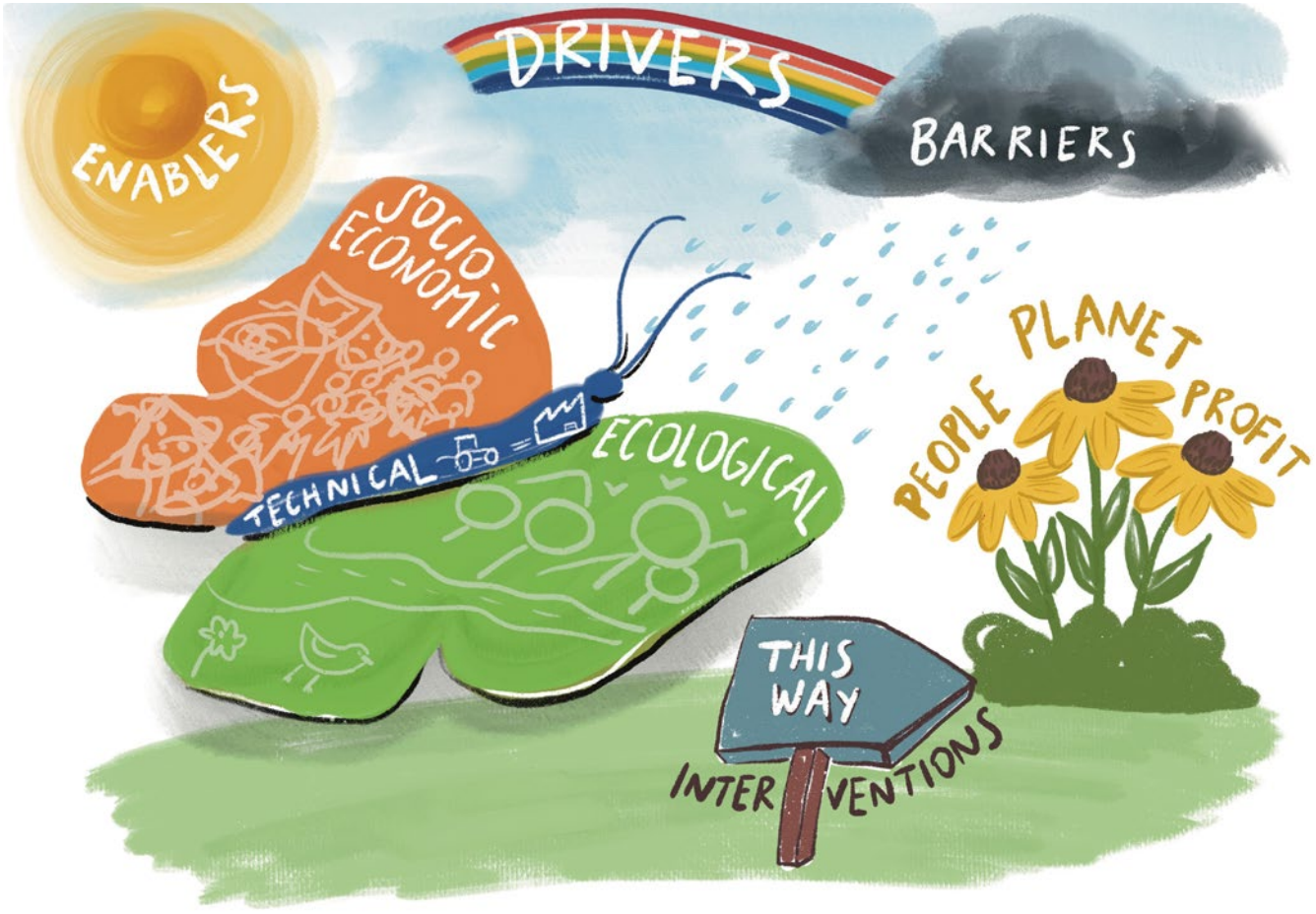
An integrated conceptual framework for the assessment of transitions towards a circular climate-neutral society



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Content

Introduction

This booklet describes the butterfly model, a practically oriented framework that helps to place, link and highlight all specific Wageningen University & Research (WUR) research domains, developments and projects within the context of a circular and climate-neutral society. The framework helps us to better support our customers and also to better link our own activities. Even though there is a significant number of frameworksthat describe and structure (elements of) a circular or climate-neutral economy and/or the bioeconomy, we felt that a truly overarching framework in our domain was missing, which urged us to build the butterfly model.

The overarching theme of the framework is the transition and the related transition pathways towards a circular, climate-neutral society, a transition to which WUR customers contribute on a day-to-day basis. The strengths and ambitions of WUR within the circular and climate-neutral society are focused especially on the development of the bioeconomy. The butterfly framework is, therefore, specifically aimed at the bioeconomy aspects of a circular and climate-neutral society.

The framework has a systems perspective. It contributes to the narrative on the transition towards a more circular and climate-neutral society. It helps to understand the interlinkages, synergies and trade-offs between different aspects and scales of the bioeconomy system in this transition.

Definition of the bioeconomy

While the bioeconomy can be defined in many ways, the European Commission defined the bioeconomy as: "all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services".

Purpose and use of the framework

The framework can be used for various purposes: for supporting the interaction of WUR employees with stakeholders and clients, for instance, on strategic issues, but also for strengthening the ties within the WUR organisation itself. There are thus different ways to apply the framework:

- The framework provides tools to pose questions on how specific actions, intended innovations, policies or projects fit into the broader transformation towards a circular and climate-neutral society and what contribution they are expected to have on the development towards a circular and climate-neutral society.
- The framework can be used to define circularity and climate neutrality in specific situations. It is helpful in discussing client's opportunities for actions and their costs and benefits. The system perspective is useful to assess specific systems in broader contexts.
- The framework is helpful to show the relationship between different activities, projects or developments by WUR within its rather broad domain - which encompasses ecological, technological and social-economic aspects of the bioeconomy. Visualisation of the analysis within the butterfly drawing can be helpful to show clients and other stakeholders on which issues WUR has specific expertise.
- The framework helps to get an overview of gaps in knowledge, for instance, concerning models and indicators.
- The framework helps to identify hot spots: human actions or technologies that affect the development towards a circular and climate-neutral society and can be changed.

- The framework structures elements that may be included in a monitoring and evaluation framework, including requirements for the integration of effects of activities at lower scales to analyze effects on higher level ambitions. This makes it an inclusive tool for interdisciplinary projects in the field of the bioeconomy.
- The framework can help students to define the system scale for their case studies, and identify drivers (enablers and barriers) and possible interventions at that scale.

The circular and climate-neutral society

The framework is designed to assess (the transition towards) a circular and climate-neutral society, but what does this imply? Let us start with the definitions of circular and climate neutral.

A circular economy is a metaphor that focuses attention on opportunities to reduce the impact of human consumption by closing loops and reducing losses, minimising waste, and reducing the use of raw materials. The EU defines the circular economy as an economy "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" (European Commission 2015). The circular economy can be seen as a list of activities like recycling, designing products with a longer product life and changing consumption patterns, and is, therefore, a means to broader societal goals.

Sometimes these goals are specifically defined. For instance, in its action plan for the circular economy (EC, 2015), the EC formulates as goals:

- Ensuring food security (including safety)
- Managing natural resources sustainably
- Reducing dependence on non-renewable resources
- Mitigating and adapting to climate change
- Creating jobs and maintaining European competitivenes

A climate-neutral society is a society where net greenhouse gas emissions are zero and negative impact to society is minimised. To fulfil the Paris climate agreement, which sets a target to reduce average global temperature increase to a maximum of 1.5 or 2 degrees Celsius, there is a small budget for positive net greenhouse gas emissions till 2050. After 2050 net greenhouse gas emissions must have been reduced to zero.

In many cases, a change towards circular activities is good for the climate. However, some circular activities are at the cost of increased greenhouse gas emissions, and striving for circularity sometimes requires different interventions from striving to climate neutrality (see table 1). Therefore, a careful analysis is required.

Table 1 Intervention logic behind Circularity and Climate neutrality

	Circularity	**Climate neutrality**
Goals for people planet and profit	Sustainability, including no degradation of the functioning of the ecological system as a condition for human existence	
Preferred state of the system	Minimal use of resources, minimal waste	Minimal greenhouse gas emission
Strategy to achieve this	Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Recycle, Recover (9R framework, Potting et al., 2017)	Several strategies (reduce the use of fossil fuels, enhancing sinks, etc.), but contrary to circularity, the concept does not imply a specific strategy

The framework in short

The framework is represented by the picture in Figure 1. The core of the figure is a butterfly which represents the whole system that needs to be considered and which consists of the ecological system and the socio-economic system (the two wings) with the technical system (the body) at its centre.

The technical system includes all the processes in which people try to use (natural) processes and inputs to improve their quality of life. It is the (sub)set of human activities and processes that intervene with the physical world at a given place and over a defined period. The technical system, therefore, is part of both the socio-economic and ecological system.

The ecological system is the whole of physical and ecological processes. The ecological system is the physical manifestation of all living and non-living matter and physical flows of materials. Part of these processes takes place beyond human influence. Others include humans and their interaction with the natural system through their physical activities.

The socio-economic system is the whole of social, economic and cultural processes. Social processes relate to the dynamics in human relationships based on power, rules, habits, personal preferences, etc. Economic processes are about how individuals and societies choose to allocate scarce resources. Cultural processes relate to shifts in values, meanings and opinions.

The socio-economic system influences the ecological system by deliberate choices but also by unintended side effects. The ecological system provides all kinds of services to the socio-economic system, which can benefit human well-being, but may also have negative

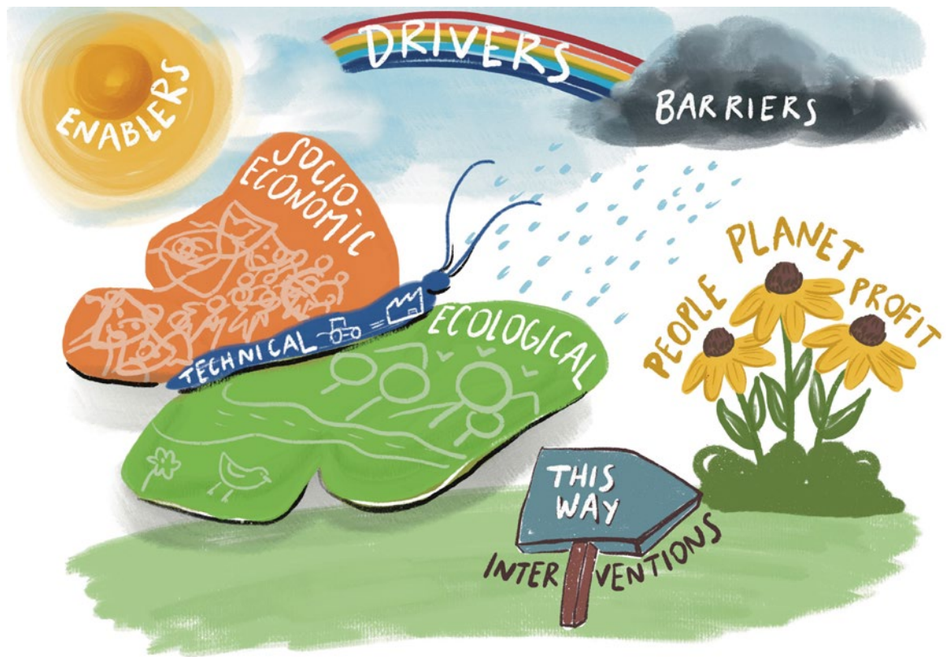

Figure 1 The full framework

impacts with potential knock-on effects on human well-being.[1]

From the perspective of achieving a circular and climate-neutral society, the most important flows from the ecological system (often created by the technical system) are the extraction of resources and the deposition of waste flows, including greenhouse gas emissions. However, any human activity, whether part of a technical system or not, may have an impact (e.g., on biodiversity). The degree of circularity and the degree of climate neutrality follows from the magnitude of these flows or pressures and their trade-offs.

While the butterfly represents the whole system, some aspects of the system require emphasis to understand the relevant dynamics of the system. Therefore, these three aspects are presented outside the butterfly for clarity but are still inherently part of the whole system.

First, the **flowers** represent **the societal goals** we aim to achieve. These goals are defined by humans, where humans may define characteristics of the ecological system, like biodiversity, as separate goals that are evaluated independently of human benefits. Some internationally accepted frameworks exist that define broadly accepted international policy goals across three aspects of sustainability, i.e. environmental, social and economic, and can together be considered synonymous to the overarching goal of well-being in the vision of the OECD (2019). Two examples are the People-Planet-Profit (PPP) framework and the Sustainable Development Goals (SDGs) of the United Nations.

Second, if one wants to explain why the system is or is not developing in the direction of the goals, one must understand the forces that drive the development of the system. Therefore, it is useful to assess the main driving forces of the system separately. Driving forces not only include changes in, for instance, consumer preferences, technology or demographics, but also institutional factors like regulations, the current tax and subsidy system, cultural practices and national and international organisational configurations. These are represented in Figure 1 by the sun and the raincloud. These two images represent the fact that driving forces can both drive the system further away (barriers) and closer towards (enablers) the societal goals. From the perspective of the transition towards a circular and climate-neutral society, it is important to understand which driving forces are barriers and which are enablers for the transition.

Third, actors like governments, public administration, NGO's, businesses, researchers and consumers want to influence the development of the system in such a way that it moves in the direction of their goals. All humans and organisations may potentially intervene in the system to help the transition towards a circular and climate-neutral society. Change of the system emerges partly from 'daily' activities but also results from planned actions. Both these activities and actions are part of the socio-economic system. However, in the butterfly model, **the planned actions** are conceptually distinguished. These are represented by the **signpost** in Figure 1, which encompasses the whole of the intervention processes, such as the implementation of policy, development of knowledge and innovations, etcetera. The signpost leads the system in a direction that changes processes and behaviour within the system while using information on the extent to which goals from the indicator framework are reached.

In **summary**, the framework (Figure 1) is a useful instrument to pose questions on system relations on the level of the technical system, the ecological system, the socio-economic system, and their interrelation. It poses questions about system boundaries and what driving forces should be considered extraneous, and which actions can lie within the circle of influence of specific actors. It poses questions on the available instruments for decision-makers and the consequences of using these instruments to reach societal goals. Also, it structures the elements that may be included in a monitoring and evaluation framework. This makes it a useful tool for interdisciplinary projects in the broad domain of WURs activities. The separate elements of the model are explained further in the following paragraphs.

1 While distinguishing the socio-economical and ecological system conceptually, one must be aware that humans - which, in fact, shape the socio-economical system through their behaviour - are physically part of the ecological system.

The technical system

The technical system is determined by and defined as the set of human activities and processes that intervene with the physical world. The technical system manifests itself as the combination of human inventiveness and the options the physical reality offers. It is presented in more detail in Figure 2.

The technical system is typically where a part of WUR and its clients operate. In the technical system, the production of food and non-food takes place to fulfil human needs, i.e., value creation. Material streams from the ecological system are converted by activities in the primary sector, industries, retail and by human consumption, leading to the desired value relevant to the societal actor(s).

Decisions on changing the activities in the technical system can be initiated by drivers outside the system. They can also be influenced by interventions from others within the socio-economic system. Creating value influences other system variables, which may or may not occur outside the area of vision or the area of interest of single actors.

The technical system has a 'day to day' component and a strategic component. The 'day to day' component covers the bioeconomy: the production and use of natural/ biological resources, e.g., mining, agriculture, transport, agrifood and biobased industry, etc. The strategic component is aimed at improving the system. This includes the choice of the goals that the improvement

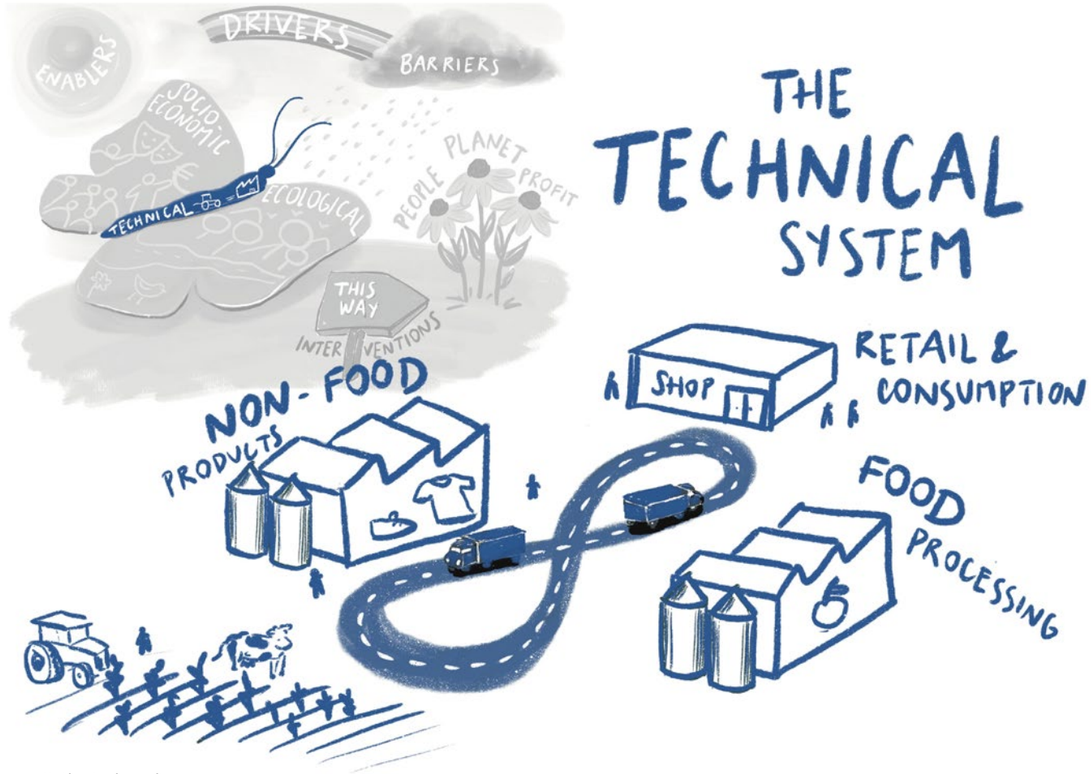

Figure 2 The technical system

aims to achieve. These goals are described separately, using the flowers as a metaphor (see paragraph 5). The strategic component also includes the actual intervention in the system (see paragraph 7).

Changes in the technical system often relate to innovation. A technical invention (something new that "works") can be developed into innovation and thus obtain economic value. Further (technological) development can help improve the economic value and/or reduce the environmental impact of the innovative activity or process. In the transition towards a circular and climate neutral economy, the costs and benefits of technologies will change during the transition process. New technologies become more feasible when they are applied on a larger scale and when organisations adapt their ways of working. Furthermore, learning by doing and practical research will make the new technologies more efficient. Incentives in society, like prices and regulations, may influence the choice of technologies used for different activities and, therefore, are essential for the transition of technologies in a more sustainable direction.

New technologies only become relevant when they are applied. Even if technologies are beneficial, it may require time to develop and optimise them and to see how they work in practice. Living labs are a relatively new approach that may be used to investigate how to apply the new technologies in real-life settings and may even be a force towards innovation itself. Another way forward can be to support or protect innovation niches, for instance, by subsidies, regulation, procurement and other measures.

The material flows that pass through the technical system can be depicted in a material flow diagram (Sankey diagram). Such a diagram quantifies relations between resources from the ecological system and their application area in the socio-economic system to fulfil human needs. Flows are expressed in analytical variables of interest for a specific research theme, such as dry weight of biomass, carbon, nitrogen, phosphorous, or other variables (e.g., safety hazards). Flow diagrams can thus also show the deviation from the desired circular and climate-neutral production system. An interesting aspect of the diagrams is their applicability at different system scales, by being able to upscale and downscale material flows easily. These aspects of material flow analysis help identify the main focus of innovations to be effective in solving climate, resource, and other societal challenges.

An important question for WUR and our clients is how to choose directions for new technological opportunities. These choices are embedded in the socio-economic and cultural system and depend on the insights and entrepreneurship of different people at different places with different opportunities. Questions that need to be answered by actors seeking to improve the sustainability of the technical system are about how to develop new ways to create the value we want by improved or new processes that require fewer inputs, increase resource use efficiency, (re)use (waste) flows, and to define innovative business models for that without introducing harmful trade-offs.

The ecological system

The ecological system is the physical manifestation of all living and non-living matter and flows of material. This implies that it includes humans and how they interact with the natural system through their physical activities. Many of these activities take place as part of the technical system

The ecological system, which is depicted in Figure 3, contains several 'great cycles' in which key materials are transported through the environment. The key elements that cycle through the major biogeochemical cycles are carbon, oxygen, hydrogen, nitrogen, phosphorous and sulphur - all of which, sometimes in combination such as water (H2O), are essential for life. The biogeochemical cycles operate at the global scale and involve all of the main components of the ecological system; thus, materials move continuously between the geosphere, atmosphere, hydrosphere and biosphere. However, since the biogeochemical cycles involve elements that are essential for life, organisms (including humans) play a vital part in those cycles. Typically then, the biogeochemical cycles involve non-living components (i.e. water, minerals, nutrients) and living components (i.e. biota comprising of plants, animals and humans).

Non-living materials are essential for life. As such, humans compete with the other "natural" components to sustain life. The ecological system has developed many circular mechanisms. When waste streams emerge, evolutionary processes may develop organisms that use these waste streams as food for their growth, development and survival.

Figure 3 The ecological system

With the emergence of humans, and especially their technical system, material and energy flows have changed while the emissions of what is considered “waste” (often chemicals or other pollutants) have increased, thereby compromising - or putting pressure on - food and environmental safety or sustainability. In addition to these pressures on the ecological system involving (changes in) material flows, there are pressures involving biological disturbances (e.g., extraction of flora and fauna or introductions of microbial pathogens or introductions of non-indigenous species), physical disturbance (e.g., abrasion, water abstraction, visual disturbance, extraction of non-living resources, habitat loss) and undesired input of energy (e.g., through noise, electromagnetic or thermal changes). All those pressures can impact the natural system resulting in lower abundances of various ecosystem components (various animal or plant species or higher taxonomic groups) or even extinction of sensitive species, thereby compromising various conservation (i.e., biodiversity) and sustainability goals (i.e. at least the planetary SDGs 6,13,14,15).

There are many processes and functions carried out by the different ecosystem components that help maintain the earth’s natural balance, such as growth and decomposition of matter and nutrient recycling. In addition, these processes also may have the capacity to provide goods and services that satisfy human needs, either directly or indirectly. We refer to these natural processes and functions as ecosystem services once they satisfy human needs. Three types of ecosystem services are distinguished: provisioning, regulation & maintenance and cultural services. Because of the value of these ecosystem services for humanity, it is important to understand how the ecosystem capacity to supply services may be influenced by human activities. In order to understand these relations, one must understand the dynamics of the ecological system. The valuation (not necessarily in monetary terms) of these ecosystem services in terms of how they contribute to human well-being occurs in the socio-economic system and hence is part of this integrated assessment framework.

The socio-economic system

The socio-economic system (Figure 4) includes social, economic and cultural processes that explicitly or implicitly attribute a value to (the outcomes of) ecological processes and which may (or may not) occur through changes or activities in the technical system. The social system is about human interrelations and whom you know. The economic system is about how individuals and societies choose to allocate scarce resources and respond to incentives (decision-making). The cultural system is about norms and values and what you know. These three systems might reinforce each other. For example, if you need a job, your social relations might provide you with a job which enhances your economic position, this enables you to go to art exhibits/concerts where you meet ‘similar’ people, and so you enhance your social network, etc

Developments in the socio-economic system are determined both by social processes and economic processes. **Social processes** relate to the dynamics in human relationships based on power, rules, habits, personal preferences, etcetera. All these processes have their own dynamics that influence concrete decisions and behaviour, which are also reflected in the technical system. The pursuit of circularity and climate neutrality is manifesting itself partly in new social relationships which are gaining power and contribute to new rules and habits but may also be hindered by the existence of persistent interests, rules, and habits that counteract change. This implies that striving to achieve circularity and climate neutrality may be the cause of major social conflicts.

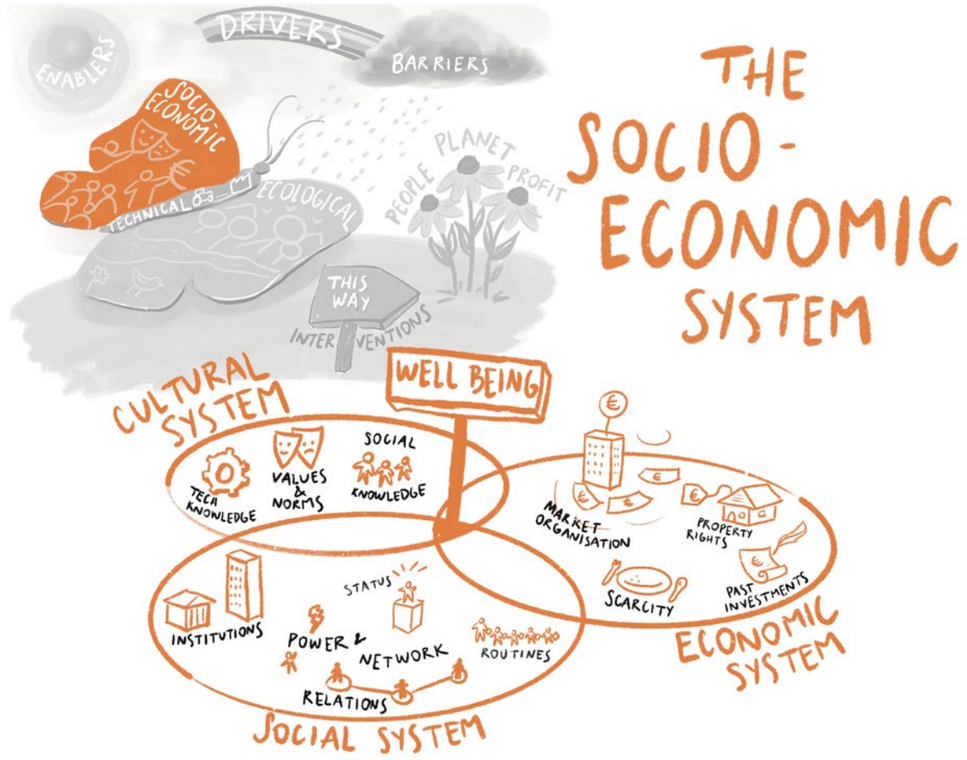

Figure 4 The socio-economic system

Economic processes are about how individuals and societies choose to allocate scarce resources, why they choose to allocate them that way, and the consequences of those decisions. The economic processes are based on decisions determined by factors like scarcity, cost and benefits, market organisation, and incentives. The economic system can be a command economy, a pure market economy or a mixed capitalistic economy (the latter is prevalent in the Western world). The pursuit of a circular and climate-neutral economy raises a challenge for the ways the factors and the economic system are functioning now. It has often been observed that price formation in the free market does not sufficiently take into account the external effects on the ecological system and income distributional effects. This includes the question of market organisation, the organisation of economic chains and the balance between the public and the private in the mixed capitalistic economy.

Cultural processes relate to shifts in values, meanings and opinions. Concepts such as sustainability, circularity, etc., are the products of cultural processes. In this respect, the idea that a paradigm shift is needed seems to grow. New concepts come up that not only describe a development but also indicate a change. This may include concepts such as the doughnut economy (Raworth, 2017), degrowth, intergenerational solidarity, but also circularity. However, it is not just about theoretical concepts but much more about the values, norms and views in everyday life. For example, we see a change in perception of the way animals are treated. However, changes are slow and are often linked to systems of deep values. This implies not only that cultural changes may take a long time, but also that they can cause great controversies, and last but not least, vary greatly between people from different backgrounds and environments.

Interrelation. In practice, the social, economic and cultural processes are closely connected. A job, for instance, is more than an economic position. It also affects someone's social network and enables his or her cultural life. This is reflected in integrated concepts in the social sciences, such as practices or the broad interpretation of capital.

This interrelation is important in the search for indicators that reflect the state of the socio-economic system. Well-being is such a concept, just as social quality.

This interrelation plays a large role in **changing** the socio-economic system towards a circular and climate-neutral society. Change implies new business models, alternative social practices and new ideas, standards and norms. These reinforce each other: new ideas lead to new practices, new business models require new regulations etc. They almost never change at the same pace, which means they can slow each other down. Furthermore, it should not be forgotten that this difference in pace can also cause major social conflicts.

In summary, the socio-economic system comprises social, economic and cultural processes, and these together determine the well-being of people in society, the way they value the ecological system and the way they operate in the technical system. All three interrelated aspects have to strengthen each other to change the system towards more circularity and climate neutrality.

Goals

To determine if the technical, ecological and socio-economic systems are moving towards a circular and climate-neutral society, a comprehensive framework to assess progress towards the related goals and targets is needed. Such an assessment framework can be used to measure the impact of (changes in) drivers and of interventions (actions) of all actors using a broad set of indicators. The indicators can be measured at different levels and across different scales. The assessment framework enables us to identify trade-offs and/or synergy effects using these indicators and related policy goals.

The technical, ecological and socio-economic systems (butterfly) each have their dynamics, and the question is whether and to what extent those dynamics move the system in the right direction. To answer this, one first has to define what the preferred direction is. In terms of the framework picture: to what extent are the driving forces and interventions, in combination with the system dynamics, pushing in the right direction to achieve the relevant policy goals

Important international approaches to connect sustainability to policy goals are the United Nations Sustainable Development Goals and the EU Societal Challenges (see Table 2). The Sustainable Development Goals (SDGs) are the main overall goals as formulated by the international community. The SDGs and SCs and their interrelation are presented in Table 2. Moreover, the EU

Figure 5 The assessment framework

distinguishes five goals for the bioeconomy in its bioeconomy strategy: 1) Food and nutrition security 2) manage natural resources sustainably 3) reduce dependence on non-renewable unsustainable resources, 4) limit and adapt to climate change 5) strengthen European competitiveness and create jobs.

There is a broad international agreement that the overall aim of the transition towards sustainability is to achieve a sustainable economy (Brundtland 1987). Based on this, we grouped SDGs and the EC Societal Challenges along the three dimensions of sustainability: social, environmental and economic, often referred to as people, planet and profit (Triple P, Brundtland 1987 and Stockholm Resilience Centre, 2016). In Figure 5, the overall assessment framework is therefore depicted as a bunch of three flowers, people, planet and profit. The two key goals within the SDG framework that are directly related to circularity and climate neutrality are 'responsible consumption and production (SDG 12)' and 'climate action (SDG 13)', respectively. Therefore, aspects of these two key SDGs are explicitly included around the separate flowers. Table 2 furthermore summarises the relations between the triple-P framework, the EU SCs and the SDG framework

The focus above is on the assessment of reaching the goals. However, it is also important to relate these to indicators of the direction of the transition process itself. For example, the number of innovations that potentially reduce resource use (and can thus move the system towards its sustainability goals) may be an important indicator of the extent to which the transition is on the right track. The same holds for the ratio between private and societal costs, i.e., externalities. The combination of these kinds of transition indicators and indicators on goals helps to assess whether the system is moving in the direction of a circular and climate-neutral society.

Table 2 Relationships between systems of goals

People Planet Profit	Societal Challenges of the European Commission	SDG[1]
All		17 Partnership for the Goals
People (Society)	1 Health, demographic change and well-being 6 Europe in a changing world - inclusive, innovative and reflective societies 7 Secure societies - protecting freedom and security of Europe and its citizens	1 No Poverty 2 Zero Hunger 3 Good Health and Wellbeing 4 Quality Education 5 Gender Equality 11 Sustainable Cities and Communities: 16 Peace, Justice and Strong Institutions:
Planet (Biosphere)	5 Climate action, environment, resource efficiency and raw materials	6 Clean Water and Sanitation 7 Affordable and Clean Energy 13 Climate Action 14 Life below Water 15 Life On Land
Profit (Economy)	2 Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy 3 Secure, clean and efficient energy 4 Smart, green and integrated transport	8 Decent Work and Economic Growth 9 Industry, Innovation and Infrastructure 10 Reduced Inequalities 12 Responsible Consumption and Production

1 According to the 'Wedding Cake' model. Stockholm Resilience Centre, 2016.

Drivers

In order to understand the dynamics of the socio-economic system in relation to its biophysical environment, it is useful to recognise which forces drive the direction in which the system develops. These forces are called drivers. They are part of the system but taken out for analytical purposes. The drivers are presented by the sun and rainy and windy clouds in Figure 6.

Drivers can influence the socio-economic, technological and ecological system and are very relevant to understand what the restrictions and opportunities are for interventions to reach a circular and climate-neutral society. Below we provide examples of such drivers.

Drivers in the ecological system

- Changes in availability of land and its soil quality, for example, through urbanisation and land degradation.
- Changes in availability and quality of minerals like phosphor for fertilisation.
- Changes in availability and quality (including safety) of water, for example, because of erosion, irrigation or climate change.
- Changes in climate, for example, through greenhouse gas emissions in the past
- Changes in biodiversity resulting in changes in resilience and regulating services for agricultural systems.

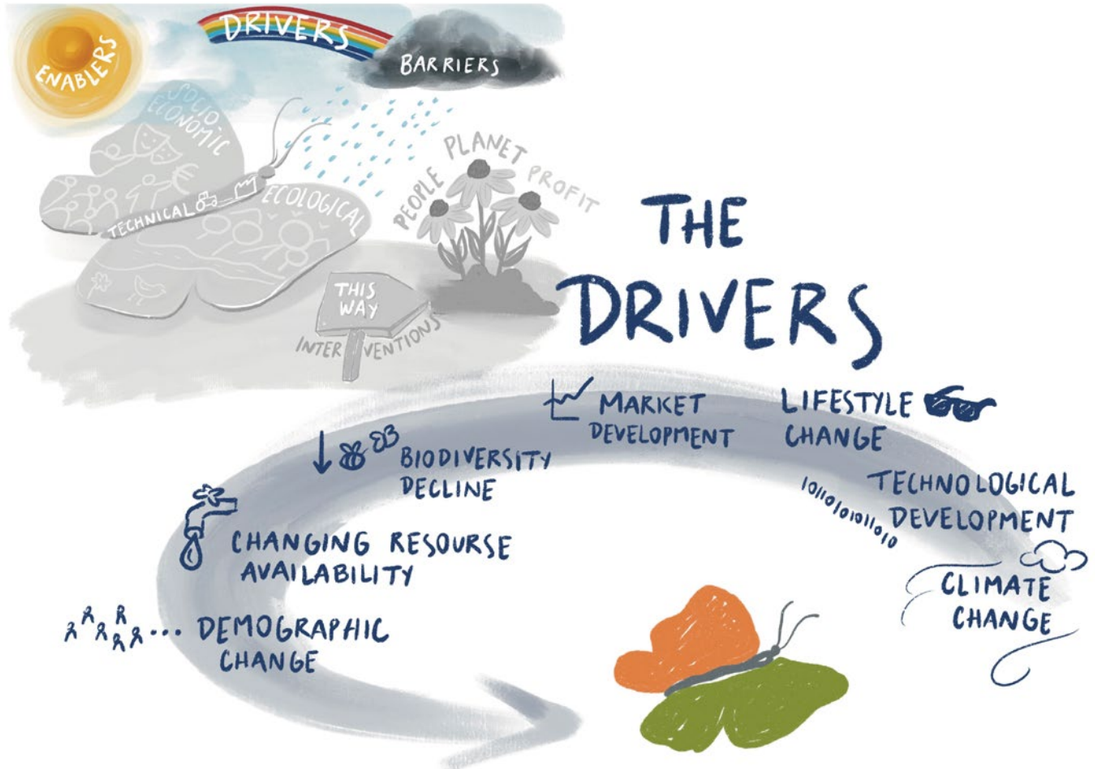

Figure 6 The drivers

Drivers in the socio-economic system

- Changes in scarcity, for example, because of changes in preferences, population growth or mining in the past, manifested in changes in market prices.
- Changes in population determined, for example, by reproduction behaviour, health systems and welfare.
- Changes in psychological and social factors like values, lifestyles, beliefs and attitudes, cultural perspectives and understanding of the world.
- Changes in the legal and institutional regimes and power.
- Changes in societal or industrial organisation.

Drivers in the technical system

- Changes in availability or price of fuels for energy use for harvesting, fertiliser production, transport, subsequent processing steps etc.
- Changes in technology through research and development or learning by doing.
- Changes in the direction of technology development through stimulation (for example, funding programmes) or discouragement (such as legal barriers or negative public perception).
- Advancement in state-of-the-art and freedom to operate in new technological fields (related to patenting)
- Changes in the percentage of the population with a technological background

Drivers are interdependent

There are many relationships between the different drivers. For example, welfare growth may reduce population growth, and more equality may reduce conflicts and increase trust. Further, some drivers are implied in others. Equality, for instance, depends on other drivers like legislation, habits, routines, social structure and culture, power relations, perception, discourses, trust and capabilities. Some of these are completely outside the scope of many models but may be very important in explaining the development of the socio-economic and ecological system.

Drivers are scale-dependent

The question of which are the external drivers depends on the scale of analysis, i.e. for which actor the analysis is made and on the time scale. Some examples: a single farmer is not able to influence the market price of his products if he is selling on a national market, and therefore the market price is an external driver for which he may develop different scenarios; national governments may influence the national market by setting stricter ecological or circular requirements, but the influence is limited because of competition with products from countries with less regulation.

For an assessment of the development in the direction of a circular and climate-neutral society, it is important to understand which drivers are barriers to the transition and which drivers enable the transition towards a circular and climate-neutral society.

Interventions

All human actors may potentially try to intervene in the evolution of the technical system and transform it into a circular and climate-neutral direction. These actors are part of the system, but the intervention module highlights the actors in their role as strategic actors aiming to change the system towards a circular and climate-neutral society (Figure 7). Each actor has its own intervention tools, ways to operate and interests.

Governments and semi-governments

Governments can intervene in different ways depending on political preferences. From the traditional viewpoint, governments set common goals and develop legislation including tax regulation consistent with these goals.
For a circular and climate-neutral society, this implies that clear goals must be set (e.g. similar to that for energy policy), that legislation and taxation are focused on reducing environmental externalities (e.g. by a compulsory system of deposit fees for many products or taxation that approximates true pricing), and that public procurement sets requirements consistent with circularity and climate neutrality.

Governments may also create new arrangements between institutional partners, resulting in collaboration and concerted actions. Furthermore, a government can facilitate frontrunners in transitions to circularity and climate neutrality and stimulate small wins, both by taking a role as catalyst, by creating room for experiment and by supporting learning processes.

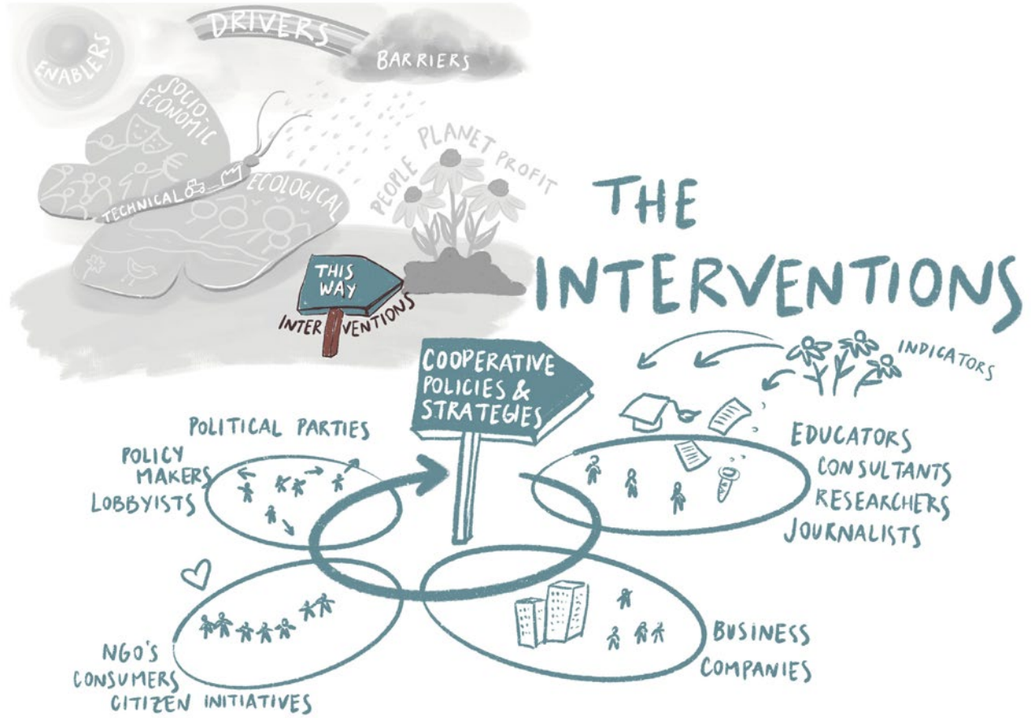

Figure 7 The interventions

Companies

Many companies – small and large – work on new products, new production methods, new business models, new forms of cooperation or participate in strategic discussions in the context of the circular and climate-neutral society. Some do so to create strategic advantage, some to fulfil new expected regulations, and others to work on a new economy out of idealism. Companies striving towards circularity can adapt several aspects of their business: circular design of products, requirements for suppliers, or cheaper services for customers that fulfil sustainability criteria. Also, production methods can be transformed to use waste as raw material, to reduce the use of non-renewable resources, or to improve resource use efficiency. Furthermore, it is possible to develop new business models, including, for example, shifting from buying to leasing.

A circular economy has consequences for the cooperation between companies. Usually, they are organised in chains or sectors, but circularity requires cooperation across the borders of chains and sectors. Firms may also engage more in deals with governments.

Business organisations can play a role in the circular transition by means of developing charters, codes of practice, reporting requirements, awards, declarations of intent, and best practices.

Knowledge institutions

A transition towards a circular and climate-neutral society requires new information, new insights and new technologies. Traditionally, these knowledge innovations are produced by universities, research institutes and in the laboratories of companies. Circularity and climate neutrality require research that is not only aimed at understanding systems but also at the design, testing and implementation of new circular and climate-neutral systems. Research will focus more on higher levels of understanding: from linear relationships to systems-approach thinking but also of multidisciplinary and a more interdisciplinary character, with the societal challenge as a focal point instead of a specific discipline. Finally, it requires research carried out in cooperation with social partners or with citizens or private partners. Such new types of research create a huge challenge for knowledge institutions.

Education

Development towards a circular and climate-neutral society requires different skills and knowledge and hence changes in education. Education should (1) provide general substantive knowledge about circularity, and climate neutrality and (2) contribute to specific 'circular' skills, like working across borders and with people in very different sectors and (3) include several new specialisations aimed at the circular economy.

(Organisations of) Citizens / Consumers

Citizens and consumers as a collective form a strategic actor that influences the transition from a linear to a circular economy. They do this in their conduct in purchasing decisions and in the way they treat their waste. Nevertheless, their strategic influence includes campaigning, influencing governments, developing circular initiatives and promoting them.

The politics of transitions

The preceding is about examples of interventions by individual strategic actors, not about the interplay between these actors. Cooperation between these strategic actors is expected to become more important than ever and a condition sine qua non in the transition to a circular and climate-neutral society. However, the different actors will not always have the same interests. In general, a circular and climate-neutral society will not arise without struggle, which will produce winners and losers. How to deal with losing actors will be one of the challenges of the governance of transitions.

Concluding remarks

A framework to analyse the transition towards a circular and climate-neutral society has been developed with a focus on the bioeconomy. It is meant to provide structure to different projects and to pose questions that put developments of new technologies and business models in a broader systems perspective. The framework helps us to find answers together with WUR's customers, following our motto: science for impact.

The starting point is, in many cases, a development in the technical system that may generate new business models. These technologies have consequences that could be positive but may also lead to trade-offs in both the ecological and the socio-economic system. They often also require changes in one or both of these systems to become effective. Becoming aware of the relations between different system components is relevant. However, it is essential to focus on some central issues. Therefore, at a selected scale, drivers, interventions and the assessment framework are explicitly considered outside of the larger system. The drivers help to answer the question of what determines the direction in which the system develops. For interventions in the system by an actor, it is important to distinguish between possible actions that are within the circle of influence of the actor and drivers that are not. If drivers are not in the circle of influence of one actor, such as a company, it may be that they are in the circle of influence of other actors, such as a government. In such a case, perhaps the company may try to influence the government's behaviour and, in this way, try to indirectly influence a driver. Finally, it is important to evaluate new technologies, business models and policies based on societal cost-benefit principles, where it is important to evaluate to what extent well-being in a broad sense of the word is affected. To operationalise this broad welfare or well-being concept, one may use a number of goals, sometimes organised according to people, profit, planet dimensions that may be related to sustainable development goals or goals of the bioeconomy.

With the presented overall framework for a circular climate-neutral society, WUR and its clients are able to identify important drivers and possible interventions, monitor relevant indicator values, and predict up- and downscale possible effects transparently and objectively. The framework will be applied in several future WUR projects.

The framework is developed by WUR to broaden the view for specific projects, research, policies or evaluations. Therefore, it is important that the questions that are raised by the framework are made more precise, as is presented and illustrated in The Butterfly Handbook that accompanies this narrative.

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