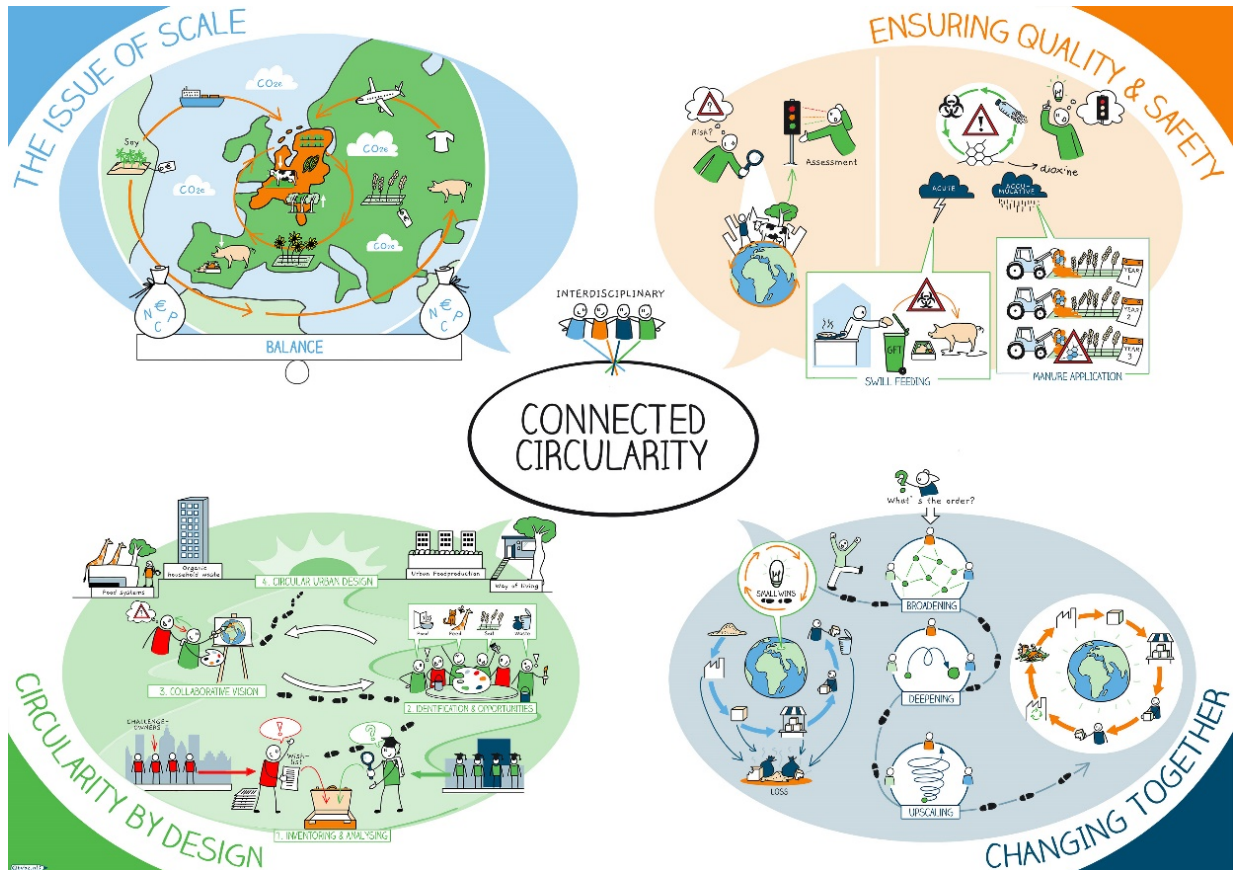


Connected circularity

Dreams and small wins for a circular bio-economy



Program team: Imke de Boer, Saskia Visser (coördinators), Hariëtte Bos, Jaap van der Meer, Gert van Duinkerken, Marian Stuiver, Katrien Termeer, Pytrik Reidsma, Nora Sutton

Introduction

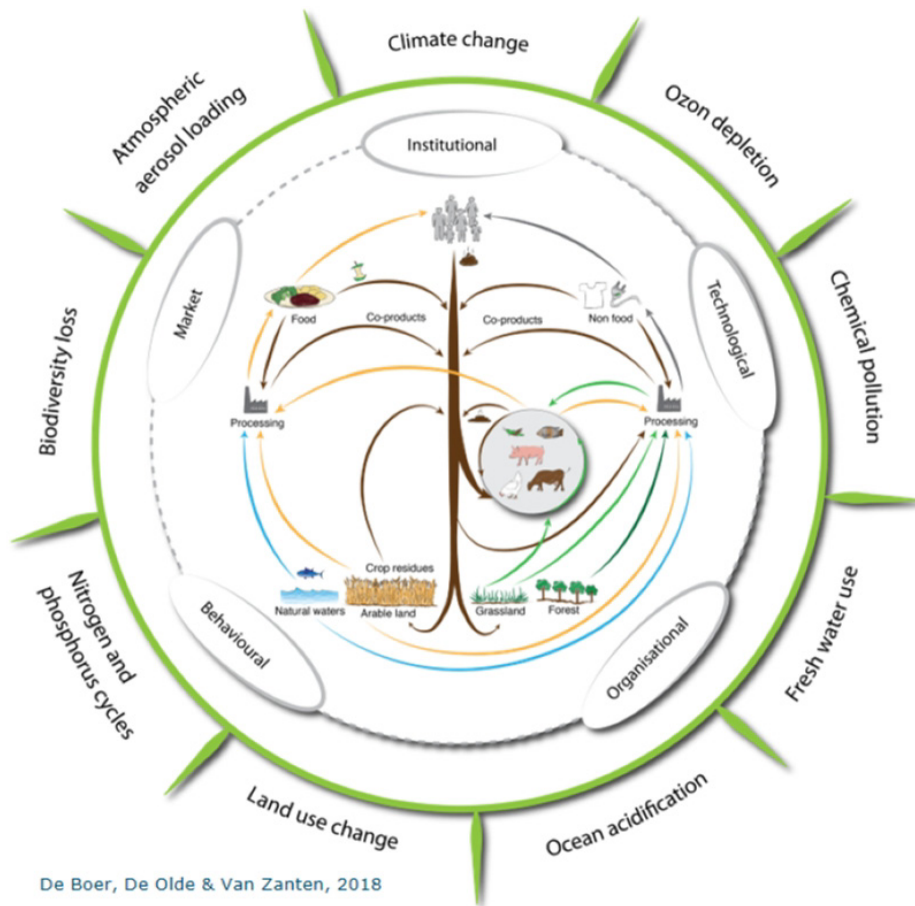
It is widely affirmed that the physical limits of the Earth set the ultimate boundaries for all human economic activity. Without a healthy planet, societies cannot thrive and economies cannot flourish. The 'circular economy' is increasingly seen as an important alternative for a sustainable (food) future. A circular economy aims to reduce resource consumption and emissions to the environment by closing the loop of materials and substances, implying that losses of materials and substances should be prevented, and otherwise be recovered for reuse, remanufacturing and recycling.

Connected circularity focusses on the potential of biomass in the circular economy, or in other words on the bio-economy. Biomass is the basis of the bio-economy, which "comprises those parts of the economy that use renewable biological resources from land and sea" – such as crops, forests, fish, animals and micro-organisms – to produce food, chemicals, materials and bio-energy. Although a complete circular bio-economy may be a utopia, as zero-emission biomass production might not be realistic, moving towards a circular bio-economy is essential for a sustainable future.

Connected circularity makes use of a conceptual framework for circularity in the food system, including the production of bio-renewables, such as clothing, bio-plastics and bio-energy (see Figure 1). This extended framework yields the following principles to move towards **circularity in the bio-based economy**.

1. plant biomass from land and natural waters is the basis of our circular food system, and should be used by humans first;
2. by-products from production, processing and consumption of food and bio-renewables should be prevented by moderating demand or reducing losses and waste, but if unavoidable be recycled back into the bio-economy, with a healthy soil as a first priority and,
3. animals should recycle biomass unsuited for direct human consumption (both in terms of food or non-food) into the food system.

We hypothesize that an optimized bio-based food and non-food system (based on these principles) is more efficient with natural resources, has lower emissions per capita and, will enhance nature-inclusiveness and biodiversity compared to current conventional food and non-food systems.



A transformation towards a circular bio-economy, therefore, calls for a **connective** change, involving *technological* changes (e.g. new knowledge and technology), *organizational* changes (e.g. reconfiguration of social networks and patterns of interaction), *behavioural* changes (e.g. in paradigm, underlying norms and values and in power structures), *market* changes (e.g. innovative business models, subsidies, taxes); and *institutional* changes (e.g. new institutional arrangements and regulatory frameworks (IPCC 2012).

To accelerate a transformation towards a circular bio-economy, we will build on the small-wins framework as developed within WUR. Small wins are defined as **concrete, completed, in-depth changes** towards circularity. The small-wins framework consists of three steps: 1) setting a provocative ambition following the previously explained principles, or in other words identifying a **dream**); 2) identifying and valuing **small wins** that contribute to these dreams; and 3) activating incentives and unblock barriers to enable accumulation of smalls wins into transformative change.

Mission

The **aims** of the theme “Connected circularity”, therefore, are to provide an integrated system analysis of potential futures (**dreams**) of a circular bio-economy, and to study associated “**small wins**” to accelerate a transformation towards a circular economy.

To these aims, the following **key aspects** are essential.

1. **The issue of scale.** At what scale and to what extent can and should we close the loop of materials and substances to ensure enough safe and high quality human materials (food, clothes, bio-energy) while maintaining the biological and physical resources of the planet (e.g. region, country, continent), and what are the integrated technological, environmental and socio-economic consequences of different choices (e.g. changes in consumption patterns, in- and export of food products, including animal-source food products, agricultural production volumes).
2. **Ensuring quality and safety.** How to ensure the quality and safety of recycling bio-based products and materials for animals and humans (e.g. health and welfare risks), and the environment (e.g. accumulation of residues of veterinary or human drugs in soils or water)?
3. **Changing together.** A transformation to the bio-economy is embedded in society, and, therefore, requires research in clear connection with relevant actors or in other words a science-in-society approach. Involvement of actors in the design of potential futures (dreams), the identification and valuation of small-wins (**real-life in-depth changes**), or the development of living-labs, therefore, is needed.

Flagship projects

Connected circularity focusses on projects that relate to cases that are primarily relevant for the Netherlands, as part of Europe, as circularity forms the basis of the new vision of the Dutch government on the food system (e.g. Vision "Landbouw, natuur en voedsel, waardevol en verbonden: from the Ministry of Agriculture, Nature and Food Quality in the Netherlands), and of the future bio-economy for Europe (EU, 2018).

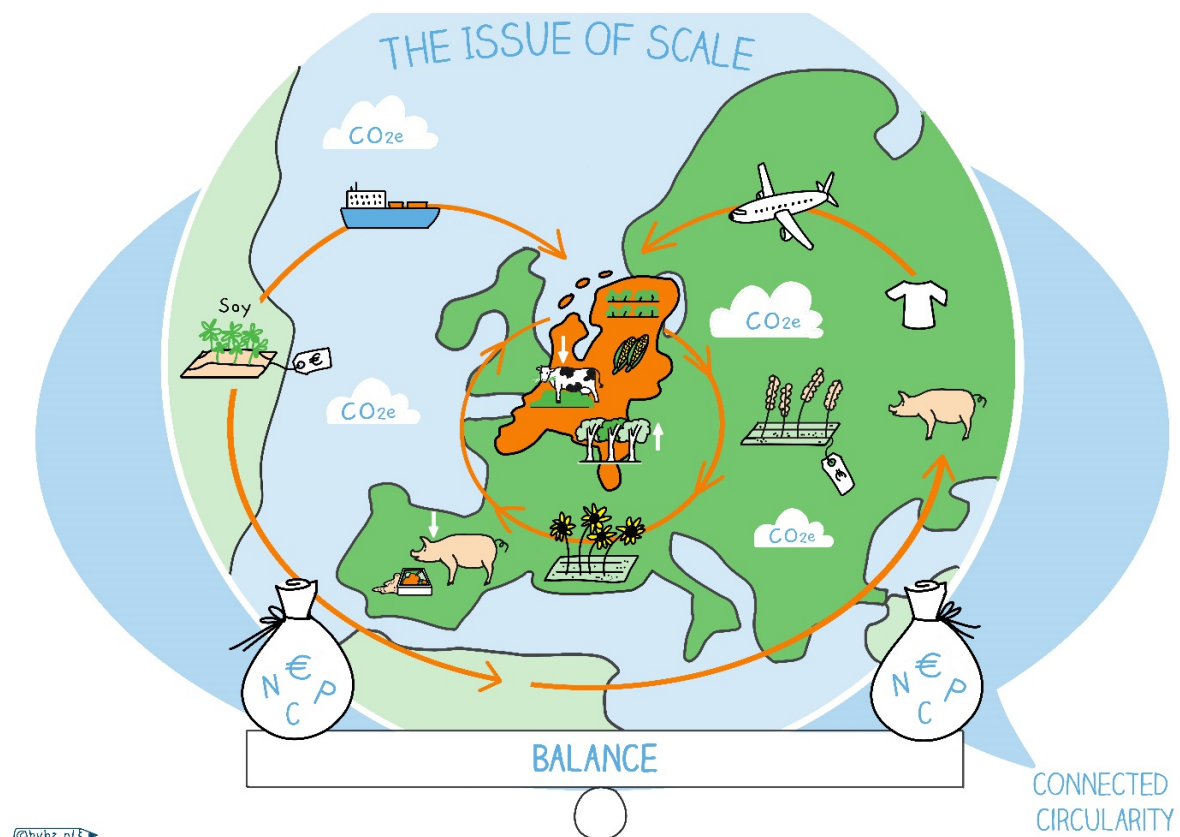
The investment theme has granted 4 so-called *flagships*. Flagship projects are longer-term projects (minimum of 2 years, with potential to extend to the end of 2022) with researchers from both University and Research across Science groups together find solutions to the key aspects of the research aims of connected circularity.

Flagship 1: Alternative futures of a circular bio-based society: the environmental and economic consequences of adopting circularity at different spatial scales

Project lead: Hannah van Zanten

Summary

The transition towards a circular bio-based society requires knowledge about the environmental and socioeconomic consequences of adopting circularity of materials and substances at different scales (e.g. country, continent, globe). The aim of this project is to design alternative futures of a circular bio-based society in the Netherlands - differing in scale of circularity adopted - and to evaluate their environmental and economic consequences.



Background

It is widely recognized that food production generates a broad range of environmental impacts, increasing the pressure on the Earth's system (Poore and Nemecek, 2018). Our current food system operates on a linear model, in which nutrients in biomass are only partly recycled, and accumulating in soils, landfills, oceans and sediments, or are emitted to the atmosphere. Such systems in general have a high energy use, mainly originating from fossil fuels, resulting in additional substantial emissions to the environment. An increasing body of literature suggests that a transition towards a circular bio-based-society might be a solution (De Boer and Van Ittersum, 2018; Van Zanten et al., 2018). In circular systems losses of materials and substances are largely reduced, and otherwise be recovered for reuse, for remanufacturing, and recycling (Jurgilevich et al., 2016). Under this paradigm plant biomass is the basis, and should be used primarily to produce human food; leftovers such as by-products from food production, processing and consumption should be reused or recycled into the food system; and farm animals should not consume human edible biomass, such as grains, but unlock leftovers and grass resources into valuable food and manure. This manure (together with e.g. crop residues and by-products) can be used again to maintain soil fertility and minimize the dependency on finite resources (e.g. fossil energy or phosphorus). A bio based society, however, does not only require the production of food but also bio-energy and bio based materials, such as clothes or bio-plastics. Bio-energy and biomaterials, however, can not only be produced from leftovers and grass resources, but also from biomass harvested from arable land or natural waters. The selection and use of biomass streams for these non-food functions, therefore, should respect rules of circularity as well. This implies that we aim to avoid competition between e.g. food, feed, and fuel production altogether.

Project objective & description

While the concept of a bio-based circular economy makes sense scientifically and resonates in society, there is no understanding of the actual implications of circular use of biomass and nutrients at different scales. The scale at which we may adopt circularity is determined by the interaction between various factors. Differences in agroecological and socio-economic circumstances make some areas more suitable for producing specific types of crops than others. The advantages of a certain imported crop may outweigh the emission impact of transport. The choice of our future crops and their rotations depends on their main and by-products, and their food value for humans and non-food value for the soil, farm animals and the production of bio-energy/bio-based materials. Oil production for human consumption, for example, originates from soy cultivation resulting in the by-product soybean meal (SBM). Compared with other by-products from oil processing, such as sunflower meal, SBM has a high nutritional value for animals. Combining all such aspects – e.g. quantity and nutritional quality of main product and by-product versus transportation – ultimately determines the optimum scale at which nutrient loops are to be closed. The optimal scale, therefore, is context specific, and requires an integrated analysis of the above mentioned factors (Van Zanten et al., 2019). In this proposal we will focus on the case study of the Netherlands, as an example of a society in which the cycles of biomass and nutrients are incomplete and broken.

Our aims are to design alternative futures of a bio-based society in the Netherlands, that differ in the scale at which circularity is adopted (e.g. closing nutrient loops in the Netherlands, the European Union (EU) or the globe), and to evaluate their environmental and economic consequences. For reasons of feasibility, we focus on food and bioenergy production.

Deliverable 1: define the potential use of up- or recycling food leftovers and grass resources through animals and/or bio-energy production in the Netherlands as part of the EU. To this end, we first estimate the current availability of leftovers and grass resources in the EU. Subsequently, a nonlinear optimization model will be developed to optimize nutritious food production from animal versus bio-energy production, while accounting for environmental and economic consequences. The results provide insight in the potential of animal and bio-energy production based on current leftovers and grass resources available and answer the question: which leftovers would have most value for what purpose, animal or bio-energy production.

Deliverable 2: design food systems scenarios for the Netherlands that produce enough food to meet the nutritional requirements while minimizing the environmental impact (e.g. land use and GHG emissions). A bio-physical optimization model will be used that simulates farmers' choices of a combination of crop rotations (including different achieved yields based on different assumptions of fertilizer use (amounts of mineral fertilizers, organic fertilizers etc.)) and farm animals that minimize the environmental impact (e.g. agricultural land use and GHG emissions), while meeting the daily nutrient requirements of humans. Note that the optimal Dutch food system might differ across scale (Netherlands, EU, globe). We will therefore demonstrate pros and cons of different food systems design options and their related environmental and economic consequences. For each design option, conditions for effective performance are defined. Based on that the issue of scale is addressed.

Deliverable 3: integrate the use of biomass for food and non-food products. To this end, we will extend our model developed from a food systems perspective (deliverable 2) towards a circular bio-based society perspective and account for sustainable energy production targets set in the European Union.

Flagship 2: Ensuring product safety and quality

Project lead: Bjorn Berendsen

Summary

In a system that is changing from linear to more circular processes, it is of utmost importance to not only regard the potential for more economic resource use and greenhouse gas reduction, but also to ensure safety and quality aspects. Issues regarding safety include chemical, physical and biological hazards. Within this project a semi-quantitative safety assessment tool will be developed and applied to the flow of hazards in the circular scenario. High risk processes in the circular scenario will be restricted or, in case these are highly important processes in the system, the process itself and correlated/related processes will be redesigned to diminish the risks.



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Background

In a system that is changing from linear to more circular, focussing on the reuse, remanufacturing and recycling of 'waste'-streams, it is of utmost importance to not only regard the potential benefits, but also to be prepared for potential issues regarding safety and quality. Clearly, a prerequisite of a circular system is that not only all individual processes, but also the system as a whole is safe. Issues regarding safety include chemical residues (resulting from use of drugs/medicines/biocides/feed additives), physical particles (e.g. plastics) and biological hazards (following from concentrations of viruses/bacteria/zoonoses). Chemical and biological hazards are introduced at various places and move through the system in different ways [1]. Some relevant examples are discussed below.

Medicines, be it human or veterinary, are commonly used and large fractions of the administered drugs are excreted in the faeces and urine as the native compound or as a metabolite. The use of sewage sludge or human faeces as fertilizer in agricultural crop production are being considered, but might clearly pose a risk. The largest fraction of livestock manure is directly (without further processing) applied to land for fertilization. Thus, agricultural land is exposed to antibiotics, hormones and anthelmintic compounds. Some compounds persist in manure and soil [2] and others flush to ground or surface water. It is demonstrated that they can have negative effects in soil or in the aquatic system [1, 3-5]. Also they can be transferred to crops grown for animal feed and thus be reintroduced into the animal. Risk assessment usually focusses on a limited part of the system. Accumulation, especially in soils, is hardly studied.

Furthermore, manure application can also introduce biological hazards such as bacteria (e.g. Salmonella, E. coli or antibiotic resistant bacteria) and parasites (e.g. toxoplasma) [6, 7]. Transmission pathways of pathogens and antimicrobial resistance are not fully understood, as well as their fate during various new ways of manure processing to improve quality of nutrient flows for application and export [15].

Chemical residues are also introduced in the system through animal feed. Heavy metals and drugs are deliberately added as feed additive but also animal by-products (e.g. feather or bone meal) are used as feed commodity, via which animals are unwillingly exposed to all sorts of residues at low levels [8]. Also the re-use of green waste from roadsides as soil amendments may lead to increased heavy metal contents in soils [16]. The risks associated with the exposure to such low levels of these compounds is unclear. Furthermore, expired packed food products are mixed through animal feed, and even though packaging material is removed in the process, small amounts of plastics are introduced into the system. The fate of such minute particles is unclear, but it is demonstrated that humans are exposed to microplastics through their diet [9]. Studies on the risk for humans, animals and the environment are currently lacking. Also the effect of carcinogenic plasticizers like bisphenol A should be considered [10].

New feed sources are needed to decrease waste streams in culinary practices, including swill feeding. It is demonstrated that land use for pig feed production can be decreased by a fifth by applying swill feeding [11]. However, with swill feeding veterinary hazards are introduced including foot-and-mouth disease [12], African [13] and classic swine fever [14].

Even though several hazards can easily be identified when reusing different waste streams, safety assessment procedures have not yet been developed.

Project objective & description

In the optimization of a circular bio-economy scenario, safety and quality assessment should be implemented and could eventually result in constraints within the optimised scenario and force studying alternative options. Adding the dimension of quality and safety to the circular scenario is of main importance (figure 1) and therefore the focus of the proposed project.

Safety issues do not only regard humans, but a one health approach is needed and as such also risks for animals and the environment should be assessed. Furthermore, in a circular system, safety issues

to be considered are either of acute nature, but could also be the result of a long-term cumulative effect, for instance the accumulation of substances in specific reservoirs within the system. Also interaction among them should be considered: intervention in a single process could influence (both in- or decrease) risks related to other aspects or in other reservoirs or processes.

To safeguard the circular bio-based economy, the project 'Ensuring Quality and Safety' will consist out of four work packages

WP1:	Semi-quantitative Stocks & Flow model development
WP2:	Semi-quantitative safety assessment
	a: tool development
	b: risk assessment
WP3:	Blind spots data collection
WP4:	Redesign and mitigation

The main activities in the proposed project are WP1 and WP2. First we need to understand the locations and flow of products and waste streams including the level of chemical, physical and biological substances in them. Therefore, within WP1 a stock & flow model will be developed for chemical residues, biological and physical hazardous components in the circular system. This model will include the levels of the relevant contaminants in each reservoir, the transfer amongst reservoirs and the possible accumulation in the system in a semi-quantitative way. At first the model will focus at the large stocks and flows and later we will focus at specific processes (e.g. developed within a living lab of flagship 4 "Amsterdam Metropolitan Solutions"). In parallel, WP2 aims to develop a semi-quantitative risk assessment tool (traffic light approach). Individual flows/processes and their interactions will be considered taking into account acute and cumulative aspects within a one health approach. The stocks & flow model (WP1) will be used as input for the assessment tool to indicate the possible risks in the circular system in which also the variability will be considered because hazards are expected to occur in the tails of the statistical distribution. Quality aspects will be taken into account (if risks are mitigated this should not result in severely diminished quality of the product), but are not the main focus of the project. The developed risk assessment tool will be tested and further improved by applying it to specific relevant cases (e.g. from flagship 4: food waste as animal feed in Artis).

During the development of the stocks & flow model and the application of the risk assessment tool, specific processes might be indicated for which knowledge or data are lacking, so called blind spots. Most likely the prevalence of biological risks in human food waste that is applied as animal feed (swill feeding), the accumulation of veterinary drugs and hormones in agricultural soils and/or the transfer of microplastics through the system will be indicated as blind spots. The role of these processes in the system will either be estimated (if data is available from literature review and expert consultation) or additional experimental data will be produced within WP3.

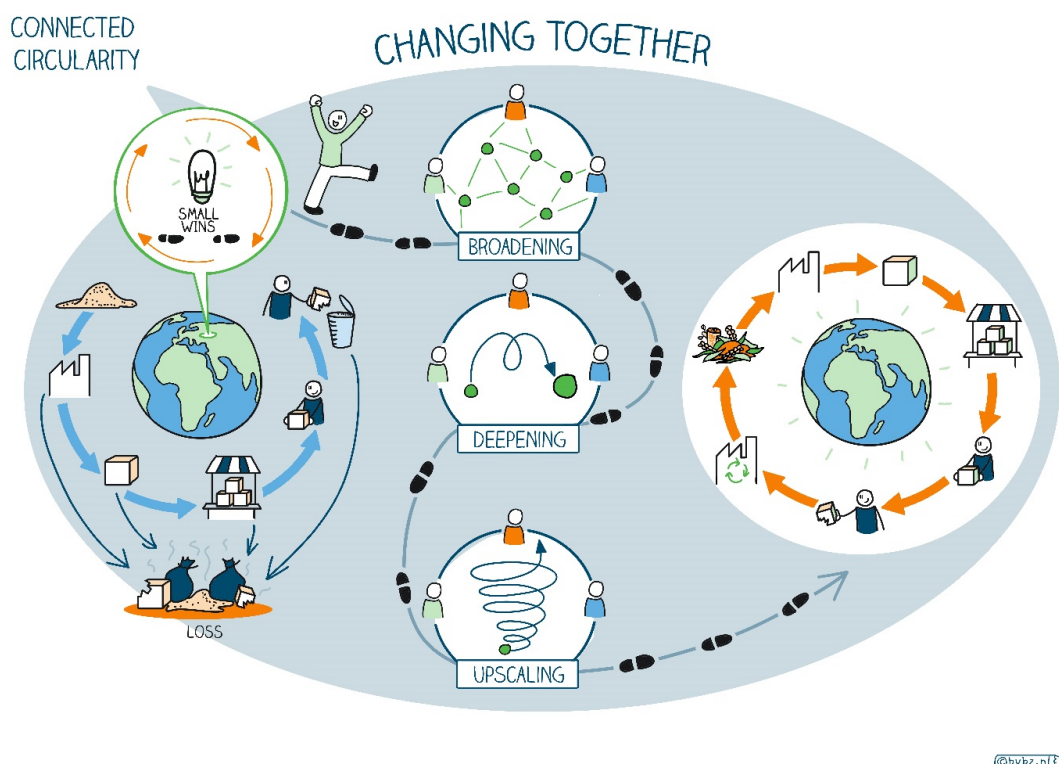
From the tool's application, risks will be indicated and prioritized. If risks are identified, we either suggest to consider the specific route as a constraint or we will redesign the system and/or suggest/develop mitigation strategies to overcome the indicated risks (WP4). Mitigation strategies might include the design of new practices (including spatial planning), technologies (including safe by design) or monitoring tools (e.g. early warning systems).

Flagship 3: Collaborative design of transformative pathways towards a biobased circular economy

Project lead: Tamara Metze

Summary

English To encourage a transformation to a bio-based circular economy we need transformative pathways, which consist of small but concrete steps and mechanisms to scale-up, deepen and broaden. This transformation to a circular bio-based economy/society does need an ambitions and energizing perspective and is building on small steps in technological, organizational, behavioural, market, and institutional innovations. In this project an interdisciplinary team of Wageningen researchers conducts (action)research into successful and failed small wins in biobased economy and circular agriculture in order to develop and test these transformative pathways as courses of action for societal actors.



Introduction

This flagship focusses on the realization of more circularity in the bio-based economy, which consists of those parts of the economy that transforms biomass from land and sea into food, fuels, chemicals and materials. Principles of a circular economy involve: replacing the 'end-of-life' concept with restoration; shifting towards renewable energy; elimination of waste; zero emissions; redesign of materials, products and systems (Ellen MacArthur Foundation 2012). Although total circularity is problematic in a bio-based economy; moving towards more circularity is crucial for a sustainable future. This calls for transformative change that involves technological, organizational, behavioural, market, and institutional changes (see IPCC 2012; Grashof-Bokdam et al 2018). This change is difficult due to various lock-ins and path dependencies (PBL 2018 a, b). Moreover, transformative change cannot be achieved by top down steering, planned linear change models, single rationalities, mono-disciplinarity and de-politization (e.g., Korhonen et al. 2018).

Achieving transformative change through accumulating small wins provides an alternative governance framework (Termeer et al 2017, 2018). Small wins are defined as concrete, completed, in-depth changes (Weick, 1984). They include radical change in routines, beliefs and values; go beyond nicely framed promises; always combine technical and societal change; and inherently imply that many challenges and barriers have been overcome. Small wins are not limited to innovative technological projects in niches but also include innovative regulations, new collaborative networks or innovative business models. In the long run, these small wins can amplify and accumulate into transformative change through non-linear mechanisms such as energising, learning by doing, the logic of attraction, the bandwagon effect, coupling, and robustness. The small-wins perspective is promising for designing governance arrangements for a biobased circular economy as it embraces ambiguity, cherishes emerging change, and encourages circular systems thinking. It values the emergence of innovative initiatives at the micro level, and offers a new understanding of how small wins accumulate.

3. Project objective and description

This flagship project aims to develop realistic and energizing transformative pathways to a bio-based circular economy by: (1) ex-post learning from successful small wins and accumulation trajectories (for example Vegetarische slager, Kipster, green deal Herenboeren); (2) ex-post learning from failed or stagnating initiatives (for example 'nieuw gemengd bedrijf'); (3) experimentation in some existing projects identified as small wins (for example Geofoods); (4) ex-ante studies based on, for example scenario-development or back-casting. The focus is on the Dutch context. The transformative pathways concern multilevel and multi-stakeholder dimensions and include operationalised ambitions, series of governance interventions, stakeholder activities and investment propositions. Moreover, the results of the flagship will be translated into research collaborations (grant applications) and a research agenda for the Wageningen community.

The project follows an interdisciplinary and knowledge co-creation approach. We will erect a "core-team" of researchers of Wageningen University (PAP) and Animal Science (ASG), and Wageningen Research: Plant Research (WPSR), Livestock Research (WASG); Environmental Research (WENR), complimented with Marine Research, Economic Research (WECR), Food Biobased Research (WFBR). This team with help of researchers from those groups and the junior researcher, will conduct a quick scan of cases to select 1 successful (small wins) and 1 failed case in each of the domains. We will also collaborate closely with KB1.1.D "Governance in Transitions" for both the theoretical approach as well as the case selections.

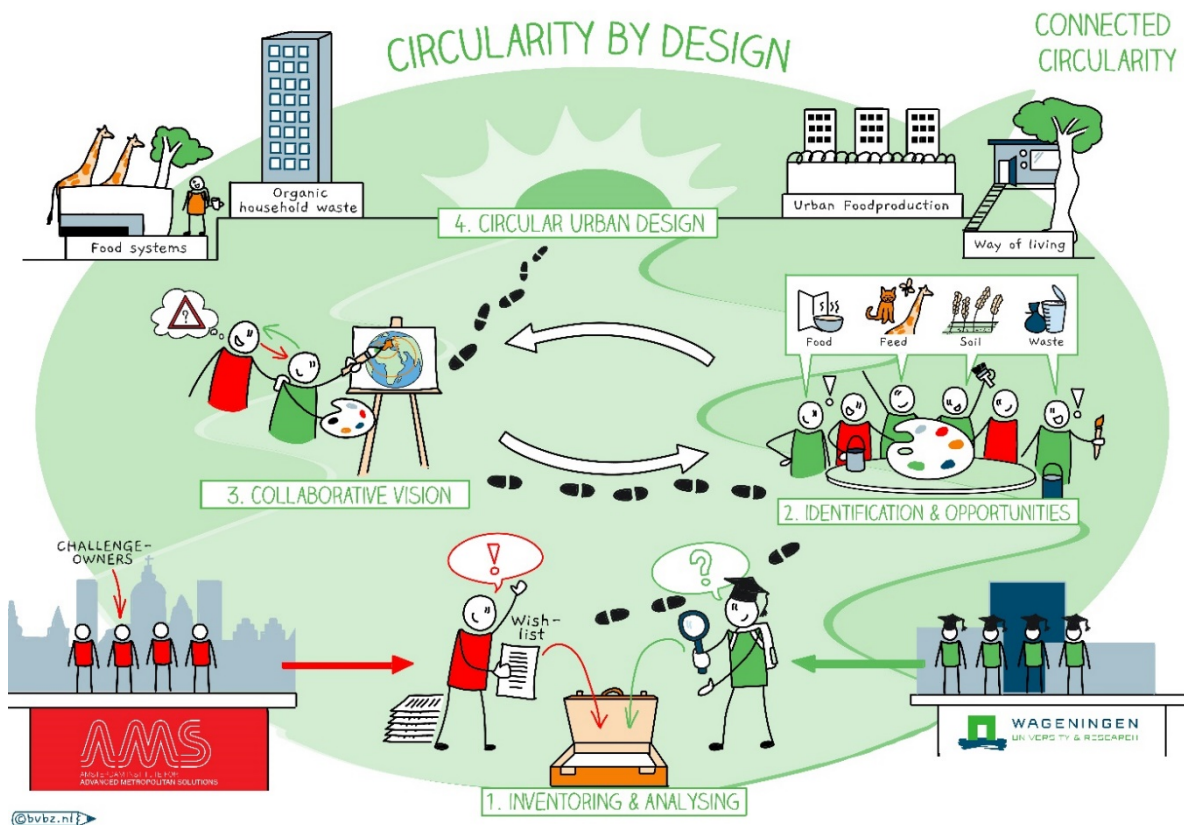
The project consists of 5 building blocks that each involve various methods such as: desk research, interviews, experiments, action research and co-creation in participative workshops. We take a transdisciplinary approach (Leavy 2016) in which interactive reflectivity is necessary (Metze et al 2017). The 5 building blocks are: (1) inspiring ambition; (2) identifying and valuing small wins and small failures; (3) identifying and experimenting with mechanisms for transformative change through accelerating small wins; (4) identifying and experimenting with mechanisms to break lock-ins; (5) cocreation of transformative pathways.

Flagship 4: Circularity by Design

Projectlead: Hilke Bos-Brouwer

Summary

Within the Flagship project “Circularity by Design” a (re)design process based on circularity will be applied within the Amsterdam metropolitan area with the aim to create a sustainable agri-food system. Various tools will be developed and tested within Living Labs to achieve high-end re-use of food and residual (organic) flows. The project is a collaboration between AMS Institute and 12 different scientific disciplines of Wageningen University & Research, and is joined by various local Amsterdam-based partners.



Background: Towards a CbD Framework

Existing Circular Economy frameworks and recommendations are by and large trapped in a linear growth paradigm (see Hobson and Lynch 2016 for this critique). As a result, the indicators and data that are being collected about the AMA circular economy have focused on the linear economy as we know it, material and energy flows, and economic and job growth. Within this framing, businesses are the logical leaders and innovators in the circular economy – and the success of their innovations are judged in terms of ecological impact, value preservation, profitability, and transition potential. Along these lines, the report Circular Amsterdam describes the role of government as a facilitative role, while law and regulation are identified as the largest barriers to circular economy innovation (Circle Economy 2016).

Nearly absent from this vision of circular economy are citizens, civil society, and the numerous grassroots and social economy actors who are practicing circular economy in the AMA region through growing food in underutilized spaces, recycling and redistributing surplus food, and nurturing rural-urban connections. Furthermore, it neglects the important role governing bodies must play in safe guarding public health, environmental protection, and animal welfare in our agri-food system.

However, previous research does identify the significant role that public procurement can play in strengthening and steering the circular economy, by adopting purchasing criteria that incentivize socially and environmentally responsible circular enterprises, short supply chains, local food economies (Witjes & Lozano 2016; Alhola et al. 2019, Circle Economy 2016).

We propose a CbD framework for agri-food economy that takes a food systems perspective to map all of the flows, benefits, and burdens of our current agri-food and waste system in the AMA city-region, as well as the governance structures and policy levers that keep this system in place, and have the potential to change it. Importantly, our CbD framework proposes to capture not only environmental and economic impacts, but also social impacts in the AMA city-region, including for example quality of life, social inclusion, food security, and transitions potential (Hobson 2015, Moreau et al. 2015, Robinson 2019).

The CbD framework takes a geographic, sectoral, and sustainability perspective on circularity, to ensure that not only are materials reused – but that they find their highest and best use in the local food economy. For example, surplus food is redistributed to people rather than bio-digesters, organic waste is composted or converted to animal feed rather than being burned for home heating or converted to jet fuel. These re-generative loops are depicted in the diagram below by Feedback Global.

Furthermore, circularity by design takes seriously the role of urban design in reproducing or disrupting our current agri-food-waste system through the (re)design of green space, logistics, waste, and waste water infrastructure. Approaching urban design and infrastructure as vital components of agri-food systems offers opportunities for crafting shorter and more regenerative loops at every stage in the agri-food system, including the “end of pipe” recovery of nutrients.

In order to align with the circularity goals that are already present in the AMA region, the proposed framework takes as point of departure the seven principles of circular economy that have been adopted by the City of Amsterdam (Circle Economy 2016).

The city of Amsterdam works according to the following seven principles of the circular economy:

1. All materials enter into an infinite technical or biological cycle.
2. All energy comes from renewable sources.
3. Resources are used to generate (financial or other) value.
4. Modular and flexible design of products and production chains increase adaptability of systems.
5. New business models for production, distribution and consumption enable the shift from possession of goods to (use of) services.
6. Logistics systems shift to a more region- oriented service with reverse-logistics capabilities.
7. Human activities positively contribute to ecosystems, ecosystem services and the reconstruction of “natural capital”. (p. 9 Circular Amsterdam)

The methodological framework of Circularity by Design also takes up current best practices in urban Circular Economy research and visioning. These include the following steps.

1. Analysing current material-energy flows and impacts (WP 2-5)
2. Identifying challenges with the potential to make the greatest impact (WP6)
3. Working with stakeholders and challenges to develop an ideal future vision (WP 1,6)
4. Developing a roadmap, following an iterative process of testing and refining (WP1)

We innovate upon these best practices by also

1. Mapping social flows and impacts, and the policy landscape (WP1)
2. Conducting Living Labs with specific urban challenges (WP6)

Our guiding principles elaborate those of the Nederland Circulair! and Circular Amsterdam to include an important but under valorised social dimension.

- Ecological **and social** impact
- Economic **and social** importance
- Value preservation
- Transitions potential

Project aim & objectives

In order to redesign the entire network of interrelated supply chains in a way that both the flow of intermediate and end products is considered, we propose a novel framework called "Circularity by Design" or CbD. CbD will explore how to design circular agri-food systems, which meet societal expectations and manufactured from fossil free resources.

The aim of this program is to demonstrate the feasibility of "Circularity by design" within the context of the greater Amsterdam metropolitan area (AMA). During the runtime of the project, circular (re)design principles will be applied to create designs for urban circular agri-food systems.

Although we take the "urban" as our central departing point, we acknowledge that interconnected circularity may well go beyond the urban scale. Utilising resources with variable input qualities (e.g. from surplus, residual flows or waste collection) for new intermediate or end-products will be pivotal to create a waste-free, closed loop system.

In order to support the circular designs for AMA, a comprehensive set of tools will be developed to allow evidence based decision making within a portfolio of design options and scenarios. These will be exemplified by Urban Challenges identified at different scales in AMA, and will highlight possible trade-offs to gain socially acceptable, end-user oriented solutions.

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