfacing). Farm lands on peat are sinking, which makes them even more vulnerable to water excess.

Examples of ongoing projects:

1. Rijnenburg: residential/industrial area to be built on peat lands. Various adaptive and mitigating measures will be taken. Feedback on their usefulness will continuously be measured and discussed with end users in the Community Lab. Web link, at the moment only in Dutch, translation will be available shortly:
<http://www.provincie-utrecht.nl/prvutr/internet/milieu.nsf/all/Dig.Klimaat.2.Rijnenburg?opendocument>
2. Biomass production and sustainable land use in peat lands, to economically use the lands without increasing their vulnerability. No web link yet.
3. Grebbedijk: Plans to upgrade the water barrier by using innovative techniques, that would allow for multi-purpose use of the area. No web link yet.
4. Water safety: Use of data, mapping climate effects. No web link yet

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Programme: Transitioning to resilient, low-carbon cities

See **also** under Strategic road maps

Other examples of ongoing projects which are of interest for KIC:

1. Plans for creating one stop shops for energy efficient living. Here, demonstration, planning, financing and subsidies will be integrated for various types of buildings. No web link yet.
2. Rijnenburg: residential/industrial area to be built on peat lands. Various state of the art adaptive and mitigating measures will be taken. Feedback on their usefulness will continuously measured and discussed with end users in the Community Lab. Web link, at the moment only in Dutch, translation will be available shortly:
<http://www.provincie-utrecht.nl/prvutr/internet/milieu.nsf/all/Dig.Klimaat.2.Rijnenburg?opendocument>
3. Sustainable roofs: scans to see where on the roofs in the Province, PV technology and green roofs could be an option. No web link yet.
4. Deep geothermal energy: Scans to check the feasibility of this way of energy production.
5. Reconstruction of former military air base “Soesterberg” to a natural and recreational area, financed through construction of buildings. They area has to be made accessible by means of high quality, innovative and sustainable ways (not decided how yet), starting point is a nearby train station. The means of transportation has to be an attraction in itself. Web link, at the moment only in Dutch, translation will be available shortly:
www.hartvandeheuvelrug.nl/nl/home/projecten/projectencontent/herinrichting-vliegbasis-soesterberg

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Stadshavens Rotterdam

Stadshavens Rotterdam represents one of the biggest within urban restructuring programmes of the Netherlands in the coming decades.. It sets itself to be a leader in sustainability. 1600 hectare of former port area will be given a new destination as sustainable and climate neutral hotspot for high level housing, knowledge institutes, recreation and green zones and creative activities. Specific attention will be given to design mobility schemes which set the standards for environmental sustainability linked with high level economic and societal value.

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TNO (Netherlands Organisation for Applied Scientific Research)

TNO is the largest fully independent Research, Development and Consultancy organisation in the Netherlands. TNO supports and assists trade and industry including SME's, governments and others in technological innovation and in solving problems by rendering services and transferring knowledge and expertise. TNO has a staff of about 5,400 and a total annual turnover of about 500 million Euros. TNO participates in many EU programmes aiming at technological development. TNO has concluded co-operation agreements with a range of foreign research institutes and companies in Western, Central and Eastern Europe, USA, Canada, Japan and India. TNO performs its widely ranging activities in 5 core areas. One of them is TNO Built Environment and Geosciences, which includes expertises in the fields of geology, building technology and environment. Within this core area climate research is being done on:

- The climate system, focusing on the interaction between climate change and atmospheric pollution (especially particles).
- Climate mitigation, focusing on understanding greenhouse gas emissions, and mitigation actions in various sectors, such as the energy sector (CCS, geothermal energy, smart grids), the transport sector (improvements in vehicles, fuels, transport networks and logistics), the building sector (materials and components, heating and cooling, and building systems), and horticulture (energy producing greenhouses).
- Climate adaptation, focusing on vulnerability and adaptation in cities.

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Programme: Assessing climate change and managing its drivers

TNO has a long lasting experience in the compilation of integrated emission inventories at national level, including a separate system for emissions by individual companies, facilities and installations and the support of national and international organisations in setting up emission inventory systems and data flows, including the development of guidance documents and guidelines and of emission inventory software tools. Emission inventories are combined with remote sensing data to provide an input into dispersion models. From another angle we are developing LCA based tools for industry for dealing with their carbon footprints. Starting from this background we envisage to contribute to CarboCount type projects, in particular on topics related to monitoring of emissions and allocating emission factors to (industrial) activities, installations etc.

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Programme: Adaptive Water management

The expertise in this area is in the area of 'water safety', i.e prevention/reduction of flood risks and in water treatment. For this program TNO will align with other partners in the Dutch node (Deltares, Wageningen UR).

Programme: Zero carbon production systems

TNO plays a major role in developing CCS (CO₂ Capture and Storage) in the Netherlands and Europe. Research focuses on capture technologies, transport logistics and safety and underground storage. Pilots are being developed in Rotterdam and Nijmegen in cooperation with industry. TNO acts as the coordinator of the national CATO2 research programme. Within Europe TNO has played a role in developing tools for the design of CO₂ transport infrastructure networks.

TNO is also a partner in the development of new technologies with a strong emphasis on efficiency and sustainability. Examples of areas where TNO plays a leading role include exploration of oil and gas, energy from biomass (also within BE-Basic program).

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Programme: Transitioning to resilient, low-carbon cities

TNO plays a major role in national R&D programmes such as Building Future, aiming at substantially reducing energy use by buildings. TNO is one of the core partners within the KIC-energy and especially assigned with the role to further develop the program line 'Energy in the Built Environment'. Furthermore, TNO is national focal point for the European PPP E2B (Energy Efficient Buildings). TNO also coordinates major projects on adaptation in cities and climate resilient infrastructure within the national research programs Knowledge for Climate. We aim to contribute from both angles: focusing on mitigation and adaptation in cities, and preferably in combination. Our strength is in approaches combining the building and neighbourhood/district level. In addition TNO can provide expertise in transition management.

In the field of mobility TNO combines expertise in vehicle engineering, broad experience of ICT applications and knowledge of driver behaviour and the traffic system all within a social context where quality of life and pressure for space are key issues.

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University of Utrecht

Utrecht University (www.uu.nl) is an internationally renowned top research university. Its quality is evidenced by the good results of research assessments and our outstanding performance in international rankings. Utrecht University conducts fundamental and applied research covering a wide variety of scientific disciplines. This diversity has inspired multi-disciplinary research collaborations with partners both from inside and outside the University. Regionally, as well as nationally and internationally, Utrecht University works together with universities, knowledge institutions and industry. These partnerships foster innovative research and contribute to economic development and the solution of social issues.

Utrecht University has concentrated its leading research into fifteen research focus areas. Within these focus areas, scientists pursue multidisciplinary collaborations within faculties, between faculties and with other research organisations, industry and societal institutions. Through the selective research themes and the integrated approach, Utrecht University is able to foster solutions to issues such as climate change, health, social cohesion and sustainability.

One of the focus areas is Earth and Sustainability. The faculties of Sciences of Geosciences are collaborating in this focus area that has strong matches to the four Climate-KIC programmes. Moreover, Utrecht University plays important roles in large scale national and international collaborative projects and programmes, such as CATO/CATO2, CatchBio and Knowledge for Climate.

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Climate-KIC programmes in relation to the activities and developments within the Utrecht focus area of Earth and Sustainability.

Programme: Assessing climate change and managing its drivers

Various research groups of Utrecht University focus on the Climate KIC programme for Assessing Climate change and managing its drivers.

- Reconstruction of past climates. The Department of Physical Geography (Dr. Hoek, Prof. Middelkoop and Prof. Weber) has key experience and an excellent record in the reconstruction of past climates at the glacial to human time scale.

The group focuses on climate fluctuations since the LGM, including short periods of rapid warming and the ecological implications, as well as century to decennial-scale minor fluctuations across NW Europe.

- Paleoenvironments and paleoclimate (Department of Earth sciences: Dr. Hilgen, Dr. Lourens, Prof. Sinninghe Damsté): past climate over longer, geological time scales, driven by orbital parameters, and impact on global biogeochemical cycles and ecosystems.
- Within the frame of the Knowledge for Climate programme the Department of Physics and Astronomy, Faculty of Sciences (Prof. Oerlemans, Dr. Van der Wal) focuses on the accelerating rate mass loss of the Greenland ice sheet and mountain glaciers in relation to Climate change.
- Climate change and governance: Climate proofing the Netherlands is not only a technical issue but also a demanding matter of governance. Within the frame of the Knowledge for Climate programme Utrecht researchers (Prof Driessen, Prof. Van Rijswijk (Faculty REBO at UU), Dr. Runhaar and Dr. Dieperinck) aim to develop and test governance arrangements that can contribute to realizing adaptation options, and to increasing the adaptive capacity of society. These arrangements should be effective, legitimate and resilient.

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Programme: Adaptive water management

Lowland deltas are under increasing pressure of climate and humans. Global change not only will affect water quantity, but also its quality. This is on the short term relevant for the human environment and river and coastal ecology, as well as on the long term for the global bio-geochemical cycles.

At Utrecht University several groups are active in water management related issues. Most of these groups reside in the Faculty of Geosciences, one group resides in the Science faculty. In the field of to adaptive water management, the groups have a strong expertise and interest in the following issues:

1. Coastal development and coastal safety under climate change (coastal morphodynamics group; Prof. Hoekstra). These is strong collaboration within the Netherlands Centre of Coastal Studies with Deltares and NIOZ.
2. River process studies (Prof. Middelkoop): response of river basins, river channels and floodplain/deltaic environments to global change. Study of the interaction between climate and human-induced changes in river systems as well as long-term autonomous developments. Transport and fate of pollutants in river systems. These studies are undertaken in close collaboration with Deltares, and the Netherlands Centre for River Studies.
3. River management studies: river safety, integrated river basin management under climate change: mitigation and adaptation strategies (global change geomorphology group; Prof. Middelkoop). There is strong collaboration with KNMI, Deltares, Univ Maastricht, and Ministry of Transport, Public Works & Water management. The focus lies in the development of modeling instruments at system and policy relevant spatial and time scales, and the integration of the natural and societal systems.
4. Water and food: global water system modeling, current and future global water stress issues, groundwater depletion and crop water demand (earth surface hydrology group; Prof. Bierkens).
5. Integrated water management and wetlands: mitigation of climate-induced floods and drought by using wetlands as natural buffers; wetlands as natural controls on surface water pollution (environmental sciences group; Prof. Wassen) (landscape ecology group, Faculty of Sciences; Prof. Verhoeven) (earth surface hydrology group; Prof. Bierkens).
6. Flow and transport processes in porous media: theory, soil and groundwater remediation, underground heat and CO₂ storage, groundwater development, industrial and medical applications of porous media flow (e.g. fuel cells, tissues, organs) (environmental hydrogeology group; Prof. Hassanizadeh).
7. Environmental geosciences (Prof Middelburg, Dr. Slomp, e.a.): biogeochemical dynamics in groundwater, coastal regions and oceans

Some of these groups are also participating in the programme Knowledge for Climate Utrecht.

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Programme: Zero carbon production systems

Prof Bert Weckhuysen (Chemistry, Faculty of Science, Utrecht University) is leading the public-private partnership programme Catalysis for Sustainable Chemicals from Biomass, CatchBio (<http://www.catchbio.com>).

CatchBio has initiated an ambitious research program of 8 years in the field of catalytic biomass conversion. Its aim is to process the various components present in biomass (cellulose, hemi-cellulose, lignin, proteins and oils) in useful fuels, chemicals and pharmaceuticals. Also the socio-economical and ethical aspects of the different generated technological options will be investigated. 21 partners are taking part in CatchBio. Among these partners are most of the Dutch universities, research institutes and industries operating in the field of catalysis research. Industrial key players are involved but also more specialized SMEs take part in the consortium.

CatchBio is part of the € 100 million investment program Smart Mix of the Dutch government aimed at boosting innovation in the Netherlands. Approximately half of the M€ 29 budget is financed through this investment program by the Dutch ministry of Economic Affairs and the ministry of Education, Culture and Science. The other half is financed by all the industrial and academic partners involved in CatchBio.

A second major activity in this KIC programme is the research on carbon capture and storage (CCS), within the public-private funded programmes CATO and CATO2.

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Programme: Transitioning to resilient, low-carbon cities

The Department of Human Geography and Planning of the faculty of Geosciences participates in the public-private partnership programme Knowledge for Climate. In this frame the group of prof. Spit works on “Climate proof cities”. The objective is to obtain a multi-scale (from the level of buildings via neighbourhoods to city agglomerations) quantitative knowledge base on (1) urban climate, (2) vulnerability of cities to climate change, (3) expected impacts of possible future changes in climate, (4) technical and economical effectiveness of adaptation measures, (5) governance required to achieve this adaptation. Based on the various impacts in cities and possible adaptation measures, an overview can be provided of costs and benefits of adaptation

measures in various scenarios for the development of the global climate. This will be linked with an in-depth understanding of the governance processes needed for implementation.

The transition to 'low-carbon-cities' will require new choices for mobility within cities such as a reduction in (combustion-engine) car usage and stimulating public transport and opportunities for walking cycling. Further elements explore the opportunities of ICT developments to eliminate certain needs for car transportation. These new mobility concepts are being addressed within the Department of Human Geography and Planning (Prof Dijst).

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Wageningen University and Research Centre

Wageningen University and Research Centre (Wageningen UR) is an internationally renowned centre with 5600 staff that links education and training to fundamental, strategic and applied research in the fields of plant and animal production, agrotechnology and food processing, rural development and environmental management. Wageningen UR is a collaboration between Wageningen University, Van Hall Larenstein School of Higher Professional Education and specialised former research institutes (DLO) from the Dutch Ministry of Agriculture. Globally, Wageningen UR ranks high in its domains with respect to the scientific quality (<http://www.wageningenuniversity.nl/UK/research/prominence/>). Wageningen University is one of the most important international universities with study programmes and research in the field of healthy food and the living environment. Research is conducted by the 92 chair groups of Wageningen University, each under the guidance of a professor. The scientific quality of Wageningen University is assured by seven graduate schools responsible for carrying out all university research. The DLO Foundation is a research organisation that aims to contribute in the public interest to strategic and application-oriented research into agricultural products (production, processing, sales and trade), fisheries, nature and environmental management, outdoor recreation and rural planning. Research Institutes within the legal entity of DLO Foundation include:

1. Alterra: Sustainable, societal development and use of our green living environment.
2. Applied Plant Research: Applied research in arable farming, green environment, multifunctional agriculture and field production of vegetables, flower bulbs, nursery stock and fruit.
3. Central Veterinary Institute: Diagnostic, scientific research, and (policy) consultancy in the prevention of and fight against animal diseases.
4. Food & Biobased Research: Develops and transfers knowledge in the field of sustainable application of agricultural raw materials for safe and healthy food and non-food products.
5. IMARES: Carries out strategic and applied marine ecological research within the field of aquaculture, ecology, environment and fishery.
6. LEI: Develops economic expertise in the field of food, agriculture and the natural environment.
7. Livestock Research: Innovation in the livestock industry and the health of (farm) domestic animals.
8. Plant Research International: Plant genetics and reproduction, genomics, crop protection and agrosystems.
9. RIKILT: Carries out research into the safety, health and quality of Dutch food and feed.
10. Wageningen UR Livestock Research is the main centre for research and development with respect to animal husbandry in the Netherlands. It combines expertises in different areas of technology with social sciences, in an integral interdisciplinary approach to develop sustainable production systems

The DLO institutes conduct strategic, applied and practical research for industry, governments and stakeholder groups. During the past decade DLO developed from a task-oriented organisation to a more market-driven organisation.

Wageningen University and the DLO foundation for Agricultural Research are organizationally integrated in five Science Groups: Agrotechnology and Food Sciences (AFSG), Animal Sciences (ASG), Plant Sciences (PSG), Social Sciences (SSG) and Environmental Sciences (ESG). Contributions to the KIC may involve research teams from both Wageningen University and the DLO Foundation.

A quick way to find information about staff and research teams of Wageningen UR is to look at We @ WUR: http://www.wewur.wur.nl/zoeken_naam/default.aspx

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Programme: Assessing climate change and managing its drivers

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Various Wageningen UR groups carry out research relevant for this programme:

1. The Earth System Science and Climate Change department (ESS CC – prof Pavel Kabat, prof Pier Vellinga, Ir Eddy Moors), a merger of a Chairgroup and an Alterra team, advances our understanding of the Earth and Climate System as a complex system, with specific inclusion of the anthropogenic and human components. Properties and processes of the components of the Earth System, such as carbon or water cycles in the terrestrial and atmospheric compartments, are investigated as integral parts of the system, focusing on their interactions and feedbacks. ESS CC develops innovative observational and modeling methods and tools) with a common aim to advance scientific understanding, as well as to support policies and strategic decision making processes in the field of climate, water and the environment.
ESS-CC has a leading role in EU funded research projects, such as Combine, High Noon (<http://www.eu-highnoon.org/>) and WATCH (<http://www.eu-watch.org/>) and coordinates scientifically in two major national climate research programs Climate Change Spatial Planning and Knowledge for Climate (<http://www.climate research netherlands.nl/>). Info at <http://www.ess.wur.nl/uk>. More information at www.climateXchange.nl and www.ess.wur.nl/uk
2. The Meteorology and Air Quality department (MAQ, prog Bert Holtslag and Prof Maarten Krol) aims to contribute to the further understanding of atmospheric processes and their relevance for weather, air quality and climate. The natural focus of MAQ research is on atmospheric boundary layers over land and on the

atmospheric aspects of the connected energy, water, carbon and aerosol budgets. Particular emphasis is given on the interaction of the atmosphere with the (vegetated) land surface. This includes the measuring and modeling of the relevant atmospheric and related land-surface processes on the local and regional scale.

Examples of projects are found at <http://www.maq.wur.nl/UK/Research/>

3. The Environmental Systems Analysis department (Prof Rik Leemans, Prof Carolien Kroeze) aims to analyze, interpret, simulate and communicate complex environmental problems from different perspectives in a quantitative and interdisciplinary manner. The research of the ESA group combines ecological, economic, technological and policy perspectives in order to develop new insights in the causes, effects and potential solutions to complex environmental issues. The research is delineated at <http://www.esa.wur.nl/UK/Research/>
4. The Chairgroup Hydrology and Quantitative Water Management (prof Remko Uijlenhoet, Dr Henny van Lanen) develops tools for managing and reducing drought risks at different scales (river basin, regional, global). Currently research is conducted into the conversion of climate signal (meteorological drought) into hydrological drought (groundwater and streamflow) by considering the role of the hydroclimatology and the physical structure of the river basins, to the development of new low-cost smart sensors, novel satellite and ground-based technology and instrumentation to monitor hydrological fluxes and states, and their integration in hydraulic and hydrological models and to the improvement of climate services for real-time (flood) forecasting and long-term projection capabilities by applying data assimilation techniques in hydrology. Examples of research are found at www.hwm.wur.nl/UK/Research/hydrometeorology, www.imprints-fp7.eu/, www.feem-project.net/xerochore/, www.hydrate.tesaf.unipd.it/
5. The Chairgroup SEG (Soil Physics, Ecohydrology, and Groundwater Management, Prof Sjoerd van der Zee) focuses on the interactions between soil and groundwater, vegetation/crops, and the atmosphere, regarding water, energy and solute transport fluxes and balances, at different scales (local up to regional). Both experimental (laboratory, greenhouse, field) and theoretical and modeling research is undertaken. Main research lines are ecohydrology of natural and agro-ecosystems, that accounts for humid and semi-arid regions, soil and groundwater salinization, both in water scarce semi-arid regions and in humid coastal zones with saline groundwater. In addition, groundwater flow/contaminant hydrology, and regional soil physics are earth surface processes are studied in our group.
Examples of research are found at <http://www.seg.wur.nl/UK/Research/>
6. The Agricultural economic Institute (LEI) focuses on the assessment of policy effectiveness. LEI explores impact assessment studies ranging from micro-economic decision making concerning climate mitigation and adaption strategies to more socio-economic modeling and risk assessment. Integrating scaling issues and governance is one of the challenges in research and policy design. Building on experience in diverse areas of rural and environmental issues LEI is well-equipped to contribute to the topics of climate extremes and carbon management: economic analysis of ecosystem services including aggregation issues for costs and benefits and the consequences of different types of quantitative decision making. LEI has a proven track record in developing and accounting sustainability indexes, partly based on extensive datasets of trade flows.
Information: <http://www.lei.wur.nl/UK/>

7. Wageningen UR Livestock Research carries out research on the impact of climate extremes on animal husbandry and on forage production, on mitigation of greenhouse gas emissions, the carbon management of grasslands, carbon footprints, Life Cycle Analysis methodologies, Sensor technology and Decision Support Systems. Information: <http://www.livestockresearch.wur.nl/uk>
8. The Laboratory of Geo-Information Science and Remote Sensing (GRS, prof Arnold Bregt, prof Martin Herold)) deals in a multidisciplinary and collaborative manner with spatial data infrastructures, spatial data modelling, geo-visualization, quantitative remote sensing, and national, European and global scale land cover/use mapping and monitoring. Staff is working in collaboration with various national and international research institutions and organizations, including the government and private sectors to provide research in geo-information science in order to support policy development and the design and management of rural areas at various scale levels. <http://www.grs.wur.nl/UK/> and <http://www.alterra.wur.nl/UK/research/Specialisation+Geo-information/>

Programme: Adaptive Water Management

Wageningen UR Programme coordination:

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Water in a broad sense

1. The Aquatic Ecology and Water Quality Management department (AEW, prof Marten Scheffer, prof Bart Koelmans) focuses on the physical, chemical and biological processes occurring predominantly in freshwater ecosystems. The research is multidisciplinary (environmental engineering, environmental chemistry and aquatic ecology) and ranges from the laboratory scale (detailed process studies) to the scale of actual ecosystems (field studies). The multidisciplinary expertise of the team comes together in the development of integrated models for ecosystem and water quality management. The research approach thus is quantitative with a strong emphasis on state-of-the-art statistical and modeling techniques. Examples of research projects include <http://www.aew.wur.nl/UK/Research/AQUATERRA/> <http://www.sense.nl/research/2024> and <http://www.aew.wur.nl/UK/Research/Current/>
2. The Chairgroup Hydrology and Quantitative Water Management (prof Remko Uijlenhoet, Dr Henny van Lanen) 1) studies real-time integration of models and information for improved early warning systems for floods and droughts to provide, e.g., reliability assessments of Europe's aging flood infrastructure, improved evacuation strategies, and model-driven management strategies for predicting and minimizing negative drought- and flood-induced impacts, 2) develops flood risk models by bridging the gap between terrestrial and coastal flood risk studies, e.g. focusing on the coincidence of river floods and storm surges at sea. Hydraulics of river deltas are a key discipline in our group, 3) develops of new low-cost smart sensors, novel satellite and ground-based technology and instrumentation to monitor hydrological fluxes and states, and their integration in hydraulic and hydrological models and 4) studies integrated management of catchments: improved models combining socio-economic and

hydrological factors tailored to specific sectors, developed to evaluate scenarios of change and to assess adaptation options.

Examples of research projects:

<http://www.hwm.wur.nl/UK/Research/hydrometeorology>

<http://www.eu-watch.org> , <http://www.geo.uio.no/edc/>

3. The Chairgroup SEG (Soil Physics, Ecohydrology, and Groundwater Management, Prof Sjoerd van der Zee) – see under programme Assessing Climate Change and <http://www.seg.wur.nl/UK/Research/>
4. The Irrigation & Water Engineering Chairgroup (Prof Linden Vincent) is committed to understanding all there is to water in agriculture. Irrigation - from farm to watershed level - is the main focus. IWE aims to understand the technical and ecological forces, and the social forces that drive water use. Examples of research can be found at <http://www.iwe.wur.nl/UK/Research/>
5. The Integrated Water Management Team (Prof Wim Cofino, Dr Erik van Slobbe) within the Earth System Science and Climate Change department (ESS-CC) carry out research on the process aspects and on the utilization of information and knowledge in adaptive water management. <http://www.ess.wur.nl/uk>
6. Alterra Integrated Water Management Team quantifies (the effects of water management on) the hydrological cycle, waterquality concerning nutrients, and resulting environmental effects. Products (models, decision support systems and advises) are applied at fieldscale, catchmentscale and national scale in order to evaluate and monitor policy with respect to water, agriculture, nature, environmental effects and environmental planning. Knowledge and tools are developed to increase water productivity in rainfed and irrigated agriculture under water stress. New ways are sought to provide water in space and time to modern combinations of high production units and low intensive agriculture.
<http://www.alterra.wur.nl/UK/research/Specialisation+water+and+climate/Integrated+Water+Management/Projects+Team+IW-IWRM/>
7. The Alterra research group Environmental Risk Assessment has expertise in research and consultancies on the fate, effects and aquatic risk assessment of pesticides. We are characterized by a multi-disciplinary approach. Chemists, ecotoxicologists, toxicologists, soil scientists, hydrologists and aquatic ecologists cooperate closely. Simulation models describing the pathways of pesticides in soils, groundwater and smaller waterways are developed, ecotoxicological experiments are conducted under the GLP regime to study the fate of these compounds.
<http://www.alterra.wur.nl/UK/research/Specialisation+water+and+climate/Environmental+Risk+Assessment/>
8. The Alterra Aquatic ecology team performs fundamental and applied research, amongst others on effects of global and climate change by studying the functioning of aquatic ecosystems with a strong emphasis on fauna, and their contribution in ecosystem processes, interactions and scales by focusing on key environmental extremes and on climate change indicators by further developing hypotheses on life history tactics (in a broad sense) . They hereby also focus on linking patterns and processes at different scale. Furthermore, adaptive management is provided with measure-effect knowledge, especially in relation to restoration/rehabilitation of aquatic ecosystems and their surrounding catchments, the role of dispersion, migration and exotic/invasive species and in assessment, evaluation, management measures and expert knowledge concerning inland freshwater management.

Examples of research include <http://www.eurolimpacs.ucl.ac.uk/>,
<http://www.wiser.eu/>,
<http://www.alterra.wur.nl/UK/research/Specialisation+Ecosystem+Studies/Freshwater+Ecology/>

9. Economic consequences are one of the key features of the decision support systems in adaptive water management. LEI is well-experienced in estimating the costs and benefits of different adaptive water management strategies using cost-benefit and cost-effectiveness analysis. Econometric and scenario modeling (partly based on simulation models of Alterra) as well as participatory techniques are applied for estimating costs and benefits. Information: <http://www.lei.wur.nl/UK/>
10. Wageningen UR Livestock Research has experimental farms and process based models enabling research on drought tolerance of forages, optimisation of water systems at the farm scale, decision support systems and ecosystem services of forages. Information: <http://www.livestockresearch.wur.nl/uk>
11. Wageningen IMARES - Institute for Marine Resources and Ecosystem Studies carries among others research on Climate-resistant coastal zones
The aim of this focus theme is to initiate and perform (applied) research, cooperate and start partnerships with other parties and stimulate and participate in the development of education. The theme is primarily oriented towards the most sensitive aspect of the delta metropolis: areas in the major river deltas where people, buildings, farmland, and fresh/salt water converge in great density. These are the places where global climate change and the resulting rise in sea level will have a major impact. This impact will be even more significant because delta metropolises are also frequently home to major centres of economic activity. Examples include Southeast China, Malaysia, New Orleans, and, of course the Netherlands. <http://www.imares.wur.nl/UK/>
12. The Sub-department of Environmental Technology (Prof Huib Rijnaarts, prof Cees Buisman) carries out research on 1) the reuse of wastewater within industry, the urban environment, and in agricultural applications. The challenges here are to match the quality of the waste water with the quality needs of water users and to develop new tailor made water treatment technology to improve the match, 2) the closing of water cycles in production processes: closing water cycles always means a build up of inert compounds that should be removed from the water by selective separation or conversion and 3) new water resources: in arid countries brackish water is a potential new water resource. To exploit this resource low cost desalination technology is needed. Information at <http://www.ete.wur.nl/UK/Research/>

Water productivity in agriculture

13. The Centre for Crop Systems Analysis (CSA, Prof Holger Meinke and Prof Paul Struik)) sets itself to develop high quality plant production in sustainable agro-ecosystems through research and teaching.
It has programmes to improve and innovate plant production at various levels of integration; from genotypes to cropping systems and production chains and to assess risks arising from climate variability and climate change. Information at <http://www.csa.wur.nl/UK/>
14. Wageningen UR Greenhouse Horticulture is the leading research institute in the international greenhouse horticulture. Experience in both greenhouse horticulture and research allows us to develop and implement innovations for and in

partnership with the horticultural industry. Thereby we significantly contribute to the development of a sustainable and competitive greenhouse horticulture.

Information: <http://www.glastuinbouw.wur.nl/UK/>

15. The principal scientific goal of the Plant Production Science department (prof Ken Giller and prof Herman van Keulen)) is the integration of knowledge to allow analysis and design of new approaches to the dual goals of sustainable production systems: optimal production of crops and livestock combined with optimal management of natural resources in their broadest sense. We develop tools and methodologies that allow analysis and design of alternative future scenarios at local (farm), regional, national, international and global scales. A special emphasis is on the use of modelling tools, although field oriented and experimental work is also performed as an essential part of testing of our concepts. Much of our work uses comparative approaches which we apply in large interdisciplinary projects such as SEAMLESS, AfricaNUANCES and Competing Claims on Natural Resources. <http://www.pps.wur.nl/UK/>
16. The PRI Business Unit on Agrosystems design and develop socially desirable production systems, which are ecologically and economically responsible and take full account of other functions in rural areas. Agrosystems Research designs innovative land use systems to reduce emissions that cause climate change. Land use systems are developed which are able to function optimally under the changing climatic conditions. Systems are devised that simultaneously contribute to cleaning of surface waters, water storage to prevent downstream flooding and biobased energy production. This is done by growing crops that absorb substantial quantities of undesired elements from surface waters, survive under wet conditions and produce large amounts of biomass. Information at <http://www.pri.wur.nl/UK/research/agrosystems/>

Land-use and adaptive water management

17. The Alterra Landscape Centre has extensive expertise on the impacts of climate change on ecosystems and the development of adaptation strategies to climate proof ecosystem networks. Development of strategies for integrated multifunctional adaptation, finding synergy and constraints in multifunctional adaptation e.g. between nature, agriculture and water management. Development of regional adaptation plans, ecosystem services provided by nature and agriculture to increase regional adaptive capacity. There is ample experience in co-production of knowledge by scientists and regional stakeholders together, about e.g. ecosystem services, regional adaptation strategies, etc. Info at <http://www.alterra.wur.nl/UK/research/Specialisation+Landscape/>
18. The WU Land Use Planning Group develops state of the art knowledge about linking scientific knowledge to actions in the public domain, with emphasis on green functions in the peri-urban landscape. We focus on an evidence based organization of land use change and its perception, on a variety of spatial scales. By this we contribute to a better use of scientific knowledge on physical system, like water catchments, in societal decision making. Information at : <http://www.lup.wur.nl/UK/>
19. The Alterra Forest Ecosystems Team has a long track-record in climate change research on both mitigation and adaptation aspects of forestry, e.g. quantifying carbon cycles in European forests, including natural disturbances. An example of European cooperation is the MOTIVE project (<http://www.motive-project.net/>), where we advice forest managers on measures to take to adapt to anticipated

climate change, taking into account the other functions of the forest. Furthermore we have the Forest Reserves Programme (<http://www.bosreservaten.wur.nl/NL/Nederlandse+Bosreservaten/>), where we monitor development of unmanaged forests. About 100 of the trees in the reserves are equipped with automated dendrometers that continuously measure the diameter development of the trees. This monitoring gives important information on the reaction of the trees to (extreme) climatic events, like the drought of summer 2003.

25. The Subdepartment of Soil Quality Chairgroup (prof Willem van Riemsdijk, prof Tom Kuyper, prof Oene Oenema, prof Lybert Brussard, prof R Comans) focuses on interactions between soil, agrobiodiversity, and agricultural production systems. One line of research focuses on soil amendment with biochar to pursue a triple-win strategy (energy saving, carbon sequestration, enhanced agricultural productivity). Biochar also receives attention in a project on conversion of low-value agricultural side products (to avoid competition with food production) in high-value products that reduce CO₂-emissions. A second line of research encompasses trade-offs between greenhouse gas emissions in agro-ecosystems in relation to soil management (soil tillage) and agrobiodiversity. Our group has ample experience on nutrient cycling and biological interactions in the soil, and in the relation between biological and physical soil properties and processes with agricultural soil management. Information at <http://www.soq.wur.nl/UK/>
26. The Forest Ecology and Forest Management (FEM) Group of Wageningen University (prof Mohren, prof Bongers) deals with fundamental and applied ecological issues such as forest ecosystem dynamics, environmental influences on tree growth and forest development, and sustainable silvicultural systems. Based on sound understanding of growth and development of forest ecosystems, and of the ecological processes underlying forest ecosystem dynamics in relation to species properties and environmental conditions, guidelines for sustainable forest resource management are derived. Information at <http://www.fem.wur.nl/UK/>

Programme: Zero Carbon Production Systems

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1. Biorefinery.nl is a joint initiative of Wageningen University and Research Centre (WUR) and the Energy research Centre of the Netherlands (ECN), supported by SenterNovem. It is meant to inform industry, research institutes, universities, social institutes, and governments about research activities, new developments and projects. With the feedback of these groups it also concentrates on establishing a global biorefinery vision and formulating a roadmap for research on and development of biorefinery processes. Information at www.biorefinery.nl, example of project at <http://www.biosynergy.eu/>

2. The bioprocess engineering chair group (prof Rene Wijffels, prof Gerrit Eggink, prof Hans Tramper) develops new biotechnological processes for manufacturing of healthy food ingredients, biofuels, biopolymers, pharmaceuticals, and biopesticides. The challenge is to make high-quality products in a sustainable and economic way, to avoid overexploitation of natural resources and the environment and maximize the chances of utilization by existing and new biotech companies. Information at <http://www.bpe.wur.nl/UK/> , projects at <http://www.bpe.wur.nl/UK/Research/Projects/>
3. The Wageningen University Chair of Valorisation of Plant Production Chains (WU-VPP, Prof Johan Sanders) is a multidisciplinary research group within the Agrotechnology and Food Science Group (AFSG) performing scientific and applied research aiming at the development of economically and environmentally sound (bio)chemical, enzymatic and biological conversion and fermentation processes. These processes are based on plant raw materials and should substitute fossil resources of bulk chemicals, transportation fuels and animal feed. Key components of the research are the definition of measures to reduce industrial energy consumption on a global scale, to fully exploit available and as yet uncovered cheap resources of agricultural (waste) streams, and to decrease CO₂ emissions and pollution. Info at <http://www.vpp.wur.nl/UK/>
4. Plant Research International operates the research theme biobased economy in its business unit Agrosystems . Knowledge about plants and production systems is utilized for the development of new propagation material, crop growth, fitting crops into the cropping plan, and the optimisation of biomass for further processing. Info at <http://www.pri.wur.nl/UK/research/research+themes/Biobased+economy/>
5. The implementation of bio-renewable crops that optimize GHG savings might have significant consequences from an economic perspective. These consequences should be assessed in an early stage of development, so that the economic consequences can be part of the decision making process for implementing bio-renewable crops. Economic consequences include the location of bio-renewable crop production, changes in market competition of crops, changes in economic structure at national and regional level, for instance. LEI has developed models that calculate the impacts of market based instruments to stimulate the implementation of bio-renewable crops in the energy system. Furthermore, LEI has models and tools to assess the economic consequences of the implementation of new bio-renewable crops alongside its life cycle. LEI has GIS experts that can help to incorporate the spatial dimension at grid level in *ex ante* evaluations of policies affecting crop production and consumption. <http://www.lei.wur.nl/UK/>

Programme: Transitioning to resilient low-carbon cities

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1. The Urban Environmental Technology and Management Group, Prof. Huub H.M. Rijnaarts, focus on innovative treatment and management practices of especially domestic wastewater and (solid) waste in cities. Domestic (waste)water is increasingly recognized as a source of raw materials. At several locations in Europe, new sanitation concepts based on source separation and recovery of resources are demonstrated. In developing countries, novel tailor made sanitation and treatment concepts are developed and demonstrated in Africa, Asia, and South America. The integration of innovative technologies into (peri-)urban cycles is done through basic concepts such as Urban Harvest, Water-Energy-Material Cascading, and Consumption-Production feed backs. Info at <http://www.ete.wur.nl/UK/>
2. Decarbonising cities will substitute materials and activities for lower carbon usage. This is related to short term and long term decisions (investments) and public and private aspects that are tied together. The price of carbon price can be a driving force for the desired transition and can be related to all kinds of goods with more or less public good characteristics. Developments of rural and urban areas are more and more linked. This linkage can be exploited more to increase the resilience of cities. Integrated planning and management of the rural-urban fringe will be an important issue, to improve the resilience of cities. LEI has experience in the economic assessment of integrated spatial planning and management policies and associated pricing models that will be efficient tools in the transition to resilient, low-carbon cities. <http://www.lei.wur.nl/UK/>
3. The Landscape Architecture Group (prof Adri van den Brink, prof Jusuck Koh) studies strategic spatial planning, urban design, and landscape architecture to mitigate climate change (e.g. energy-neutral regions) and at the same time to reveal how to adapt the built environment to the changing climate. Both mitigation and adaptation to climate change have been in the focus of research at the Landscape Architecture in the past 5 years. Our two core research foci were (1) substantial knowledge (e.g. generally applicable design principles for energy landscapes), and (2) procedural knowledge (e.g. methodological framework for regional energy visions). <http://www.lar.wur.nl>
4. The Chairgroups Earth System Science-Climate Change and Meteorology and Air Quality group are involved in urban climate and urban design studies. For a description of these Chairgroups, see the Programme Assessing Climate Change, item 1 respectively 2.. Information at www.ess.wur.nl/UK/; www.maq.wur.nl/UK/, www.climateXchange.nl
5. Green and blue cities
Wageningen UR sets up a research theme to incorporate the potentials of vegetation ('green') and water ('blue') in the planning, design and the management of resources in cities. In an integral and multidisciplinary approach we will use the opportunities of ecosystems services to create beautiful, clean and healthy cities which are pleasant environments to live in. The interaction with the surrounding country side is taken into account. Participation of the people living in and around the city is part of the typical Wageningen approach. Doing so, we address problems of climate change, water management, health and food production in urban areas.

In the following we will describe five specific research topics; topics A and B focus on planning and design at different spatial scales. topics C,D, and E address practical opportunities for food production, mitigation of climate change and cooling of cities.

A. Planning and design of green/blue cities (city/district level)

- smart application of green/blue in city design reduces impact of climate change
- creating green/blue cities and city districts that better can cope with excessive heat and precipitation (resilience)
- cities with lower 'urban heat' (because of urban green/water) needs less cooling in the summer (low-carbon)
- energy storage in soil and water bodies without adverse effects on water quality (low-carbon)
- soils and the city; making optimal use of ecosystem services of soils in the spatial planning process
- interaction between city and surrounding country side which could provide services to the city
- green buildings

Research task:: planning and design tools and strategies are needed to come to a smart application of urban green and blue.

Wageningen UR research groups: CL (Landscape architecture, Land use planning, Alterra-team Urban Regional Development), CWK (Meteorology and Air Quality, Earth System Science – Climate Change, Integrated Water Management), CE (Aquatic Ecology and Water Quality Management Group); Soil Science Centre (Soil physics and Land use)

B. Green buildings (building level)

- optimizing application of green roofs and walls in building development/renovation
- decreasing air-conditioning use in summer (low carbon)
- buffering of peak rainfall (resilience)
- closing gap between citizen and nature (resilience)

Research task: optimize the functionality of green walls and roofs in terms of ecosystem services (water, energy, biodiversity, health, livability, air)

Wageningen UR research groups: PPO, ESG (Alterra-team Urban Regional Development, Landscape Architecture, Meteorology and Air Quality Group, Hydrology and Quantitative Water Management Group, Soil Physics, Ecohydrology and Groundwater Management Group,..)

C. Food in the city: Urban agriculture

- food production in places where people live
- re-use of organic material in the city ('Cradle to Cradle')
- low transport costs, short lifecycle (low carbon)
- smart management practices prevents GHG emissions (low carbon)
- education citizens on being self supportive on food production (resilience)
- education citizens on ecosystem functioning (resilience)

- improving cohesion among citizens (resilience)

Research task: explore options and conditions to increase the quantity and quality of urban agriculture, including participation of citizens

Wageningen UR research groups: PPO, PRI, ESG... Soil Science Centre (Soil Quality and Nutrients)

D. Mitigation of climate change: Urban biomass production

- urban green produces wood (from cuttings) that can be used in local biomass centers, to produce energy (low carbon)
- locally produced energy saves energy transport from elsewhere (low carbon)
- locally produced energy makes cities less dependent of global energy issues (resilience)
- the biomass production factor of urban green adds value to urban green structures, making them more profitable (resilience)
- smart management practices increase carbon storage while preventing non-CO₂ GHG emissions (low carbon)
- management of vegetation in cities: store carbon in soil and biomass without increasing methane and nitrous oxide emissions (low-carbon)
- re-use of organic material in the city ('Cradle to Cradle')

research: explore how city environments can produce energy locally, specifically types of energy related to urban green and water

Wageningen UR research groups: ESG, CE, Soil Science Centre (Soil Quality and Nutrients)

E. Cooling the city

- predicting heat wave in cities: early warning system, using weather forecasts
- develop a strategy to anticipate on heat waves: how to cool the city?
- decision support tool for water use under extreme hot conditions
- using cold water stored in soil to cool

Wageningen UR research groups: CL (Landscape architecture, Land use planning, Alterra-team Urban Regional Development), CWK (Meteorology and Air Quality, Earth System Science – Climate Change, Integrated Water Management Soil Science Centre (Soil physics and Land use; Environmental Technology (ETE))