WAGENINGEN
UNIVERSITY & RESEARCH

White Paper

Towards a Circular and Climate-Neutral Society

In the Knowledge Base (KB 34) research programme 'Towards a Circular and Climate-Neutral Society', Wageningen University & Research strives to develop new production systems for food and non-food products. We believe these systems should not only be circular and climate-neutral, but should also have favourable effects on our climate.

Our aim is to contribute significantly to a circular and climate-positive society by the year 2030. By this we mean an environmentally friendly society where contemporary production systems have given way to closed-cycle bio-based systems beneficial to humans, animals and the world.

From new bio-based materials to governance systems

The goal of this programme was to develop knowledge to provide the necessary building blocks for the transition to a circular and climate-neutral society. It delivered concepts in which greenhouse gas emissions from the primary production sector were reduced.

It also resulted in novel biomass production systems, new bio-based materials, and alternative safe protein sources. Furthermore, monitoring and impact measurement tools were developed, as well as effective governance and learning systems. Each project was performed by teams from at least 3 different science groups in Wageningen, ensuring a multidisciplinary approach of the challenges.

PLEASE CLICK ON THE THEME OF YOUR CHOICE

Assessing our impact

The purpose of this short report is to present an assessment of the impact of the programme during its four years in operation. It gives an overview of the key performance indicators obtained, which is based on a questionnaire that was completed by project leaders.

The figures are remarkable in many ways and show what can be achieved through a focused effort delivered within the boundaries of a specific research programme.

The project results have been summarised per programme theme. More detailed information about the projects and their results can be found on the KB34 programme page.

Figure 1 A schematic overview of the 'Circular & Climate-neutral Society' programme

The broad Knowledge Base programme includes a variety of projects that cumulatively provide the building blocks for a transition to a circular and climate-neutral society.

These projects mainly focus on closing the loop for water, nutrient and carbon. They target specific points within supply chains (agriculture, greenhouse cultivation, aquaculture) as well as the links between different sectors. In terms of scale, they range from individual farms to the national scale.

Wherever possible, side streams are reused for food or animal feed. If that's not possible, they are converted into biobased products, such as building materials, chemicals, bioplastics and textiles.

New and improved primary production systems are being developed for certain contexts such as peatlands and areas affected by salinisation, in response to the need for climate mitigation and adaptation.

These production systems will encompass not just food and feed but also the production of biobased products. This will be done with reference to impact assessment frameworks and any potential synergies or trade-offs.

Interdisciplinary teams are working together wherever possible in order to manage, support and monitor this complex transition. These consist of technologists, ecologists and social scientists, as well as supply chain actors.

1 Management of transitions: developing tools for governing and monitoring

Transitions towards a Circular and Climate-Neutral Society call for fundamental changes in society and agro-food systems. Key questions of the theme "Management of transitions" are:

1 What are the possibilities and consequences of choices in the transition towards a circular and climate-neutral society that has social, economic and environmental benefits?
2 What is the impact of climate change on the bioeconomy in the medium and long run and what are mitigation actions that go beyond climate neutrality?

In 2019, this theme started with a broad consensus on the need to change from a linear to a circular and climate-neutral society. However, concepts were unclear, knowledge was fragmented, and there was lack of insight in streams of raw materials, promising options and trade-offs.

Theme 1 is subdivided into four subthemes, each with its own KB core projects. It also co-funds European and other subsidised projects that fit in the strategic direction and bring additional benefits.

Summary of project results

This theme provided building blocks for a circular climate-neutral society: (i) a conceptual framework, (ii) a monitoring system, (iii) an integrated toolbox and (iv) governance structures translating global transitions towards circular agri-food systems to individual farms and households.

One such tool, the Butterfly framework, develops the concept of a circular and climate-neutral society in a practical way, and it is now used inside and outside WUR to define action perspectives for the transition towards a circular and climate-neutral society. The butterfly framework aims to connect people with different disciplinary backgrounds and helps to define action perspectives. The framework identifies three systems which are part of the butterfly itself: the technical system, the ecological system and the socio-economic system. Important aspects are the societal goals, the planned interventions and the driving forces.

Monitoring tools are available to determine the degree of circularity and to monitor progress. The ultimate aim (Societal Goals) need to be monitored carefully (the 'roof' in Figure 3). Central principles are (i) the efficient use of resources, (ii) increasing the use of renewable resources, (iii) maximising the utility of products and (iv) reducing GHG emissions.

Figure 2 The butterfly framework

The project results also improved the Dutch monitoring system of the transition to circularity. Specifically, the focus was on the supply and use of biomass waste and side-stream categories (such as manure, plant waste, food waste and wood pellets), biomass flows and carbon, CO_2, N and P cycles in the economy and the environment.

We developed an integrated impact assessment framework or 'Policy Integrated Toolbox' to assess the potential of circularity to close the gap for climate neutrality in the future (2030, 2050). To do this, we considered a broad set of objectives and possible costs as well as synergies and trade-offs. The toolbox includes the economic system, the technical system (food system model), livestock (animal) model, food safety model, the

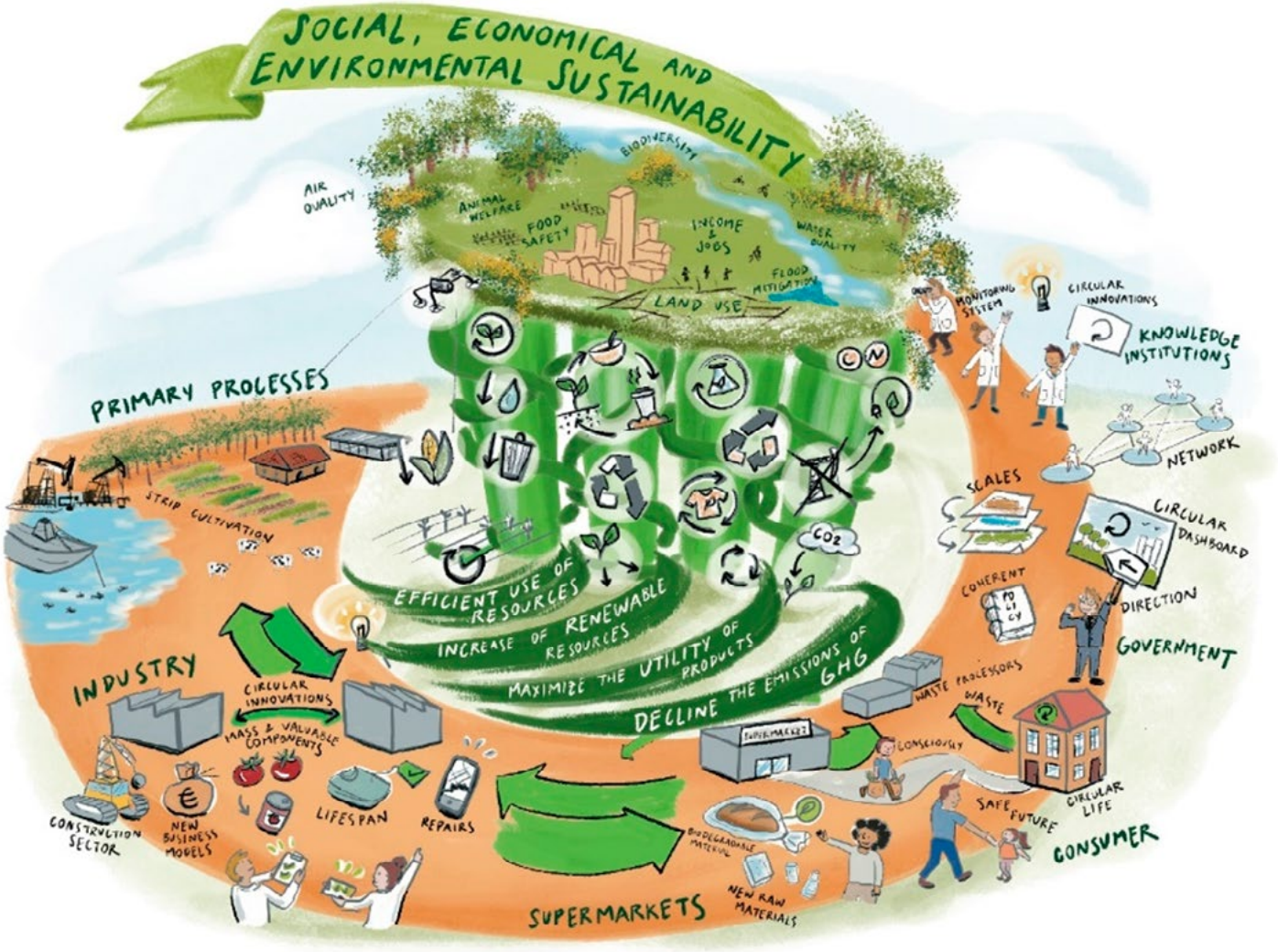


Figure 3 Monitoring framework

ecological system (land allocation model), and biodiversity indicators. This represents a new generation of tools designed to dynamically model the effects of circular bioeconomy on climate change mitigation in the EU agri-food system by 2050. The completion of a report for the European Commission formed the foundation for the new EU policy framework for biobased, biodegradable, and compostable plastics.

The governing transition project focused on how to realise such a transition. We gained insight in understanding the behaviour of the actors involved and how to change their behaviour (Motivation, Opportunity and Ability (MOA) model). Furthermore, we studied the effectiveness of incentives, instruments and arrangements. Viable business models are key to realising a circular economy. Based on different types of Circular Business models and the CANVAS model, the Circular Nature Inclusive Agricultural Business Model (CNABM) was developed.

Output & Outcome

Our projects have led to dialogues and collaborations with, for example, the European Investment bank, DG Clima and the FAO. We are one of the first organisations to have developed an operational framework that can be applied to different types of transitions. We analysed more than 8 just transition practices and have made the information easily available to policymakers and practitioners. Our team successfully organised a series of dialogues about justice in transition practices.

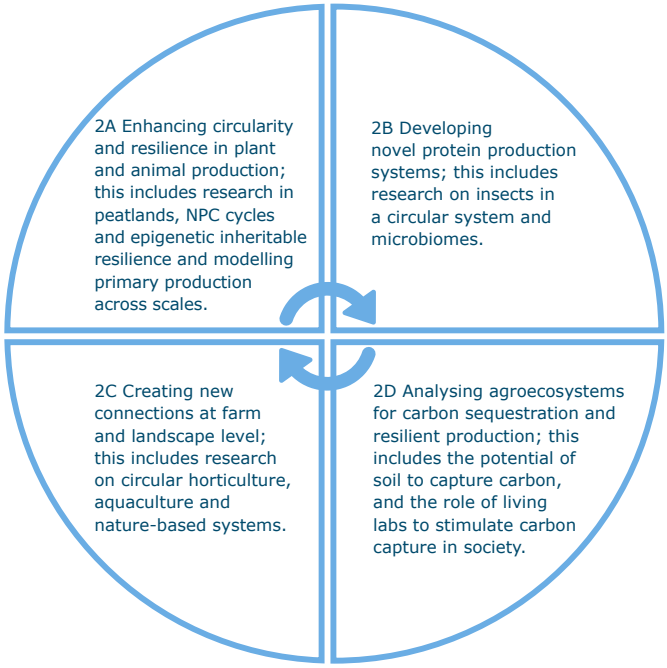
Finally, one of the project teams reached the semi-finals of the Rockefeller Foundation’s Food System Vision Prize. Together with UDC Causes, we shaped a bold yet practical vision for a nature-based food economy for the Washington DC region. Reaching the semi-finals yielded a lot of exposure and led to winning other prizes, high level lectures, book chapters, and more.

2 Primary production systems: redesigning processes towards circular and resilient systems

Theme 2 aims at designing and redesigning primary production processes towards circular and resilient systems. The focus of this theme is on:

1 Practical designs developed for various forms of circular biomass production on various levels (parcel, farm, regional)
2 Scientific evidence based on experiments
3 Solutions for the prevention of accumulation of safety hazards when closing the loop
4 An overview of the impact of the designed novel productions systems, including the physical, environmental and socioeconomic conditions for such systems

Theme 2 is subdivided into four subthemes, each with their own KB core projects. It also co-funds European and other subsidised projects that fit in the strategic direction and bring additional benefits.



Summary of project results

This large theme delivered a wide variety of results that can help to redesign primary production systems into circular and resilient systems. We applied an integrated toolbox for scenario analysis that covered the mitigation of greenhouse gas emissions and circularity objectives at different scales: from parcel to sector and from a national context to an international context. In another approach we used an integrated assessment of the carbon, nitrogen and phosphorous cycle and showed that the required reductions in Dutch agriculture cannot be achieved with improved management only. It also requires livestock reduction, especially when focusing on NH3 objectives. A separate project identified the knowledge and technology gaps that lead to large losses of nitrogen in circular agriculture.

Various new primary production systems were investigated in an experimental setting, looking at potential products as well as food safety aspects. Interesting cross-overs emerged in projects about horticulture in a circular economy. For example, fish excreta from aquaculture could be used to replace

mineral nutrients, and water exchange between greenhouse and fish culture resulted in efficiency gains.

Seaweed and shellfish were proven to play a key role in future product development. Extensive plans for wind farms in the North Sea provide the potential to increase aquaculture production significantly. However, large-scale aquaculture in the North Sea will have impact on the ecosystem functioning. We developed a model (see figure 4) for the impact of large-scale production that can give insight into the carrying capacity of the system.

The role of insects in the bioconversion of low-value waste streams was also investigated. Catering waste proved a very good source to grow black soldier fly larvae on. The application of organic waste streams supports plant growth and suppresses diseases, while reducing fertiliser and pesticide use, and has the potential to increase circularity in agriculture.

Three of the projects investigated how to improve the health and resilience of agricultural and forestry production systems that contribute to climate mitigation and adaptation. An important strategy to achieve this is to increase both biodiversity and genetic diversity in crops, trees, and livestock. For example, the Epigenetics project investigated whether sufficient resilience can be inherited, in this case by a model crop tomato. The project showed how plant resilience against pests and pathogens can be achieved without the use of genetic modification. The Microbiome project positioned microbiome research as a connecting factor between environments in a circular agriculture system. It also demonstrated the relevance of microbiome research in relation to the health and resilience of a circular food production system.

Output & outcome

This theme led to the publication of academic and popular articles and the start of follow-up EU and PPP projects. Our projects resulted in policy advice, high-level lectures, webinars, movies, and meetings with the Minister of Agriculture, Nature and Food Quality and parliamentary committees. Finally, internal WUR initiatives like the Microbiome initiative have emerged, partly based on the KB project.

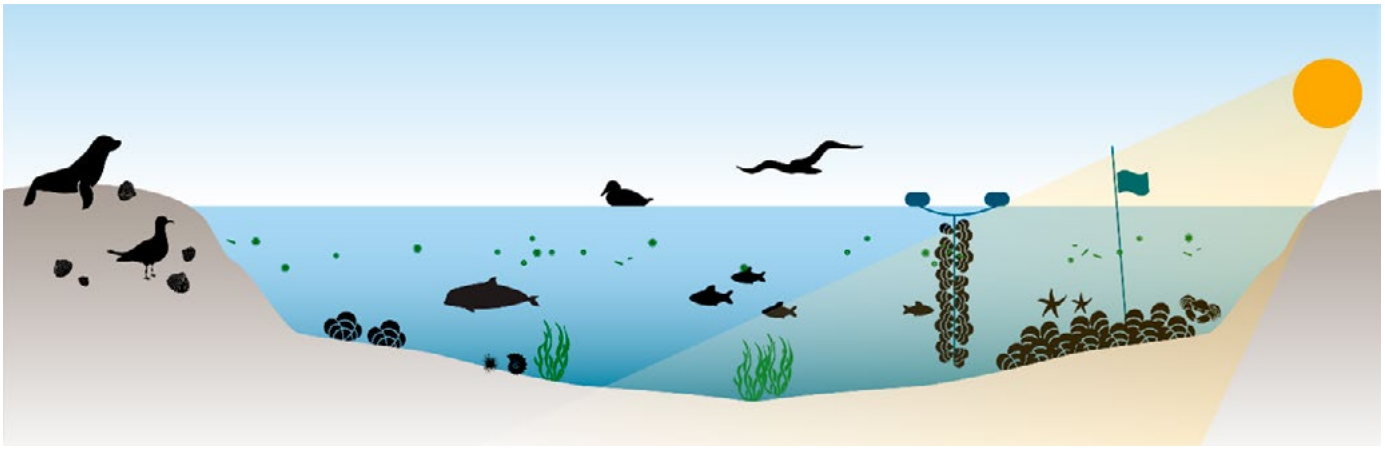


Figure 4 To address the carrying capacity questions for large scale aquaculture in the North Sea, a simple ecosystem model has been developed for the North Sea.

3 Biobased products: diversifying the use of biomass resources

The third theme focuses mostly on processes after the farm. This includes optimisation of the use of biomass resources through cascading and biorefinery, using biomass resources to replace products from fossil feedstock and investigating long-term carbon sequestration by the use of biobased products in applications with a long lifetime such as in building and construction. Furthermore, attention is paid to keeping carbon-based materials in the system for as long as possible with circular approaches.

Key questions for his theme are:

1 How can valorisation of secondary biomass and biomass side streams towards food/feed, chemicals and materials contribute to climate mitigation and circularity?
2 How can the development of new circular biobased materials contribute to climate mitigation by replacing fossil-based materials?
3 Which strategies can be followed for carbon sequestration via industrial processes, biobased products and materials?

Theme 3 is subdivided into four subthemes, each with their own KB core projects. It also co-funds European and other subsidised projects that fit in the strategic direction and bring additional benefits.

Summary of project results

To support the transition to a fossil-free feedstock system, we developed a discussion model for chemicals and materials in a circular carbon economy. This model makes a clear distinction between intrinsically single-use and potentially recyclable chemicals and materials, and their preferred carbon feedstock. In addition, methodological approaches were created towards more integrated understanding of how forestry, agricultural and marine ecosystems could contribute to the capture and reduction of greenhouse gas when biobased raw materials are used in the production of biobased products.

Furthermore, new strategies were developed for the safe reuse and recycling of carbon-based materials. New technological insights in the development of recyclable composite materials and the recycling opportunities of textiles were also delivered. The chemical and biochemical recycling of polyethylene furanoate was demonstrated at high yields.

The local supply and application in paper and in the construction of lignocellulosic biomass were mapped. Dissemination of these results to regional stakeholders was organised via a number of workshops. Additionally, we investigated new products and production methods in the biorefinery of mussels. The resulting products showed bioactivity, with a positive health effect on cultivated sole.

In addition, new genetic tools were applied to develop high-yield crops, and to develop fungi that can be applied for selective lignocellulose modifications. The goal of both these approaches is to improve the yield of a subsequent biorefinery step. In an experimental investigation, organic fertilisers (sewage sludge, manure, and organic household waste) were evaluated and compared to traditional fertilisers with regard to agronomic, environmental, carbon-sequestering, health and safety, and economic aspects.

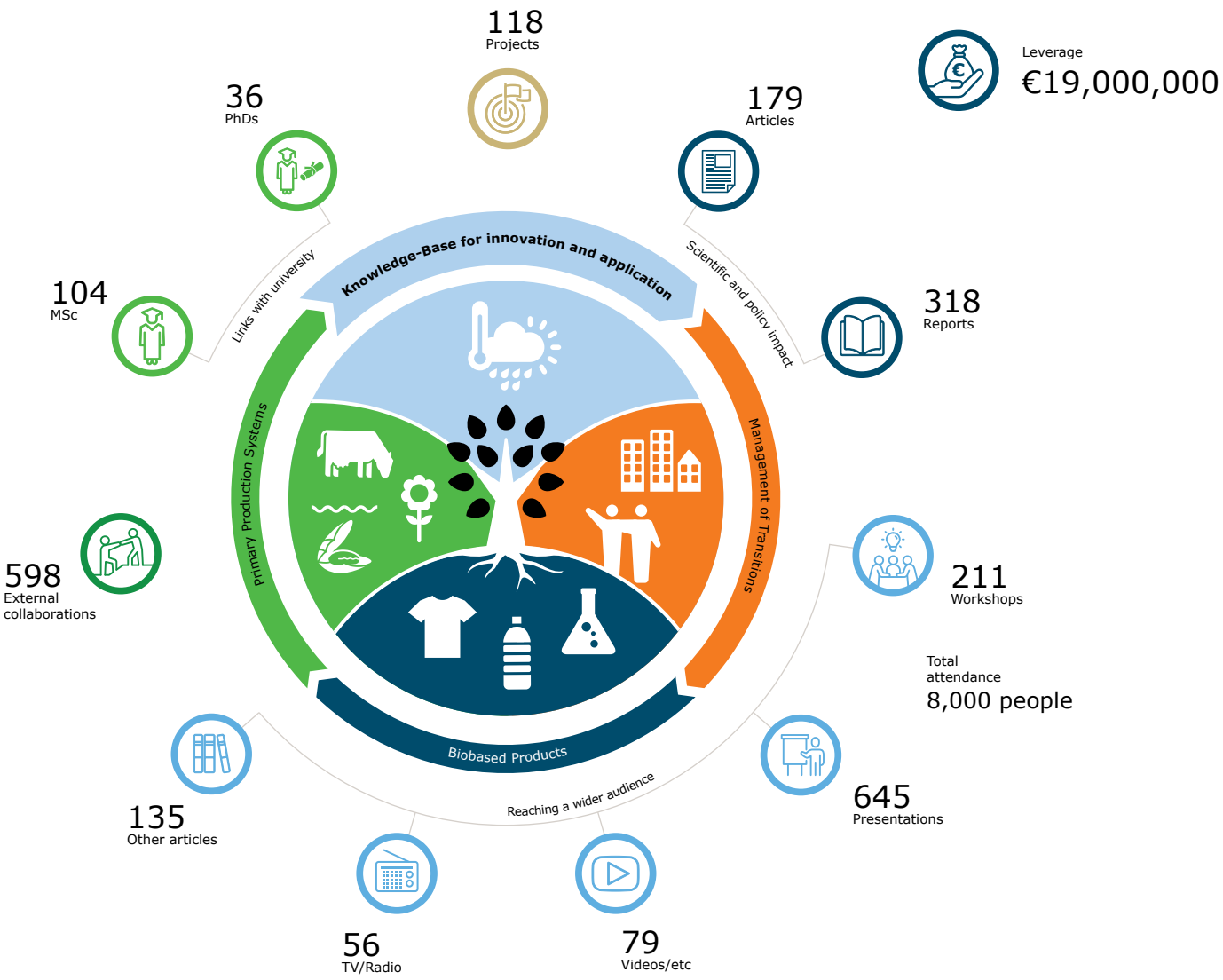
Inspired by early results, starting year 2, specific attention was paid to the generation of a vision about the contribution of WUR to the development of renewable carbon feedstock and products to support the phasing out of fossil feedstock (see figure 5).

Output & outcome

This theme contributed to the profile of WUR by producing several scientific as well as popular scientific papers. It also helped prepare WUR Research Institutes to respond to emerging research questions, for which EU and PPP projects were initiated. Finally, the knowledge generated flowed into education through the development of massive open online courses (MOOCs).

Figure 5 The renewable future of materials

Wageningen Research Impact visual



The visual above portrays the following results:

Scientific and policy impact: These figures represent published, peer-reviewed articles and reports, as well as articles and reports in preparation or in the press. As far as possible these are made available via the Kennisonline website.

Reaching a wider audience: A total attendance at workshops and presentations of around 8,000 people is astonishing. The overall figures for outreach in terms of popular articles, TV and radio appearances and other media are also high. This is very positive in light of our desire to bring science and research results to a wider community of interest.

External collaboration and interdisciplinarity: The large number of external collaborations is a welcome result. There is a strong need to engage with other research institutes and universities, key stakeholders, business and industry in order to take many of the projects forward. These collaborations often involve other disciplines and provide a further multi-transdisciplinary component within projects.

Links between the research institutes and the University: Whilst the programme funding is targeted at the Research Institutes, we had a clear ambition to ensure collaboration with the University chair groups. One way of achieving this was the engagement of Master's and doctoral students in the research projects.

Leverage: The leverage achieved from the initial investment, measured through further, related project funding was just below €19 million. This figure obviously does not include the intangible benefits of carrying out project work whose innovation and knowledge generation 'buys a seat at the table' with important and influential partners in the development of further innovation, knowledge sharing and the discussion of policy and practice.

Colofon

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