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WP 2 - New concepts and paradigms for policies for resource efficiency

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1 Introduction

POLFREE (Policy Options for a Resource-Efficient Economy) is a major EU funded project that aims to design policy pathways towards a resource efficient Europe. The project is next to a Management (WP5) and Dissemination (WP4) Work package divided in the following main Work packages and tasks (see also figure 1.1):

1 Why have resources been used inefficiently?
- 1.1 Analytical framework
- 1.2 Lessons from EU policy experiences
- 1.3 Comparing trends and policies of key countries
- 1.4 Resource reduction cost curves for material consumption
- 1.5 Business barriers
- 1.6 Individual behaviour barriers
- 1.7 Synthesis and conclusions

2 New concepts and paradigms for policies for resource efficiency
- 2.1 Synthesis of new concepts
- 2.2 A vision for a resource-efficient Europe
- 2.3 A policy mix for a resource-efficient economy in Europe
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- 2.6 Synthesis and conclusions

3 Scenarios and modelling of policy implementation for resource efficiency
- 3.1 Linking economic and ecological models
- 3.2 Scenario formulation
- 3.3 Executing the simulations and generating results with linked models
- 3.4 LCA analysis with relevance to MFA/ resource efficiency
- 3.5 Integrated scenario interpretation

This deliverable is part of WP2 on ‘New concepts and paradigms for policies for resource-efficiency’, and the result of Task 2.1 ‘Synthesis of new concepts’. The main prevailing concepts and paradigms inspiring EU (environmental) law and policy are sustainable development and ecological (eco-)innovation, which have led to reliance on a combination of legally binding standards and market-based instruments. For some areas, a complex governance regime has been put in place (for example, EU ETS, Water Framework Directive, REACH). However, despite some successes, the Commission acknowledges that resource inefficiency and environmental degradation have not been addressed to the required extent.

As a part of the POLFREE vision of an adequate policy mix for resource efficiency, WP2 is expected to find answers to the following main challenges:

What kind of policy framework is needed to boost resource efficiency in Europe and leads to total reduction of both primary resource use and global environmental burdens? How can such a policy framework be formulated and implemented?

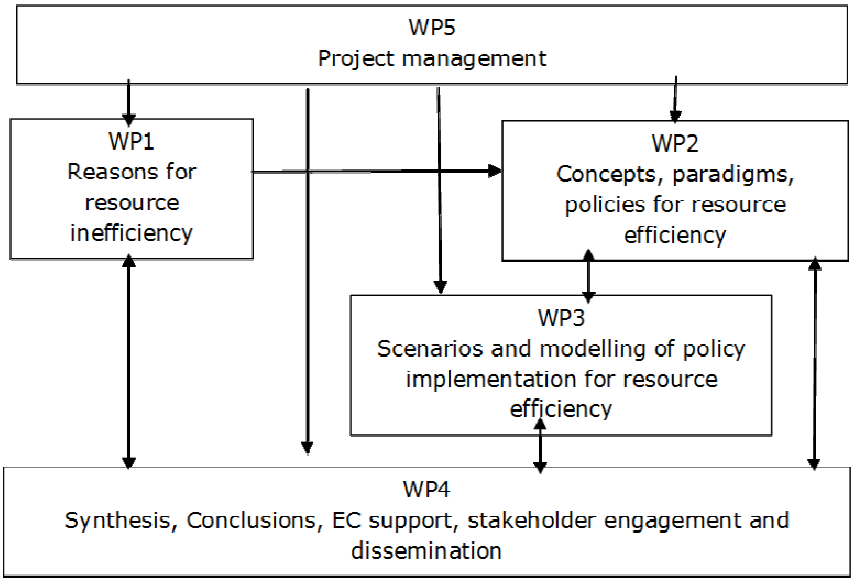


Figure 1.1: Structure of and Interactions between the Work Packages

In this context, Task 2.1 will synthesize a framework incorporating new concepts and paradigms, and relate them to policy-relevant goals and measures. Since there is hardly one perspective on sustainability in general or resource-efficiency in specific, this project will approach the synthesis of new concepts as follows:

1. Review **existing goals** that a resource-efficiency policy at minimum should strive for, in terms of **planetary boundaries** that must be protected, **key groups of resources** as a starting point and targets of a resource policy;
2. Review potential **policy pathways and perspectives** that can help identifying how policies that stimulate resource-efficiency can be shaped
3. Make an comprehensive **inventory** of visions and concepts, and developing a meaningful policy-relevant form of **classification** (e.g. by level in society or actors that they address, or type of activity such as monitoring, governance, and other characteristics);
4. Finally, a synthesized **strategic mapping of related operational strategies** will be done to prepare the subsequent subtasks.

These elements will be discussed in the next 4 sections. Chapter 2 discusses the scope and ambitions of sustainability policies in general and resource-efficiency in specific. Chapter 3 discusses in more detail processes of major societal change (such as 'resource revolutions') and how these can be supported by policy. From that, and an evaluation of existing classifications in Annex 2 we provide then in Chapter 4 dimensions for a classification of visions and concepts, as well as the strategic mapping of them. The concepts themselves have been described in Annex 3. The resource-efficiency policy field further uses a specific terminology. Some important definitions we chose to use in the POLFREE project are discussed in Annex 1 and summarized in Box 1.1.

Box 1.1: Some key definitions and terminology
This box summarizes a discussion on terminology in Annex 1, defining the concepts of resource-efficiency, resource productivity, resource or pollution intensity, and eco-efficiency.

Resource Efficiency
Ratio of two identical resource variables. For example, a ratio between material output, M_o, and material input, M_i, or between energy output, E_o, and energy input, E_i:

M_o/M_i = material efficiency

E_o/E_i = energy efficiency

Resource Productivity
Ratio of two different variables. Numerator measured by some welfare, Y, indicator unless otherwise qualified:
Y_o/M_i = material productivity

Y_o/E_i = energy productivity

Y_o/L = labour productivity

Or a ratio of any two variables of interest which indicate the production of a (non-welfare) numerator by a denominator:
M_o/L = material productivity of labour

M_o/E = material productivity of energy

Resource or Pollution Intensity
The inverse of resource productivity, or the production of some undesirable factor by some other factor:
E_i/Y_o = energy intensity
C_o/E_i = the carbon (emission) intensity of energy
P_o/Y_o = the pollution intensity of output
C_o/Y_o = the carbon (emission) intensity of output

Eco-efficiency
As discussed above, the inverse of pollution intensity:
Y_o/P_o = the eco-efficiency of production

2 Goals of a resource-efficiency policy

2.1 Introduction

This section reviews goals that a resource-efficiency policy at minimum should strive for, in terms of planetary boundaries that must be protected, key groups of resources as a starting point and targets of a resource policy, etc. We will approach this topic as follows.

First, it has to be acknowledged that resource-efficiency is closely related to sustainability in general. Resource-efficiency policies, like any sustainability policy, can have an environmental, social and economic dimension. As for resources, there is in particular a huge strand of policies related to development in resource-rich countries, to security concerns and to issues of human rights. Those issues can hardly be separated from resource efficiency policy, and one can assume a number of trade-offs between the various related goals. Further, it has to be noted that any such goals cannot be set entirely in an objective manner. Section 2.2 will hence discuss various sustainability perspectives. Third, using mainly an 'maximum tolerable impacts' perspective, section 2.3 will introduce goals a resource-efficiency policy at minimum should strive for, in terms of planetary boundaries that must be protected and other resource-related goals. This will be dealt with in more detail in WP 2.2 of POLFREE.

2.2 Perspectives on sustainable development and related goals of resource policies

2.2.1 Introduction

The concept of sustainable development originates in the 1980s. One of the early definitions was given in the 'World Conservation Strategy', developed by the United Nations Environment Program (UNEP), the World Wildlife Fund (WWF) and the International Union for Conservation of Nature and Natural Resources (IUCNNR). However, the concept made its true breakthrough when the Brundtland report was published (WCED, 1987). Over-consumption and grinding poverty had to be reconciled by sustainable development: '*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*'.

At global level, the sustainable development concept and related goals to be achieved have been refined over time during the United Nations Conference on Environment and Development at Rio in 1992 and the World Summit on Sustainable Development in Johannesburg in 2002 (see Annex 1). Most of the concepts suggest an environmental, economic and social dimension.

Having said this, in real life sustainable development is conceptualised in various different ways reflecting a 'plethora of paradigms' (e.g. Fowke and Prasad, 1996; Fischer-Kowalski et al., 1994; WRR, 1994; Gallopín, 2003). This has profound impacts on what goals should be pursued by a sustainability policy in general, or resource policy in specific. Overmore, one should acknowledge the limits of analytical evaluations of conceptualisations, since substantial content of sustainable development always incorporates normative valuations that only become ascertained in the process of social interaction (see Box 2.1; Voss and Kemp, 2006). In the next three sections we present three perspectives on sustainable development and translate them to some related general goals of resource policies. The perspectives are based on some widely

used concepts such as strong and weak sustainability and relate loosely to the individualist, hierarchist and egalitarian perspectives in Cultural Theory (Thompson et al, 1990; WRR, 1994).

Box 2.1: Sustainable development as a contested concept hiding from view real tradeoffs

In essence this chapter is an attempt at capturing sustainable development analytically through the use of principles, components and indicators. Here we should pause to think about an important social fact which is that policy choices and individual decisions (about choice of transport and diets) are almost never based on such elements. The labelling of particular options as green or sustainable is having more of an influence on decisions of consumers, producers and policy makers but the term green and sustainable usually hide from view the negative environmental impacts and problems related to resource use. The Prius car is widely viewed a green car but its emissions are above those of small gasoline cars. A diesel car is more fuel efficient, popular under those who want to drive a lot and now can afford to do so.

Information about environmental performance may help to dispel simple ideas about greenness but in any life cycle assessment different aspects must be weighted: lower greenhouse gas emissions from battery & hybrid electric vehicles have to be weighed against the possible depletion of dysprosium a rare earth material used in batteries. Science cannot weigh the two things and cannot even determine the likelilhood of depletion and the costs of this to society. The substantial content of sustainable development cannot be scientifically determined as 'objective knowledge' but will always incorporate normative valuations that only become ascertained in the process of social interaction (Voss and Kemp, 2006). It is important recognise the limits of knowledge and the importance of subjective valuation. From a governance perspective such disagreement is an essential part of sustainable developments, one that makes operationalisation difficult:

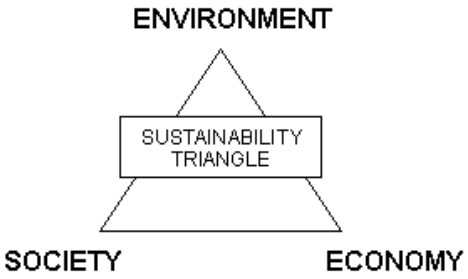
- there are different ideas of what sustainable development amounts to for actors in various sectors (energy, transport, agriculture, food systems, waste management);
- existing solutions tend to be sustainable within these sectors rather than across the whole of society
- new developments bring new risks that cannot be anticipated;
- it is a long-term, open-ended project that precedes and supersedes limited term, democratically elected governments;
- it involves making choices and perhaps trade-off decisions on highly contested issues (which is to say that in some cases the notion of a 'trade-off' might prove to be no more than a euphemism for fundamental irresolvable dilemmas). (Farrell et al. 2005, p. 132)

Policies for resource efficiency are likely to be contested and resented in society because of uncertain knowledge, different views and valuation and because people always will resent government interference with their lives. Given the low salience of resource efficiency in society, it may be necessary for resource efficiency policies to draw on things people actually value: greater well-being, lower energy costs, better systems of transportation, tasty food. Relatively easy wins may be obtained this way, but it should not stop at that. To decouple well-being from resource consumption, political choices must be made about the phase out of fossil fuels, the implementation of energy improvement programmes for the built environment, use of nuclear power and compulsory targets for recycling and re-use.

2.2.2 Weak sustainability: maintaining the productivity of manufactured, human, social and ecological capital

Some authors operationalised the concept of sustainability as a number of interrelated capital stocks, for instance manufactured, human, social and ecological capital (Ekins, 1992). Wealth is created by production of a flow of products and services making use of this (total) capital. Weak sustainability assumes that such stocks are – to a certain extent – exchangeable. What matters is that the productive value of this capital (determined by its quality and quantity) must be kept intact (or better: increase) to ensure the inter-generation sustainability meant by Brundtland (compare Solow, 1992). The famous 'sustainability triangle', portraying sustainability as interrelated development along economic, social and environmental axes, reflects this approach.

Figure 2.2: Sustainability triangle



The so-called 'weak sustainability' view accepts a full substitutability of stocks as long as the total productivity and output can be maintained or enlarged. Environmental resources hence can be sacrificed if man-made alternatives emerge. Pharmaceuticals can replace medicinal plants and livestock wild animals while biodiversity is maintained – so no problem if African savannahs are turned into agricultural land (cf. Munasinghe and McNeely, 1995). The result is a very human-centred interpretation of sustainability. As formulated by Williams and Middleton (2004): "This [human centred discourse] is composed of three strands: the perception that people are separate from nature; the idea that nature is a 'resource' to be used for the benefit of society or individuals; and the view that we have the right to dominate nature". One of the exponents of this line of thought is to see impacts on nature by human economic activities as 'externalities', implicitly or explicitly assuming that externalities only are to be mitigated if the investment pays off. Williams and Middleton (2004) conclude that in weak sustainability

- a human-centred worldview is adopted;
- there is an emphasis on a growth-oriented approach to economic development;
- there is a relative lack of consideration given to the need for radical change in people's demands on the Earth; and
- there is a perpetuation of the view that nature is merely a collection of natural resources that can be subdued by the human race.

Typical concerns for a resource related policy in this framing would be:

- Economic aspects:
    - Resource efficiency and resource productivity are to be pursued for reasons of economic efficiency and enhancement of competitiveness (cf. McKinsey, 2011)

  - A free, global market for resources should exist and security of supply should be arranged to should be strived for (e.g. EC, 2010);
- Social aspects: basic human rights and labor rights should be honoured;
- Environmental aspects: some basic environmental standards (e.g. emissions) have to be adhered to.

This framing is likely to rely significantly on market-based solutions, and emphasise the 'private good' benefits of a resource-efficiency policy: lowering economic costs, and enhancing competitiveness. There is probably a role for authorities to protect public goods, but it is much less prominent as in the next frame.

2.2.3 Strong sustainability: setting clear environmental boundary conditions for economic and social development

Other studies aim to determine more or less objective boundaries for economic and social development. On the environmental dimension, such studies typically try to propose more or less scientific criteria for values, objects or resources in the environment that need to be protected, which policy makers than could use to select a protection goal. This would then give insight in the maximum impact that could be tolerated, and by calculating backwards via e.g. the emission-effect chain a maximum emission or resource use level could be established. Depending on the geographical scale of the environmental problem, this then could serve as a basis for emission quota or targets for the world, regions, countries, or sectors. Acknowledging that such boundaries never can be assessed with 100% certainty, recently authors like Rockström et al. (2009) and Griggs et al. (2013) have developed the concept of a 'Safe operating space'. These conceptualisations do not use the sustainability triangle as a model anymore, but portray the Earth clearly as setting boundary conditions for human (social) development, with the economic system enveloped by the human societal system (see Figure 2.3 and 2.4).

Figure 2.3: Strong sustainability paradigm (e.g. Griggs et al., 2013).

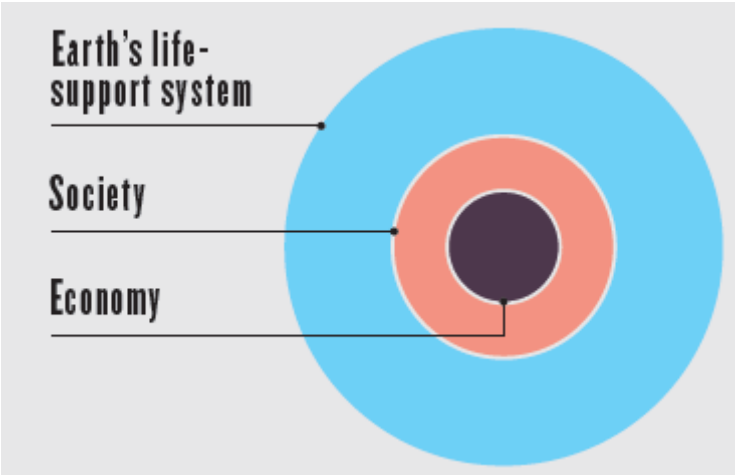
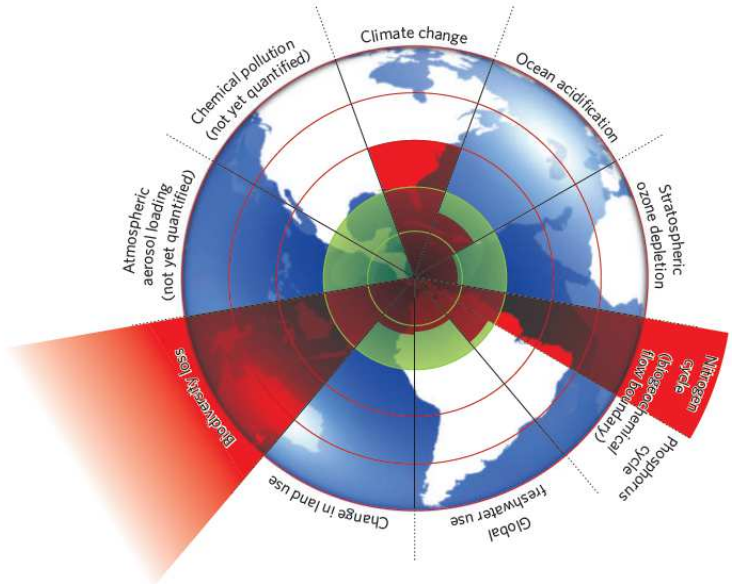


Figure 2.4: Safe operating space (green) and planetary systems for which boundaries already have been exceeded (in red; Rockström et al, 2009)



The Safe operating space concept as developed by Rockström et al. is not specifically looking from a resource perspective, and is apart from freshwater use and land use change somewhat emission and impact oriented. Annex 2 to this report analyses in some more detail potential resource limits, which are summarized in Table 2.1. This analysis suggests that – line with the findings of Rockström et al – that the use of fossil energy resources in relation to climate change needs a radical improvement of resource productivity of a Factor of 10 or more; that the land/water/biodiversity nexus needs a improvement of resource productivity of at least a Factor 2; and that for metals and minerals the situation is very diverse depending on the material at stake (e.g. EC, 2010). Since there are linkages between resource use categories (Graedel and van der Voet, 2010), some additional complexities have to be taken into account – the use of certain metals or building materials like cement may not be problematic from a scarcity perspective per se, but are so due to a strong linkage with energy use and CO2 emissions.

This conceptualisation emphasises the common good argument for a resource policy: a clear government intervention is needed to avoid that economic processes destroy the Earth's life support system, or deplete resources. There is a prominent role for authorities in formulating boundary conditions and planning and intervening to create change. With regard to resources, for instance the following concerns would be addressed (cf. Daly, 1991:44) [1]:

[1] Daly further mentions as attention points that human scale (throughput in the economy) must be within the carrying capacity of the earth, which requires choices of population and consumption limits (and hence and efficiency). Long run-marginal costs of expansion should be equal to long-run benefits of expansion. Furthermore, technical progress for sustainable development should be efficiency-increasing rather than throughput-increasing.

- Harvesting of renewable resources should not exceed regeneration rates;
- Waste emissions should not exceed renewable assimilative capacity;
- Nonrenewable resources should be exploited, but at a rate equal to the creation of renewable substitutes.

Table 2.1: Potential resource constraints

Type of resource	**Fraction of global resource extraction**	**Basis for planetary limits**	**Potential limit**	**Reference**
Fossil fuels	20%	Absolute scarcity CO_2 emission targets	EU greenhouse gas (GHG) targets (20-20-20 or30% reduction by 2020) Scientific targets (>80% reduction by 2050)	IPCC (2007), EC (2008, 2010), Meinshausen et al. (2009).
Biomass	30%	Maximum human appropriation of net primary production of biomass (HANPP)	Currently, 30%-35% of available biomass is extracted by humans. Target may be stabilization or minor growth	Vitusek et al. (1986), Haberl et al. (2007).
Metal ores and industrial minerals	10%	Absolute scarcity (varies by metal). Most metal ores need high levels of energy to be transformed, implying a 'linkage' to CO_2 emission targets and energy constraints	Focus on 14 critical raw materials identified in the Raw Materials Initiative. Changes in energy and mobility infrastructure (solar cells, batteries) determine future criticality	EC (2010). For linkages with energy use, see Graedel and Van der Voet (2010).
Construction minerals	40%	Absolute scarcity seems irrelevant, except in densely populated areas where space for sand, clay and gravel mining is limited.	Implicit targets for construction minerals that need high levels of energy in their production (e.g., cement, ceramics) and linkages to land use targets (e.g. soil sealing)	For linkages: e.g. Hanle et al. (2006). http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf
Land	p.m. (not expressed as mass)	Available bioproductive land, with reservations for nature areas (e.g., rainforests)	Conflicting information about remaining areas that can be converted to agricultural use	Erb et al. (2009), OECD/FAO (2009), Nature (2010a and b), WWF (2010). EC 'Soil sealing guidelines' (2012)
Water	p.m. (usually not included in Material Flow Analysis)	Renewable supply (varies by region); agriculture is dominant user	A global 'water gap' of 30% expected in 2030,	Hoekstra and Chapagain (2007), Water resources group/ McKinsey (2009).

2.2.4 Paradigmatic change: fundamental renewal of our socio-economic system

A last group of authors has given up hope that without a major overhaul of our economic system, value orientation and related institutions sustainability will ever be possible. Authors such as Jackson (2009) and Ayres (1998) argue that society currently is based on an economic growth engine that by nature will always seek environmental limits. Increased productivity will lead to declined unit costs, increased consumer demand, increased investments and further substitution of capital and natural resources for labor. Lietaer et al. (2012) found in a recent report for the Club of Rome that the recent monetary crisis was not an accident, but that the system has inherent unstable features, and inherently promotes unsustainability. Or, as it was put by Wolfgang Sachs (1999:55):

Certainly, interpreting the state of the world chiefly in terms of 'resources', 'management' and 'efficiency' may appeal to planners and economists. But it continues to promote development as a cultural mission and to shape the world in the image of the West.… The more their language is adopted around the globe, the more difficult it will be to see nature in terms of respect and not as a resource, society in terms of the common good and not of production, and action in terms of virtue and not of efficiency. To put it in a nutshell: such reports promote the sustainability of nature and erode the sustainability of cultures. And this, for sure, will not benefit nature either. (Sachs 1999:55)

Thinkers from this strand put much emphasis on the question if small people can organise their own lives in the way they like: people should be able to determine their own destinies, to learn and grow from work and other experiences, rather than being the passive beneficiaries of structures that take care of them – or worse, exploit them (compare Schumacher, 1973; Illich, 1978; cf Sen, 1999)[2]. Rather than delivering quality of life in hedonic sense, economic systems of production and consumption should serve spiritual growth, i.e. that conditions are created that allow people to develop their capacities and potential, and hence grow to 'more complete' and 'mentally richer' human beings. Ideas diverge obviously into which direction change has to go – suggestions range from re-inventing the economic growth engine to one based on resource productivity rather than labor productivity improvements (Ayres, 1998), via 'Small is beautiful' Buddhist economics (Schumacher, 1973) to 'Degrowth' strategies (e.g. Schneider et al., 2010).

[2] Schumacher and Illich, important writers from the 1970s, had rather similar philosophies. Schumacher's book 'Small is beautiful' proposed to bring back dimensions of production to a 'human scale', so that individuals again become the masters of technology rather than the reverse. This would allow people to learn and grow again, rather than becoming passive instruments in a treadmill. 'Good work' would 'give a man a chance to utilise and develop his faculties; to enable him to overcome his egocentredness by joining with other people in a common task; and to bring forth the goods and services needed for a becoming existence'. Illich stressed the danger that specialists (doctors, teachers, language specialists developing dictionaries and grammar, etc.) would start to determine elements of life that previously were 'owned' and 'developed' by individuals, resulting in lives with ever less self-determination, capacities and development.

2.3 Discussion and conclusions

In sum, the goals that have to be set by sustainability policies, and as a derivate, resource efficiency policies, are far from unambiguous. We have discerned above three perspectives:

1. A 'weak sustainability' perspective minimizes government intervention, emphasises the 'private goods' argument for resource-efficiency since it enhances profits and competitiveness of business, and has a very human centred view on sustainable development.
2. A 'strong sustainability' perspective that puts protection of the Earth's life support system upfront, which emphasises hence the 'public good' argument for resource-efficiency policies and provides a strong argument for government intervention
3. Finally a 'paradigm change' perspective that simply said argues we have to move away from an economic system that marries creative destruction with consumerism and inevitably will push the limits of the Earth's life support systems in pursuit of maximum growth and production.

These different perspectives obviously imply different levels of change – the first obviously will be relatively incremental, whereas the last implies a complete overhaul of our way of doing things. It is at the same time so that the choice between these different approaches is not entirely subjective. As Kuhn (1962) already remarked in his seminal work on scientific resolutions, some paradigms fit better with the 'real world' as others. Even in the 'weak sustainability' frame the argument that resource-efficiency helps competitiveness will fail when resources are cheap and abundant, let alone that the two other more stringent frames will have a chance to be a successful answer in such a situation. Conversely, in case of fundamental scarcity, an economic system that is too much based on throughput will not be viable on the long term, and will force an economic system based predominantly on the first perspective to move to one of the other perspectives. In that sense, the analysis made in Table 2.1 is not too promising. There are no obvious resource limits for building materials, the most voluminous stream of materials used in society. For industrial minerals and metals the situation is far from clear – the much cited Rare Earth crisis that exists since around 2008 has its roots purely in market failures, short-sightedness of the West, and the use of power by its suddenly created monopoly by China, rather than scarcity as such[3]. The calculation of a Factor 10 or more improvement of resource productivity for fossil energy materials is not based on potential scarcity, but the need to reduce CO2 emissions – if no political agreement on drastic emission reduction is agreed upon globally, there is no driver for such reductions. Finally, with regard to biomass water and land restrictions are likely to form a real limit that only can be solved by enhancing resource productivity with around a Factor 2 in this field.

[3] In 2002 the last non Chinese RE mine, at Mountain Pass in the US, closed down. From that moment on China was responsible for almost all RE production globally. Despite that the proven reserves of RE are 800 times annual use (which is much higher as for any other resource), due to the incapability of the small Western mining companies to attract funding no alternative mining was established outside China. When China needed the majority of RE for own use by 2008, it began to restrict exports and the crisis was born.

3 Pathways of change

3.1 Introduction

With chapter 2 describing in broad sense the goals of a sustainability policy and a resource-efficiency could pursue, in this chapter we will discuss how change towards such goals can be realized. We do so in two steps.

First, in section 2 we provide a theoretical framework of how particularly major societal change can come about. We rely in this particularly on transition theories that typically span 50-100 years, but also look at even longer time frames of historical change. The reason for the last point is that some conceptualizations of sustainability or resource-efficiency call for a change that is similar to the Industrial revolution. Examples are e.g. McKinsey (2011) who claim there is a need for a 'Resource revolution' and Fischer-Kowalski and Haberl (2007) who link the sustainability challenge to the human transitions from hunter-gatherer societies to agricultural societies some 10.000-5.000 years ago, and the transition from agricultural to industrialized societies in the last 100 to 200 years.

Second, in section 3 we provide some perspectives on how long-term change can be fostered via intervention of policy or by other means.

3.2 Understanding large scale historical change

In the last twenty to thirty years a literature has developed that tries to understand socio-technical transitions. Scholars from this field typically try to explain socio-technical changes spanning up to one century (see e.g. the contributions in Elzen et al., 2004). Such transition processes can be evolutionary, where the outcome is not planned in a significant way, or co-evolutionary and goal-oriented, where some vision of the end-state is guiding decision makers or orienting strategic decisions. An example of the first is the transition from sailing ships to steam boats in the 19th century and the shift from horse-and-carriages to automobiles in the first half of the 20th century (described in Geels, 2002 and 2005) and the whole process of mechanisation. An example of the second is the development of centralised electricity systems (described in Hughes, 1983) and the transition from piston engine aircraft to jetliners (Kemp, 2008). Most authors analyzing such transition processes propose to use multi-level, a multi-actor, and multi-phase concept to describe the process of change or transition.

The multi-actor concept metaphorically points at the fact that systems have to be seen as socio-technical regimes: interrelations of existing technologies, knowledge, skill sets, routines, regulatory demands, policy preferences, available infrastructures, and prevailing cultural and symbolic meanings that usually cannot be changed independently, but must co-evolve.

The multi-level concept divides societal systems in three main levels (e.g. Geels, 2005; Elzen et al., 2004; Rotmans et al, 2001). Figure 3.1 reflects this multi-level perspective in combination with a production-consumption chain, a visualisation in the SCORE! project on sustainable consumption and production (Tukker et al., 2008).

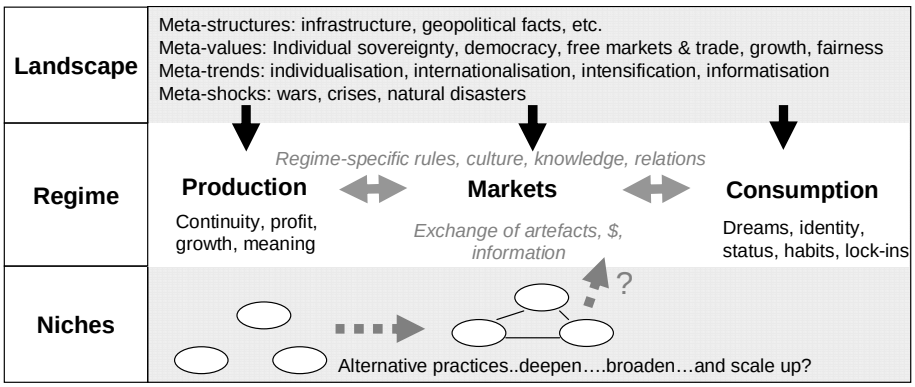
- a macro- or landscape level, which is to be taken for granted on short- and medium term. It contains very or fairly stable factors such as geopolitical realities, widely held values, and stable megatrends (e.g. in the area of demography). It poses boundary conditions for

the next level (the regime) to evolve, and is hence normally a source of stability (with the exceptions when disruptive shocks at this level occur, such as wars and natural disasters)

- a regime level. The regime itself is an interdependent and co-evolving set of technologies, symbolic meanings, services, consumer practices, rules, financial relations and expectations. It is difficult to change one part without the rest. This dynamic equilibrium changes usually only incrementally. A simple example: you cannot put a hydrogen car on the road without hydrogen gas stations, new safety rules, maybe even new driving license standards, etc.
- niches, where groups can try out new consumption and production practices. It is however often difficult for niches to become mainstream, due to the stabilizing effects at regime and landscape level.

The multi-phase concept stipulates that transitions go through distinct phases: a pre-development phase in which new practices are tested in niches, a take-off phase in which elements of the new regime challenge the old regime and start to break through, a (relatively short) acceleration phase in which the old regime starts to break down, and a stabilization phase in which the new regime has taken over. The take-off phase is crucial for the success of the transition or regime change, and needs a 'green light' at all levels: availability of promising elements of a new regime in niches, instability in the existing regime, and a growing incompatibility between regime and landscape.

Figure 3.1: The production-consumption regime embedded in a landscape context and with competing (niche) practices (Tukker et al., 2008)



This multi-level theory explains why intentional radical socio-technical change is so difficult. Both the landscape as regime levels guide developments. This dynamic equilibrium changes usually only incrementally. But the theory can also help to find tensions or 'cracks' in the system that can make stimulating changes easier. Such 'cracks' can be: internal tensions in the production-consumption regime, or misfit between regime and landscape, and can have a normative and operational dimension. Examples include a production structure evidently based on labor exploitations in the South (misfit with ethical meta-values), or a sector practicing agriculture in greenhouses, that due to rising energy prices becomes too expensive (operational misfit).

When promising niches are available that have matured (deepened) and got connected (broadened), and at the same time 'cracks' develop or 'shocks' in the landscape occur, pressure

on the regime may become so high that rapid change may become possible (niches 'scaling up'). The regime breaks down, and niches plus the remnants of the existing regime will develop new structures, which eventually will stabilise and form a new regime (cf. Geels, 2005; Kemp and van den Bosch, 2006).

This theory has been applied quite successfully to analyse a variety of changes in socio-technical systems, as indicated typically with a time horizon of 50 to 100 years. It is however also interesting to look at what Little (2000) termed 'Large scale historical change', with as examples the change from feudalism to capitalism, the development of modern states in Europe, and the evolution of institutional rules and systems of law. Such processes need to be analysed on a longer time horizon.

Historians have been struggling with analysing such large scale historical change. Some end up with narrative interpretation of single cases, which has as danger generic structures and processes are ignored. Conversely, scholars relying on grand theories face the danger of using deterministic explanations, oversimplifying certain driving forces as the only ones relevant (e.g. population, power, class), and a tendency to ignore the role of agency and the potential of multiple pathways (Little, 2000). Very much in line with the transition theories depicted above, Little pleads for an approach towards historical analysis that takes into account factors such as technical momentum (cf Hughes, 1983), institutional momentum, etc., but that at the same time is responsive to local circumstances and contingency. So large scale historical explanation should invoke general theories of commonly important historical factors—technology, population, trade and market institutions, urbanization, state institutions— and "typical" patterns of causal development. This makes certain futures more likely than others, and certain pathways impossible. Still, large-scale historical explanation will unavoidably need to be responsive to local circumstances and agency (Little, 2000).

With regard to resource policy, this then leaves us with the question what commonly important historical factors could be – without pretending that these determine developments fully. The institutional and technological momentum suggested by Little (2000) are obvious candidates. Technology forms an important factor explaining both levels of resource use, but also possible levels of resource extraction and hence resource availability. Institutions and meta-values indicate what is seen as 'right' and 'wrong' and hence can imply a tension with the existing regime of certain resource uses. Finally, (physical or geopolitical) scarcity of resources forms a factor for consideration since this forms a hard, inevitable boundary that a country or society physically cannot overshoot.

3.3 Policies supporting change

3.3.1 Introduction

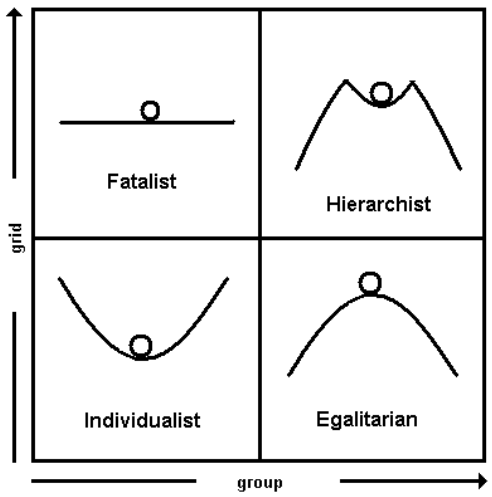
In view of the above, governance of transitions to sustainability now becomes the art of stimulating a window of opportunity for take-off and influencing the direction for change.

One could of course try to postulate a single, final blueprint for governance of system innovations. We believe, particularly at this stage, that this is not a wise course of actionIt has been stated that the scientific community that discusses system innovation and related governance models is still in its pre-paradigmatic phase (compare Kuhn, 1962). Further,

questions that deal with ‘complex’ situations have been termed ‘trans-scientific’ (Weinberg, 1972). In these cases the situation to be analyzed is so complex and the problem can be defined in such different ways that in practice different actor coalitions come to different, but equally defensible answers to the question posed. As a result of bounded rationalities (Simon, 1957), differences in belief systems (Sabatier, 1987), etc., different actor coalitions arrive at answers that have a sound internal logic, but are nevertheless coloured by the cognitive lenses that each actor coalition (unknowingly) wears.

One does not need much imagination to sense that the question of how to radical changes towards resource efficiency might be a trans-scientific one. It concerns processes that in general take a long time and involve large societal systems. However, stringent regulation can accelerate radical innovation and significantly shorten up the development process (Ashford et al, 1985). Radical innovations not only encompass a change of technology, but also organization, structure and culture. Hence, it is interesting to analyze the various views that could exist on governing system innovations in principle. An interesting heuristic to find such views is provided by four archetypical ‘belief systems’ postulated by Cultural theory (Thompson et al., 1990). In brief, Cultural theory states that in each society four groups can be distinguished in terms of their capability to influence their own needs and resources. From this starting point, each group develops its own view on nature and rationale to deal with questions posed by life (cf. Figure 3.2). If this rationale happens to fit with the ‘true’ nature of the question, one speaks of a ‘utopia’. But if this rationale is actually counterproductive, one speaks of a ‘dystopia’. Cultural theory has been successfully applied in a large number of cases. It helps to examine the different perspectives from which a problem could be analyzed and why different groups adhered to different views. In the next sections, these four positions are elaborated upon for the question of governance of system innovations[4].

Figure 3.2: The four perspectives in Cultural theory



[4] Some authors suggest that the viewpoints from cultural theory are mutually exclusive in the sense, that humans can only adhere one perspective. I do not use cultural theory in this way – cultural theory has been challenged for the fact that the same person can act like a hierarchist on some aspects, and and individualist on other aspects, or even can switch ‘modes’ when providing opinions on the same subject. I simply use cultural theory as a heuristic to discuss 4 archetypical approaches to governance of complex systems.

3.3.2 *Individualist*: 'Sustainability through the market '

The individualist basically has an optimistic view of the world and human nature, and believes that in the end individual ingenuity will find a solution. Hence, realizing transitions becomes a matter of channeling individual incentives in the right direction but leaving a great degree of freedom for individuals and groups to develop their own preferred solutions. Not surprisingly, many analyses based on Cultural theory show that industrial organizations in our Western society often represent the individualist position (e.g. Tukker, 1999).

The question of how to make the transition to sustainability is no exception. The World Business Council for Sustainable Development (WBCSD), probably the most powerful and influential industry think tank on sustainability, even has a slogan that reflects this: 'Sustainability through the market' (WBCSD, 1999). The idea is that once perverse subsidies are abolished and the undesirable side-effects of our current production and consumption systems are internalized into the market prices, the market mechanisms will direct innovations in the correct, sustainable direction. This position reflects to a large degree also the 'private good' argument why resource-efficiency should be realized:

- Businesses should be interested to act since by being resource-efficient, they can lower costs;
- Governments should be interested since by removing market failures, they can enhance competitiveness of businesses in their country.

This approach, using mainly market-based instruments is useful if one knows which changes to the market incentive system will change the behaviour of actors in the direction of more sustainability. The exact means or roadmap to the sustainability goal can in principle still be uncertain. Since this option implies that changes in the rules of the (market) game must be implemented, a party must have the power or legitimacy to make them. If there are strong impediments to change that cannot be overcome by financial incentives, this approach will not be effective. Another, more fundamental concern is that the 'individualist' approach assumes a worldview in which systems inherently seek an equilibrium (see figure 3.2). This is not a satisfactory conceptualization of the world for those who feel that important reinforcing feedback loops may be at stake that can easily lead to destabilization of societal, economic and environmental systems[5].

3.3.3 *Hierarchist:* 'Let's put a man on the moon!'

The hierarchist typically applies a top-down approach to solving problems. In its extreme form, an all-encompassing blueprint is developed and executed in an orderly, planned and stringently controlled fashion, all under the guidance of a central node. This type of approach to transition management is probably supported by those who call for a 'master plan' or 'Apollo-program' for saving the environment. It should consist of an all-encompassing effort with a lead role for the government in various fields to realize the necessary system innovations. In more moderate forms, the goals and planning are more indicative and the assessment of which means to use

[5] See for instance Lietaer et al. (2012) about the in their view inherent instable nature of our financial system. In the field of climate change, influential journals have shown that continuous greenhouse gas emissions are likely to create extreme temperatura changes on Earth (e.g. Meinshausen et al, 2009).

more participatory, but there is still a powerful central actor which can when necessary enforce progress of the process of change[6].

This position has relations with the 'public goods' argument to embark on resource-efficiency policies: preventing resource scarcity as well as pollution and impacts related to resource extraction and use.

Indeed, one can find clear examples in which major innovations were realized via this hierarchist approach. The US space program launched by President Kennedy is one example. Many of the innovation programs developed within the military-industrial complexes of the US and the former Soviet Union are another. Albeit at terrible human costs, both the Soviet Union and China transformed themselves from mainly agricultural countries into industrial nations via a number of strong centrally organized 5-year plans, changing the structure and culture of their society in the process (Kennedy, 1988).

The hierarchist approach to transition management can be applied under the following conditions. First, there must be a party in the system that has the power or legitimacy to apply a hierarchist governance model. Second, it must be fairly clear which transition goals must be reached and which means are the most appropriate to do so. Under these conditions, a hierarchist approach can be an effective and efficient way to realize a transition.

3.3.4 *Egalitarian:* 'A good transition arena will do it'

The egalitarian has a risk-averse, cautious attitude. The egalitarian society is characterized by operating in social groups without excessively binding rules.

The policy approach corresponding to an egalitarian view seems most to be found with scholars coming from a research background in governance and transition management. They try to understand how fundamental change can be fostered via 'radical incrementalism', 'variety and selection', 'connecting long term visions and goals to short-term implementation activities', and fostering 'coalitions of the willing'(e.g., Ostrom, 1990; Rotmans et al., 2001; Hajer, 2011). Rather than creating big programs lead from within a system that, by nature, seeks broad policy support (which inevitably dilutes ambitions), it would probably be better to bet on the bottom-up initiatives of front-runner companies, civil society, and progressive governments. Noteworthy initiatives include the World Economic Forum, with various agenda councils related to climate change, water and urban sustainability; the Global Green Growth Forum; the Climate Group; and the Global Compact. There are also grassroots initiatives such as Transition Towns and the

[6] See for instance the radical change in the Dutch waste management system between around 1985 and 1998. A series of soil and air pollution scandals had created a sense of urgency for prevention and more professional waste treatment. A series of government-led strategic and interactive planning processes resulted for the main waste streams in agreements with the main target groups on 'implementation plans' with significant targets for prevention and re-use. Landfill taxes and bans channeled waste to re-use and incineration. Legislation and permit systems enforced major investments in incinerator flue gas cleaning systems, but at the same time were used as a means for capacity regulation, to ensure that such investments would be profitable. Though the current Dutch waste management system is not the result of implementing a 'blueprint' developed in the 1980s, the crucial, hierarchic role of Dutch authorities in the transition is obvious (Tukker, 1996; Eberg, 1997). We would argue that also regulation induced radical or disrupting innovation in the spirt of technology forcing (e.g. Ashford and Hall, 2011) fits here, since in all these cases a strong and directive government is essential for change. Having said this, while relying on a strong government role, the change model proposed by Ashford and Hall is obviously does not take the form of detailed top-down planning or 'blueprinting' approaches.

Dutch action group Urgenda. The latest example is the recently established 'Sustainable Development Solutions Network', a new independent global network of research centres, universities and technical institutions launched by UN Secretary General Ban Ki-Moon and to be headed by Professor Jeffrey D. Sachs (UN, 2012b).

The real question is how these largely bottom-up initiatives can ultimately be channeled and consolidated into lasting change, or how these activities can legitimize a more forceful international leadership that can overcome the blockades. Otherwise, these noteworthy initiatives will end up being little more than repetitive meetings where good ideas are presented, ideas that, in the absence of institutional adjustments, cannot compete with the mainstream way of doing things and, hence, remain in their niches.[7]

This approach can be applied when there is not yet (like in the hierarchist approach) a clear central, powerful actor that is legitimized to enforce change, or (unlike in the individualist approach) market failures and other institutional failures must be overcome to realize change. The approach is particularly useful when the pathway of change is not yet entirely clear, a critical mass for change still must be organized, and when bottom-up experimentation and mutual learning is essential to uncover how the transition must be shaped. A clear problem is that this approach can easily end up in muddling through in experimenting and learning, which keeps actors occupied, but in the end simply keeps things as they are. It is not for nothing that Hajer (2012), as indicated above, sees an essential role for authorities to 'provide clarity'. In view of the persistent failure of international conferences like Rio+20, Durban and Cancun, to deliver agreements with such clarity, this provides not a minor question mark if this perspective ultimately can deliver change. In that case, what the hopefuls portray as an egalitarian approach to managing the transition, it is after all nothing more than the fatalist position in disguise – only disaster may provide the real momentum for change.

3.3.5 *Fatalist:* 'Change comes upon us'

The fatalist basically has no influence over his fate. He is basically a passive instrument in a play determined by elements beyond his power. If things are going in the wrong direction, the only thing that a fatalist can do is hope and wait for an external event that will change the situation – hopefully before a disaster has happened. But the fatalist, of course, has already experienced too often that disaster was necessary to bring about change. The fatalist position is hence characterized by an absence of influence and active governance. Only external factors can change the course of events.

[7] Even those who claim that we should build less on top-down agreements and foster and trust the 'energetic society' more (Hajer, 2012) acknowledge that there is a role for authorities: 'Authorities should give clarity (..). Then investors will dare to invest. Offer them certainty. Create new green accounting rules. Abolish subsidies that prevent innovation and keep us in the 20th century'. Maarten Hajer, column based on a presentation during the meeting 'Rio aan de Maas' (Rio on the Meuse'), 'Rio as global fair', 30 May 2012, as published on http://www.pbl.nl/node/55684 (accessed 14 August 2012). Bas de Leeuw, former secretary of the UN 10-Year Framework of Programs on SCP and later the UNEP Resource Panel, current Executive Director of the World Resource Forum, made a similar statement in a speech to the annual conference of a major Dutch political party: 'It is very important that authorities finally start to do what only authorities can do: make laws and levy taxes. Ensure that products that you don't want people to buy are not in the shops. Asking millions of consumers via campaigns to buy only environmentally sound products really is very devious.' http://basdeleeuw.wordpress.com/2012/04/27/allemaal-meer-loon-gesproken-column-voor-d66-congres-video/ (accessed 24 August 2012)

As described before, this 'evolutionary' approach is actually how the large majority of transition processes in society have happened until now. Neither the Renaissance in Europe in the 15th century nor the industrial revolution in the 19th century in many countries in the world were planned or steered but simply 'happened'. Coal mining was triggered by wood shortage. The Ottoman conquest of Constantinople blocked the silk road and stimulated navigational and technical improvements allowing European nations to use sea routes instead, leading to the era of big discoveries and colonization. And so on.

The fatalist situation can be recognized in the sustainability arena, too. In quite a few sustainability questions actor coalitions are bogged down in a stalemate, due to opposing interests, views, and a lack of room to maneuver (for instance: the agricultural sector in the Netherlands between 1975 and 1995, which kept on expanding despite ever-increasing eutrophication problems ; the chlorine industry worldwide, which was attacked intensively by environmentalists but was unable and unwilling to change to alternatives due to a lock-in related, among other things, to the capital intensive nature of the industry and different belief systems about the real danger caused by chlorine (Tukker, 1999; Stuurgroep chloor, 2001; Turcotte and Ali, 2002). Active governance is impossible. There is no option but to wait for disasters or other external events that can break the stalemate (e.g. the Chernobyl and Fukushima disasters creating windows of opportunity for policy makers to close down nuclear power plants and give more room to renewable energy).

The fatalist approach to transition management is appropriate in the following case: when most actors in the system feel no sense of urgency to change. On the contrary, they have strong interests in maintaining the status quo. Those in favour of change do not have enough influence to change this.

3.4 Summary and conclusions

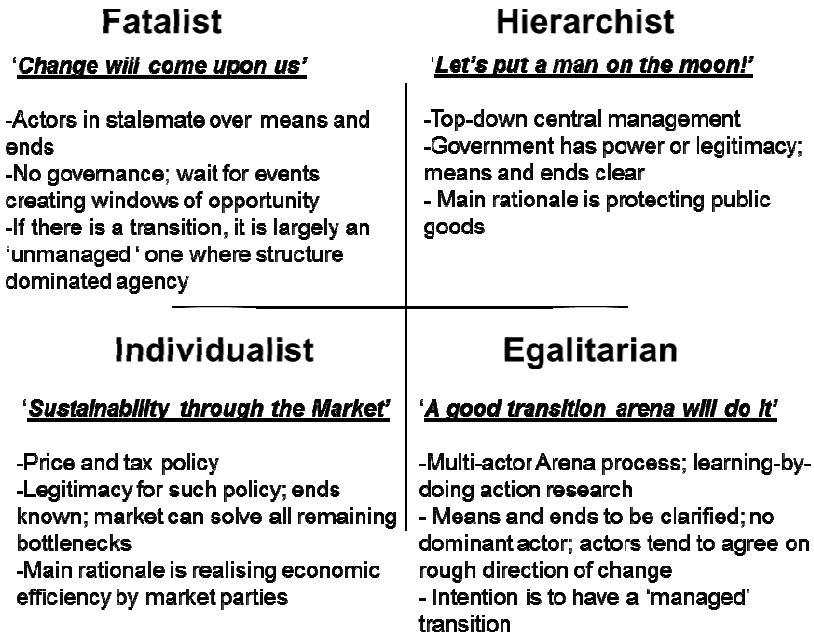
Figure 3.3 summarizes the four perspectives on change. In sum, when the problem and pathway of change is reasonably clear, and public goods are in danger, then authorities are legitimized to enforce the change, the hierarchist approach either the hierarchist approach or regulation-induced technological change is most appropriate. Market-based instruments applied in the Individualist approach are useful if one knows which changes to the market incentive system will change the behaviour of actors in the direction of more sustainability. Regulatory instruments in combination with economic incentives are likely to be most appropriate for technology forcing. Resource-efficiency should be strived for since it ultimately lowers costs and enhances competitiveness. But if more complex, far reaching and paradigmatic change is at stake – means and ends uncertain, institutional change essential, fundamental failures in the market system – and there is no sufficient critical mass to embark on change, one may end up in the egalitarian or fatalist mode. In the egalitarian mode the situation is fluid enough to create change via a bottom-up and 'learning by doing' process. But in case of a stalemate about means and ends, one inevitably ends up in the fatalist mode, as seems currently the situation in international climate negotiations. In such situations there seems no option to wait until 'system cracks' occur: a misfit between the existing way of doing things and dominant values, institutions, or physical boundary conditions (e.g. lack of resources or rising prices of resources).

It is in a way interesting to see that the Fatalist and Egalitarian modes usually are followed by more traditional top-down or market based policies. A largely bottom-up 'egalitarian' process after some time can lead to the following situations:

- Actors in the system start to understand their role in the transition, start to understand the benefits that taking up this role has (or create the boundary conditions for benefits), and learn the skills to take up this role (which then basically leads to a shift to the 'individualist' mode);
- Actors in the system start to accept that a single actor or a group of actors take up a leading and dominant role in guiding the transition (which then basically leads to a shift to the 'hierarchist' mode)

And if one is bogged down in a 'fatalist' situation an external event or disaster might make it possible to switch swiftly to a governance style from another quadrant. The feeling that the US was losing the space race after the launch of the Soviet built Sputnik in 1957 and above all the launch of Yuri Gagarin as first human being in space in April 1961 prompted President Kennedy in May 1961 to announce the dramatic and ambitious goal of sending an American safely to the moon before the end of the decade (fatalist to hierarchist). Scandals in the Dutch building sector put it under so much pressure that there might now be an opportunity to investigate how a the transition to a more dynamic, innovative and client-oriented building cluster can be made (fatalist to egalitarian).

Figure 3.3: Governance modes for Factor X transitions



4 Concepts, classification and mapping of strategies

4.1 Introduction

This chapter presents a long list of concepts that relates to resource- and resource efficiency policy (section 4.2). We then derive on the basis of the former chapters the main dimensions on which these concepts should be evaluated (section 4.3). This then allows for classifying and mapping these concepts (section 4.4) after which we draw conclusions.

4.2 Long list of concepts

Within the project, a long list of concepts has been developed by UCL and WI, which was complemented by the other project partners. This list includes:

- industrial ecology,
- industrial symbiosis,
- Natural resource charter
- Model mining for sustainable development (MMSD)
- waste prevention,
- priority waste streams,
- eco-innovation,
- transition management,
- green growth,
- green economy,
- ecosystem goods and services,
- Capital approach: natural capital, inclusive sustainable growth
- novel approaches to multi-level (micro/meso/macro) governance.
- ‘Beyond GDP’
- ‘extended producer responsibility’
- supply chain management,
- cleaner production
- eco-efficiency,
- resource-efficiency aimed at reducing the impacts of industrial processes
- Pollution prevention pays
- Sustainable Consumption and Production
- Product-service systems
- Circular economy
- Lease society
- 3R
- Degrowth
- Resilience & safe operating space
- Ecological economics
- Natural Step
- Hannover principles
- Weak, strong and sensible sustainability
- BoP business models
- Leapfrogging
- Slow food, transition towns

- Small is beautiful / appropriate technology

4.3 Classification and mapping

4.3.1 Dimensions for classification

In Annex 2 we review some classifications for sustainability concepts developed in other contexts. For instance, the European Eco-innovation observatory uses as dimensions the Scope of change (system components or systems) and the Degree of change (in terms of incremental and radical). The OECD's Eco-innovation work again uses Scope of change but then different system elements as targets. In a project on sustainable consumption and production Tukker and Tischner (2006) use the Scope of change as parameter, by discerning the production and consumption side, next to the Degree of change (incremental and radical). One study use a social and environmental dimension in combination with Degree of change, whereas another classification is ultimately portrayed in a figure with an environmental, social and economic dimension and also a Degree of change.

It is not difficult to end up with dozens of criteria on which new concepts with regard to resource efficiency can be evaluated. A drawback of using many criteria is that one easily loses oversight. We hence prefer to reduce the number of criteria or parameters to at maximum three, allowing to plot concepts in a three-dimensional graph. We think that for the analysis of concepts in this paper at least the following dimensions are relevant, and propose to use a 3 point scale to define positions on these dimensions:

Scope of change. The scope with regard to which system is covered plays a role in virtually all researched classification systems, and seems also relevant given the long list of concepts mentioned in chapter 4. Some concepts focus on parts of the value chain, such as responsible mining. Others aim at transforming whole systems. We propose to classify initiatives in one of the following three categories

- Scope is a specific industry sector (e.g. mining)
- Scope is a value chain
- Scope is societal (sub)-systems (e.g. food, energy, mobility)

Ambition with regard to the (paradigmatic) degree of change. This resembles the degree of change found in many of the classification systems, but deliberately adds the adjective 'paradigmatic' to it. As discussed in chapter 2, currently the sustainability discussion is often still framed in the utilitarian, economic rationality that has dominated Western society since enlightenment and the industrial revolution. Many concepts simply still adhere to this existing paradigm. Other concepts however see the existing paradigm as a root cause of the sustainability problem, and hence argues that an upheaval in values, institutions, etc. is essential, towards a direction that some have dubbed 'Buddhist Economics'. This goes significantly further as the differentiation in incremental and radical change, which often just is focused on technical aspects. We see further that within the existing paradigm of utilitarian, economic rationality of use of nature there is a differentiation between objectives that emphasise predominantly the business opportunities and benefits for being sustainable and resource efficient – the role of authorities then simply is to remove market failures - and approaches that see also a threat to public goods – with authorities then having a role of protecting them. This leads then to the following three categories:

- No paradigmatic change, focus on market-based solutions
- Intermediate paradigmatic change in the sense that there is a recognition of the 'public good' character of resource-related problems that need government intervention
- Fundamental paradigmatic change, the concept clearly calls for a revolution in our economic system, related values, institutions, etc.

Explicit attention for drivers and pathways of change. Major historical changes like a 'resource revolution' do not happen automatically. Particularly with regard to radical, paradigmatic changes, Kuhn (1962) already noted that these are not frequent and only happen when the existing paradigm is about to become untenable. Concepts that respond to real life driving forces, or provide a clear pathway or formula how change must come about hence have value over concepts that don't. Some concepts that do not pay attention to this may propose change in directions that are not realistic and at best create a short-lived hype. Drivers for change should not be interpreted as deterministic phenomena: as authors analysing history from a co-evolutionary perspective have convincingly shown, both structure as agency play a role in shaping historical change. Factors that may help or hinder shaping a 'resource revolution' include real (physical or geopolitical) scarcity of resources; technological momentum, social momentum, and institutional momentum. We would propose the following three categories to classify concepts on this criterion:

- The concept ignores important factors that make the proposed change unnecessary;
- The concept only shows vaguely or conceptually why change is needed or could occur
- The concepts is clear in identifying pathways for change

With these dimensions, we do not address explicitly if the concept focuses on the environmental, social or economic aspects of sustainability or resource efficiency or which actors it addresses (industry, government, civil society). A good description of the scope of change and pathways of change will however make the latter clear. Further, particularly concepts proposing radical changes almost inevitably will address environmental, social and economic aspects.

This analysis suggest that concepts for sustainability, eco-efficiency or resource-efficiency need a description along the following lines:

1. The concept in brief: main aim, origins/authors, and history/impact
2. Scope of change
3. Ambition of change
4. Pathway of change
5. Actors addressed and if it mainly focuses on environmental, social and/or economic aspects

Annex 4 gives for all the concepts such descriptions. Next to this the concept is scored on the three main aspects discussed by presenting the following table and making the cells most applicable grey. For further classification and presentation purposes a 'low' score is also presented with -1, a 'medium' score is presented as 0, and a 'high' scores is presented as + 1.

Table 4.1: Evaluation dimensions and scoring criteria for concepts

	Low (-1)	**Medium (0)**	**High (+1)**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

4.3.2 Mapping

Of course for realising real radical changes towards for resource-efficiency one would like to see concepts that score high (+1) on all aspects. Radical changes towards resource-efficiency must after all

a) Address societal sub-systems rather than single value chains or an individual industry; the volume of change otherwise simply will be too low;
b) Have a high level of paradigmatic degree of change; as Einstein reputedly remarked "We can't solve problems by using the same kind of thinking we used when we created them."[8]
c) Must obviously also have a high plausibility of pathways of change, since otherwise change simply will not happen.

We refer for a detailed analysis of the concepts to Annex 4. We summarize the results of the mapping in Table 4.2, following the sequence of concepts provided in section 4.2. The analysis, mapping has been done and cross-checked by about 5-6 people in the study team. Differences in opinion on mappings have been circulated and were discussed in a phone meeting, in which a consensus mapping was reached. With this a fairly robust mapping probably has been reached, while acknowledging that an analysis like ours always has some residual level of subjectivity.

When looking at Table 4.2, and additionally Table 4.3 and 4.4 that cluster results somewhat differently, some results stand out.

a) There is not **any** concept scoring +1 on all aspects. Or, in other words, there is not any concept that aims at changes at societal level, that are radical and paradigmatic, and that at the same time provides a clear and plausible pathway of change.
b) We see further that by far the most concepts that have a credible/plausible pathway of change in fact do not aim at a high level of paradigmatic change. Indeed, most concepts (extended producer responsibility, supply chain management, green growth, cleaner production, pollution prevention pays and eco-efficiency) simply assume that changes will be driven by win-win concepts, while it is well-known that changes based on such drivers tend to be incremental.

[8] http://rescomp.stanford.edu/~cheshire/EinsteinQuotes.html; accessesd 25.97.2013

c) Conversely, we see that concepts aiming at a high level of paradigmatic change at best have conceptual explanation of factors explaining change.

Table 4.2: Mapping of concepts

No		Scope of change	Paradigmatic degree	Plausibility of paths
1	Industrial Ecology	1	-1	0
2	Industrial Symbiosis	0	-1	0
3	Waste Prevention	0	0	1
4	EPR	0	-1	1
5	Supply chain management	0	-1	1
6	Leasing society	1	1	-1
7	Ecological economics	1	1	0
8	Natural step	1	1	0
9	Weak	1	-1	1
10	Strong	1	0	1
11	Small is beautiful	1	1	0
12	Eco Innovation	1	0	1
13	Transition management	1	0	0
14	Green growth	1	-1	1
15	Green economy	1	0	1
16	Beyound GDP	1	-1	0
17	Cleaner production	0	-1	1
18	Eco-efficiency	0	-1	1
19	Resource efficiency	0	0	0
20	Pollution prevention pays	0	-1	1
21	SCP	1	0	0
22	PSS	1	1	0
23	Circular Economy	1	-1	0
24	3R	1	-1	0
25	De-growth	1	1	0
26	Resilience, SOP	1	1	0
27	Hannover principles	-1	1	-1
28	BoP business models	0	-1	0
29	Leapfrogging	0	0	0
30	Slow food, transition towns	1	1	0

Table 4.3: Concepts with a high plausibility of pathways of change

	Scope of change	Paradigmatic degree	Plausibility of paths
Waste Prevention	0	0	1
EPR	0	-1	1
Supply chain management	0	-1	1
Weak sustainability	1	-1	1
Strong sustainability	1	0	1
Eco Innovation	1	0	1
Green growth	1	-1	1
Green economy	1	0	1
Cleaner production	0	-1	1
Eco-efficiency	0	-1	1
Pollution prevention pays	0	-1	1

Table 4.4: Concepts with a high paradigmatic degree of change

	Scope of change	Paradigmatic degree	Plausibility of paths
Ecological economics	1	1	0
Natural step	1	1	0
Small is beautiful	1	1	0
PSS	1	1	0
De-growth	1	1	0
Resilience, SOP	1	1	0
Slow food, transition towns	1	1	0
Leasing society	1	1	-1
Hannover principles	-1	1	-1

4.4 Conclusion

While as discussed there may be dispute about the individual scores in the tables provided, this overall finding is in fact very much in line with a message system innovation and transition scholars have conveyed for decades. Radical and paradigmatic change implies a shift away from existing socio-economic trajectories, the related infrastructure and sunk costs, routines, and hence also a shift to new parties dominating the system. Resistance to such change is hence significant, as exemplified by e.g. the almost continuous failure of sustainability summits like Rio+20 (2012), the COPs in Copenhagen (2009), Durban (2011), etc. ‘New concepts’ like Degrowth, Ecological economics and Small is beautiful hence may point at new ideas for

organising society in a sustainable manner, but simply having an appealing idea – even if embraced by various groups in society - is by far not sufficient to foster revolutions that can overcome the resisting powers mentioned before. The transition management concept hence indicates that the existing system and parties with power in it must already be under significant pressure before they ‘crack’ and a real revolution becomes possible. It seems hence that all the concepts we analysed in fact just managed to be convincing on one or two of the three aspects relevant for far-reaching change.

5 Summary and conclusions

This deliverable analysed drivers for a resource-efficiency policy. It further evaluated over 25 popular sustainability concepts that could contribute to the resource agenda, such as degrowth, the circular economy, green growth, and cleaner production. For each concept the report analysed if it addressed a small or main part of society, if the proposed change would be incremental or radical, and if it provided a credible pathway for pursuing this change. The report found, to put it boldly, that concepts either provide

- a vision of far-reaching change, but fail to provide a plausible and credible pathway of how to realise this change, or
- a credible, win-win pathway for change, that upon closer look however is at best is likely to result in incremental change rather than radical change.

The reason for this finding is simple. Radical and paradigmatic change implies a shift away from existing socio-economic trajectories, the related infrastructure and sunk costs, routines, and hence also a shift to new parties dominating the system. Resistance to such change is hence significant. 'New concepts' like Degrowth, Ecological economics and Small is beautiful hence may point at new ideas for organising society in a radical more sustainable manner, but simply having such an appealing idea – even if embraced by various groups in society - is by far not sufficient to foster revolutions that can overcome the resisting powers mentioned before.

Unfortunately, the analysis of exogenous factors or autonomous developments that may force societal systems and dominant actors to move towards a 'resource revolution' seems to give little hope either. When we look at the resource constraints analysed in Chapter 2 (table 2.1) it seems that the external pressures are not as strong as sustainability supporters would hope. Distinguishing the different resource categories, the picture is roughly as follows:

a) Energy materials. Given the climate challenge there is in principle a need for a radical reduction of their use, or better said: impacts of use, with around a factor 10 by 2050. This radical reduction however will only take place if enough political will materialises to really embark on strong and radical climate policies. There is no proof or sign this will happen at this moment. Carbon emissions are rising steadily, and authoritative scenario producers like IEA and Shell now put futures central in their work that have given up hope that the 2°C target will be met. It is further unlikely that absolute scarcity of fossil energy will become a bottleneck in the next decades, significant amounts of coal and (shale) gas being still available.
b) Biotic materials. Their extraction is mainly limited by water and land use constraints in relation to biodiversity impacts, which on the basis of scenario studies by e.g. the Water resources group (2009) and FAO (Nature, 2010) may require a Factor 2 improvement of resource-efficiency by 2050. While this certainly is a challenge, it is probably one that can be realised by incremental rather than radical innovations and changes.
c) Building and construction materials. Apart from materials that during their production create significant emissions of carbon (e.g. cement, steel, aluminium), there is no clear sign that resource or emission constraints will lead to a need to limit their use. They are abundant. Any pressure on the use of materials such as cement, steel and aluminium must come from climate policies, which already has been identified as a highly uncertain thing to happen.

d) Metal ores and industrial minerals. Here we encounter a very mixed situation, where some materials may indeed see absolute scarcity in the next decades, but where in most cases supply disruptions are caused by geopolitical factors or market instabilities rather than real scarcity[9]. In such cases, simply learning better how to manage a market characterised by uncertainties in future demand, long lead times for opening mines, and dealing with geopolitical factors, can reduce many of the problems that exist today.

Overall, it seems hence that strong or unavoidable drivers based on absolute scarcity that can support radical improvements of resource-efficiency are not so dominantly present as sometimes assumed. It is unlikely that scarcity problems by themselves will drive a broad, strong resource revolution in the next decades, apart from maybe a number of specific metal ores and industrial minerals, next to a need for incremental resource-efficiency improvements for particularly the extraction and use of biotic materials.

This all leaves uncontested that on the longer term, humanity is probably is better off when moving towards a resource-efficient and circular economy. The Earth and its resources are finite. Continuing economic growth on a time span of over a century or more seems only viable by designing societal systems in such a way that that resources are kept in in closed loops (without that this needs significant energy or other resource input), or that they are based on massively abundant materials. The problem lies in the fact that to make this happen without directly present scarcity drivers, on the short term such change becomes a matter of societal and/or political will. The example of the climate dossier learns us that this is a very shallow basis to make radical change happen, and none of the concepts reviewed provided a convincing answer to this problem.

[9] A clear example of this are Rare Earth Elements. In 2002 low prices of Chinese mines next to environmental problems led to closure of the only Western mine left, the US Mountain Pass mine, that had dominated supply for decades. The total value of REE materials mined annually was less as 1 billion US$ at the time. Although demand was expected to rise, the level to which was uncertain, and the (minor) mining companies in the West simply could not take the risk nor attract the capital to anticípate this new demand by opening new mines. Around 2007, China foresaw that it needed most of the nationally mined REE for its own industry, and started to reduce exports which led subsequently to a supply crisis in the West – high price volatility, price hikes. etc. Only then the West scrambled to see if new mines could be opened on the shortest posible notice – which given the long lead time to open mines would still take years. Given the fact that proven reserves of REE that can be mined economically are 800 times anual use, this crisis clearly has nothing to do with scarcity.

6 Annex 1: Definitions with regard to resource-efficiency[10]

6.1 Introduction

The concept of eco-efficiency was introduced to describe a broad management objective to decouple economic activity from natural resource use and pollution (Schmidheiny, 1992). Since then, it has been the subject of considerable discussion and analysis (see, for example, DeSimone and Popoff, 1997, where it was defined as relating to "activities that create economic value while continuously reducing ecological impact and the use of natural resources" [p.xix]), and has gained ground in many different countries and disciplines.

Resource (or eco-) productivity, resource efficiency, and resource intensity are all terms that are also used in this field, and can be seen as specific indicators of the broader concept of eco-efficiency, although in some instances resource efficiency is interpreted as a measure of resource productivity. In reality, the many related terms and concepts tend to be used rather indiscriminately and interchangeably. While the diversity and scope of application are encouraging, it is also obvious that eco-efficiency has become an umbrella term, under which many different measures and practices confusingly co-exist[11]. As eco-efficiency practices spread, and more disciplines and practitioners get involved, the lack of clear-cut definitions is likely to give rise to more confusion and cross-purpose communications.

In particular, there is often a need to differentiate between eco-efficiency measures which look at trends in economic output per unit of physical input or polluting output (such measures are closest to the definition of eco-efficiency in DeSimone and Popoff 1997, cited above), and measures which examine trends in physical output per unit of physical inputs. Both these types of measure are important indicators, as they highlight aspects of eco-efficiency that are qualitatively very different.

In order to bring some clarity to the terms in this field, and bring some consistency and coherence to the terminology of eco-efficiency indicators, all of which are basic ratios between two variables, this project will distinguish between *resource efficiency*, *resource productivity* and *resource intensity*. These distinctions in terminology also capture whether the indicators have numerators in monetary or physical units.

6.2 Resource efficiency

Resource efficiency is defined by Dahlstrom and Ekins (2005) as a basic ratio of two resource variables of the same kind, that is, the ratio is dimensionless. For example, material efficiency is measured as a ratio between useful material output, M_o, and material input, M_i, such as useful material output per total material input:

M_o/M_i = material efficiency

[10] This section is adapted from, but follows closely the argument of, Dahlstrom, K. & Ekins, P. 2005
[11] The UNEP Cleaner Production website gives a brief overview of some of these terms, but does not distinguish them rigorously, see (http://www.uneptie.org/pc/cp/understanding_cp/related_concepts.htm)

And energy efficiency is useful energy output, E_o, per input of energy, E_i:

E_o/E_i = energy efficiency

These definitions of resource efficiency are therefore consistent with the definition of efficiency used in engineering. It is also consistent with the economic concept of efficiency, which relates to economic outputs and inputs, Y_o/Y_i, although one difference is that engineering efficiencies are always less than 1 (e.g. $M_o < M_i$), whereas for a profitable company $Y_o/Y_i > 1$.

Other definititions are given by:

- Wuppertal Institute: Resource efficiency means in general the relation of a desired output of a process to the related resource requirement or -input. If the output is an economic measure, e.g. value added or GDP, we speak in the context of whole economies of "resource productivity". Resource efficiency of processes, however, can also refer to physical relations, e.g. the relation of used raw material extraction to the total extraction of primary materials.
- EU DG ENV (2011): Resource efficiency means producing more value using less material and consuming differently, to limit the risks linked with scarcity and for less environmental impacts, within our planet's natural limits. It concerns the sustainable management and use of resources throughout their life cycle - from extraction, transport, transformation, consumption to the disposal of waste. Resources include all material and natural resources, from food, timber, and biodiversity in the widest sense, to energy, metals, soil, water, minerals, our atmosphere and land.

6.3 Resource productivity

Productivity, on the other hand, tends to be used in relation to the production of some kind of welfare or, more broadly, the production of some other useful output, by an input. The welfare outcome can be measured by economic output, Y_o, so that material productivity would be the economic output per unit of natural resource input:

Y_o/M_i = material productivity

or economic output per input of energy:

Y_o/E_i = energy productivity

This definition of resource productivity has been advocated as a measure of the effectiveness with which the economy generates added value from the use of nature, and which can therefore tell whether economic growth is decoupling from resource use (PIU, 2001). Choosing specific variables to operationalise the indicator will depend on the unit and purpose of analysis as well as data availability constraints. For analysis of resource productivity trends at the firm level, a range of indicators has been suggested (see e.g. WBCSD, 2000), while at the sectoral and national levels the choices are more constrained.

This definition is also analogous to the concept of labour productivity, which is measured as GDP or value added per worker, L, and is a key indicator of economic productivity at the national level:

Y_o/L = labour productivity

However, while productivity as a term is associated with a welfare outcome, in a broader sense it obviously just refers to the production of some (desirable) factor (the numerator) by some other factor (the denominator). For example, we might wish to examine not just the economic output per worker, but also the useful material output per worker:

M_o/L = material productivity of labour

or the useful material output per input of energy:

M_o/E_i = material productivity of energy

Sometimes, of course, the various indicators might be linked. For example, in mining or smelting one might expect a good quality mine or ore to have a relatively high material productivity of energy (M_o/E_i), implying high relative material output per unit of energy input, along with a relatively high material efficiency (M_o/M_i), implying relatively low mining waste or furnace slag.

Other definitions of resource productivity include:

- Bleischwitz et al. (2007): Resource productivity describes the relation between economic outputs in monetary terms (Y – numerator) and a physical indicator (M – denominator) for material or resource input.
- OECD (2008): According to the OECD (2008) the term 'resource productivity' is […] put in a welfare perspective and is understood to contain both a quantitative dimension (e.g. the quantity of output produced with a given input of natural resources) and a qualitative dimension (e.g. the environmental impacts per unit of output produced with a given natural resource input).

6.4 Resource intensity

Resource intensity is defined as the inverse of resource productivity, so that labour intensity would be measured as L/Y_o, and energy intensity as E_i/Y_o. It can also refer to the production of some undesirable output (often resulting in pollution) by some other factor, for example carbon dioxide output, C, per unit of energy input:

C_o/E_i = the carbon (emission) intensity of energy (which, assuming no abatement of carbon emissions, is the same as the carbon intensity of the energy inputs, C_i/E_i)

or the output of pollution or waste, P, per unit of material inputs:

P_o/M_i = the pollution intensity of material inputs

or the output of pollution or waste, P, per unit of economic output:

P_o/Y_o = the pollution intensity of output

For carbon emissions, with no carbon abatement, the carbon (emission) intensity of output, C_o/Y_o, is the product of the carbon intensity of the energy inputs and the energy intensity of output, i.e. $C_o/Y_o = C_o/E_i \times E_i/Y_o$.

6.5 Eco-efficiency

Returning again to the term 'eco-efficiency', this is sometimes applied to the ratio Y_o/P_o, the inverse of the pollution intensity of output, to capture the fact that pollution may be thought of as having a negative impact on the natural capital base that supports economic production and human welfare. In other words, although this eco-efficiency indicator actually relates two *outputs* from production, one desired the other undesired, the P_o term is intended to act as a proxy for an undesirable impact on production *inputs*, so that the indicator serves as a ratio of output to input as in the uses of the term efficiency above. Clearly eco-efficiency in this sense will increase when, other things being equal, production increases or pollution declines.

6.6 Summary

Box A1.1 summarises the above discussion of the terminology that will be used in this project for these different indicators of the various concepts related to resource-efficiency.

Box A1.1: Summary of terminology for Resource Efficiency Indicators

Ratio of two identical resource variables. For example, a ratio between material output, M_o, and material input, M_i, or between energy output, E_o, and energy input, E_i:

M_o/M_i = material efficiency

E_o/E_i = energy efficiency

Resource Productivity

Ratio of two different variables. Numerator measured by some welfare, Y, indicator unless otherwise qualified:

Y_o/M_i = material productivity

Y_o/E_i = energy productivity

Y_o/L = labour productivity

Or a ratio of any two variables of interest which indicate the production of a (non-welfare) numerator by a denominator:

M_o/L = material productivity of labour

M_o/E = material productivity of energy

Resource or Pollution Intensity

The inverse of resource productivity, or the production of some undesirable factor by some other factor:

E_i/Y_o = energy intensity

C_o/E_i = the carbon (emission) intensity of energy

P_o/Y_o = the pollution intensity of output

C_o/Y_o = the carbon (emission) intensity of output

Eco-efficiency

As discussed above, the inverse of pollution intensity:

Y_o/P_o = the eco-efficiency of production

7 Annex 2: Some definitions of sustainability

Box A2.1: Some definitions and objectives of sustainable development

IUCNNR, UNPE and WWF (1980) 'For development to be sustainable, it must take account of social and ecological factors, as well as economic ones: of the living and non-living resource base, and of the long-term and short-term advantages and disadvantages of actions'

WCED (1987): 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'

Rio Declaration / UNCED (UN, 1992): the 27 principles agreed upon to support sustainable development include (1) that 'Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life.'(3) 'The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations; (4) 'environmental production shall constitute an integral part'; (5) 'eradicating poverty [is] and indispensable requirement for sustainable development' and (8) 'States should reduce unsustainable patterns of production and consumption […]'

Johannesburg Plan of Implementation / WSSD (UN, 2002): This plan 'strongly reaffirm[s] commitment to the Rio principles', and suggests to promote the integration of the three components of sustainable development - economic development, social development and environmental protection- as interdependent and mutually reinforcing pillars.

The UN Millennium goals (UN, 2000) although having a more generic character, clearly embrace sustainability principles: 1) Eradicate extreme poverty and hunger; 2) Achieve universal primary education; 3) Promote gender equality and empower women, 4) Reduce child mortality; 5) Improve maternal health; 6) Combat HIV/AIDS, malaria and other diseases; 7) Ensure environmental sustainability; and 8) Develop a global partnership for development.

The EU (2006) sets in its Sustainable Development Strategy the following Key objectives:

ENVIRONMENTAL PROTECTION
Safeguard the earth's capacity to support life in all its diversity, respect the limits of the planet's natural resources and ensure a high level of protection and improvement of the quality of the environment. Prevent and reduce environmental pollution and promote sustainable production and consumption to break the link between economic growth and environmental degradation.

SOCIAL EQUITY AND COHESION
Promote a democratic, socially inclusive, cohesive, healthy, safe and just society with respect for fundamental rights and cultural diversity that creates equal opportunities and combats discrimination in all its forms.

ECONOMIC PROSPERITY
Promote a prosperous, innovative, knowledge-rich, competitive and eco-efficient economy which provides high living standards, and full and high-quality employment throughout the .European Union.

MEETING OUR INTERNATIONAL RESPONSIBILITIES
Encourage the establishment and defend the stability of democratic institutions across the world, based on peace, security and freedom. Actively promote sustainable development worldwide and ensure that the European Union's internal and external policies are consistent with global sustainable development and its international commitments.

8 Annex 3: Natural constraints with regard to resource use

The fear that humans will run out of natural resources is not a new phenomenon. Centuries ago, Malthus feared that humanity inevitably would face a period of starvation since in his time, population growth was quicker as the growth of agricultural production. Limits to Growth (Meadows et al, 1972) warned for a collapse of society due to overexploitation of resources, something that at least until now did not yet materialise.

Some statistical evidence however provides at least food for thought. In the past fifty years humans have consumed more goods and services than in all previous generations put together. The Earth's natural resources are used at an unprecedented, and still fast rising rate (see Figure A3.1). And we still have billions living in poverty, implying that material economic growth is essential to create decent lives for all. A simple estimate indicates we need to quadruple the current global GDP from 50 trillion US$ to 200 trillion US$ to eradicate poverty by 2050:

a) There are currently 1 billion people in the rich OECD with an average GDP/capita of 50.000 US$, and another 1-2 billion in fast growing economies in the process of becoming part of this 'global middle class' (WBCSD, 2009; Meyers and Kent, 2004). Unless we reduce income in the OECD and aspirations in the BRICS countries, which form a political 'no-go area', this implies an income of some US$100 trillion in total by 2050;
b) By 2050 there will be 7-8 billion people in poorer economies, who would need some US$10-15,000 per capita, which is persistently shown in the literature as the minimum for countries to arrive at reasonable life spans, human-development indices, etc. (Layard, 2005, Abdallah et al., 2009; Jackson, 2009). This results in a further US$ 100 trillion in total by 2050.

Various sources estimate that despite relatively decoupling of economic growth from resource use such business as usual scenarios until 2050 may lead to an annual resource extraction that is 2 to 4 times higher as in 2000 (Fischer-Kowalski et al, 2011; Tukker, 2013; SERI, Global 2000 and Friends of the Earth Europe, 2009). This is, from almost any perspective, a trajectory that at some point that must 'crash the economy against the Earth' (cf. Speth, 2008; Rockström et al., 2009).

Using a classical division of natural resources into fossil fuels, metal ores and industrial minerals, building and construction minerals, biomass, land, and water, it is interesting to see what current literature says about potential future resource constraints. This analysis is summarized in Table A3.1, and roughly provides the following picture.

Figure A3.1: Global material extraction in billion tons, 1900-2005 (Krausmann et al., 2009).

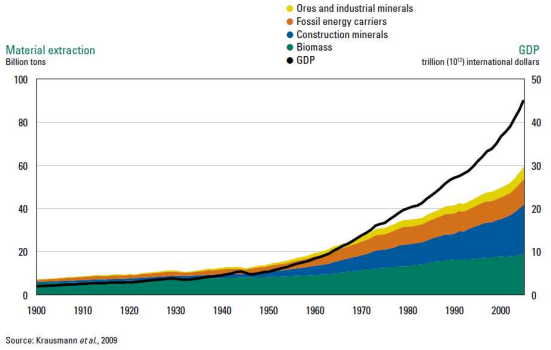


Table A3.1: Potential resource constraints

Type of resource	**Fraction of global resource extraction**	**Basis for planetary limits**	**Potential limit**	**Reference**
Fossil fuels	20%	Absolute scarcity CO_2 emission targets	EU greenhouse gas (GHG) targets (20-20-20 or30% reduction by 2020) Scientific targets (>80% reduction by 2050)	IPCC (2007), EC (2008, 2010), Meinshausen et al. (2009).
Biomass	30%	Maximum human appropriation of net primary production of biomass (HANPP)	Currently, 30%-35% of available biomass is extracted by humans. Target may be stabilization or minor growth	Vitusek et al. (1986), Haberl et al. (2007).
Metal ores and industrial minerals	10%	Absolute scarcity (varies by metal). Most metal ores need high levels of energy to be transformed, implying a 'linkage' to CO_2 emission targets and energy constraints	Focus on 14 critical raw materials identified in the Raw Materials Initiative. Changes in energy and mobility infrastructure (solar cells, batteries) determine future criticality	EC (2010). For linkages with energy use, see Graedel and Van der Voet (2010).
Construction minerals	40%	Absolute scarcity seems irrelevant, except in densely populated areas where space for sand, clay and gravel mining is limited.	Implicit targets for construction minerals that need high levels of energy in their production (e.g., cement, ceramics) and linkages to land use targets (e.g. soil sealing)	For linkages: e.g. Hanle et al. (2006). http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf
Land	p.m. (not expressed as mass)	Available bioproductive land, with reservations for nature areas (e.g., rainforests)	Conflicting information about remaining areas that can be converted to agricultural use	Erb et al. (2009), OECD/FAO (2009), Nature (2010a and b), WWF (2010). EC 'Soil sealing guidelines' (2012)
Water	p.m. (usually not included in Material Flow Analysis)	Renewable supply (varies by region); agriculture is dominant user	A global 'water gap' of 30% expected in 2030,	Hoekstra and Chapagain (2007), Water resources group/ McKinsey (2009).

- Fossil fuels: As such they are not scarce (yet). Particularly coal and shale gas is still available for decades to centuries (IEA, 2012). The real constraint with regard to their use are the now obvious limits of the atmosphere to store CO_2. In absence of massive diffusion of storage technologies like CCS, this implies the need for a fast reduction of use of fossil fuels. Meinshausen et al., 2009 estimated that to stay within a 2°C between 2000 and 2050 at maximum 1000 Gt CO2 can be emitted, where current emissions of greenhouse gases are over 40 Gt CO2-equivalent per annum. An absolute reduction of a Factor 4 or more is required by 2050 to stay within the 2°C limit (Stern, 2006, IPCC, 2007). In combination with an expected Factor 4 economic growth, this implies a decarbonisation of a Factor 10 to 20 of our economy by 2050.
- Metal ores and industrial minerals: shortage of 'critical materials' is becoming apparent (EC, 2010). For many minerals this is in part due instability in supply countries, or (temporary) concentration of supply in few countries. The most prominent current shortage, of rare earths, mainly is due to this phenomenon, related to market failure and plain short sightedness. Since 2002, China has become the dominant supplier of rare earths, and for a variety of reasons it is restricting exports since around 2008. Yet, the amount of economically available reserves are over 800 times current use. A main problem was that no one in the Western world thought about creating spare mining capacity outside China after the last main Western mine, the Mountain Pass mine in the US, closed in 2002. Western mining firms active in the rare earth business themselves were too small to attract capital in the relatively marginal global market of rare earths (a total turnover of some 1 billion dollar in 2007). Having said this, absolute shortage may occur for such rare earths in the next decades in case of a drastic transition to new energy and automotive systems. These high tech systems require such amounts of critical materials, that if implemented broadly, there is concern that enlarging mining capacity quick enough, and even absolute availability may provide a bottleneck for such a 'cleantech' transition (Kleijn, 2012).
- Building and construction minerals: in general, it concerns materials such as rock, stone, clay, and sand, which at global scale are abundant. The most pressing problem is the linkage with energy use. Some building materials like cement, steel and aluminium require a significant energy use in their production, and hence make significant contributions to carbon emissions. Another potential linkage exists to land use (conflicts) and soil sealing associated with large construction projects (EC, 2012). With buildings and infrastructure even in densely populated countries like the Netherlands covering just some 10-15% of the available land areas, this linkage is however clearly less relevant as the one between biomass and land use.
- Biomass, in relation to Land use: The Human Appropriation of Net Primary Production (HANPP) of biomass produced on Earth is already over 30% which leaves little room for expansion (Vitousek et al, 1986; Haberl et al., 2007). The Millennium Ecosystem Assessment (Mooney et al, 2005) shows the critical impacts on biodiversity, particularly with regard to fish stock and rain forests. Having said this, if land use will become a constraint in future is controversial (cf. Bringezu et al., 2012). Land use is predominantly related to agricultural production and forestry. A special issue of Nature (2010) on land use and food production flatly declared 'land is not the problem', suggesting productivity growth would solve the problem.
- Water: By 2030, a 'water gap' will exist of 40% of the global need for freshwater (Water resources group, 2009). Around of 70% of global freshwater supply used in agriculture, 10% in industry, 10% as cooling water, and just 10% for household purposes. Closing the water gap is hence predominantly a challenge related to food production and agriculture, although

locally also mining can be an important user of water and source of water quality problems (Bleischwitz et al., 2012).

9 Annex 4: Some existing classifications of sustainability strategies

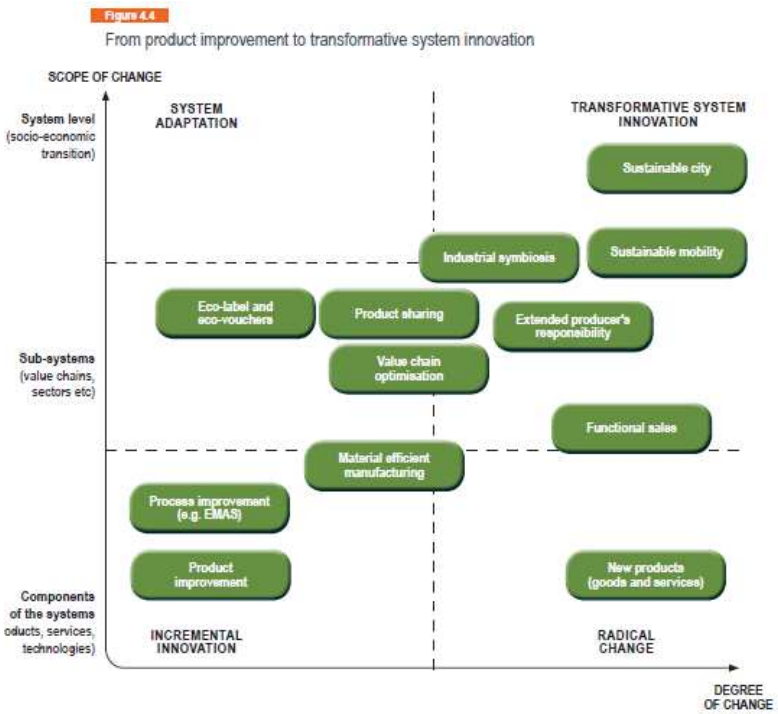
9.1 Introduction

Chapter 4 of this document tries to classify a long list of sustainability concepts that are related to a more efficient use of resources. We review here as a support of the discussion in Chapter 4 a number of other studies that came up with classifications.

9.2 Some classifications

Figure A4.1 provides the classification of eco-innovations from the European Eco-Innovation Observatory (2013). This conceptualisation discerns two dimensions: the degree of change (system adaptation, or systems transformation), and the scope of the system that is changed (system components such as individual technologies or products; sub-systems such as value chains; or transformations of major parts of society, such as the energy system, the urban system, etc.).

Figure A4.1: Classification of eco-innovations from the EU Eco-innovation observatory; Annual Report 2012, January 2013

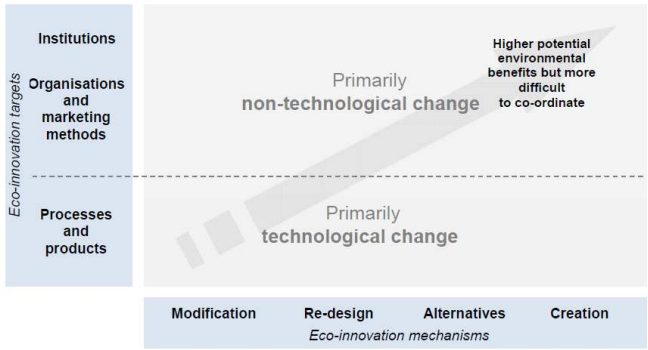


A second classification of eco-innovations is given by the OECD (2009) in its Sustainable Manufacturing and Eco-Innovation Synthesis Report (see Figure A4.2). The x-axis resembles very much a parameter that is also used by the EU Eco-innovation observatory: modification of

existing systems or creation of fully new systems. The y-axes however looks at elements of the system that is targeted, rather than the scope of the system: products and processes, organisation and marketing methods, or institutions.

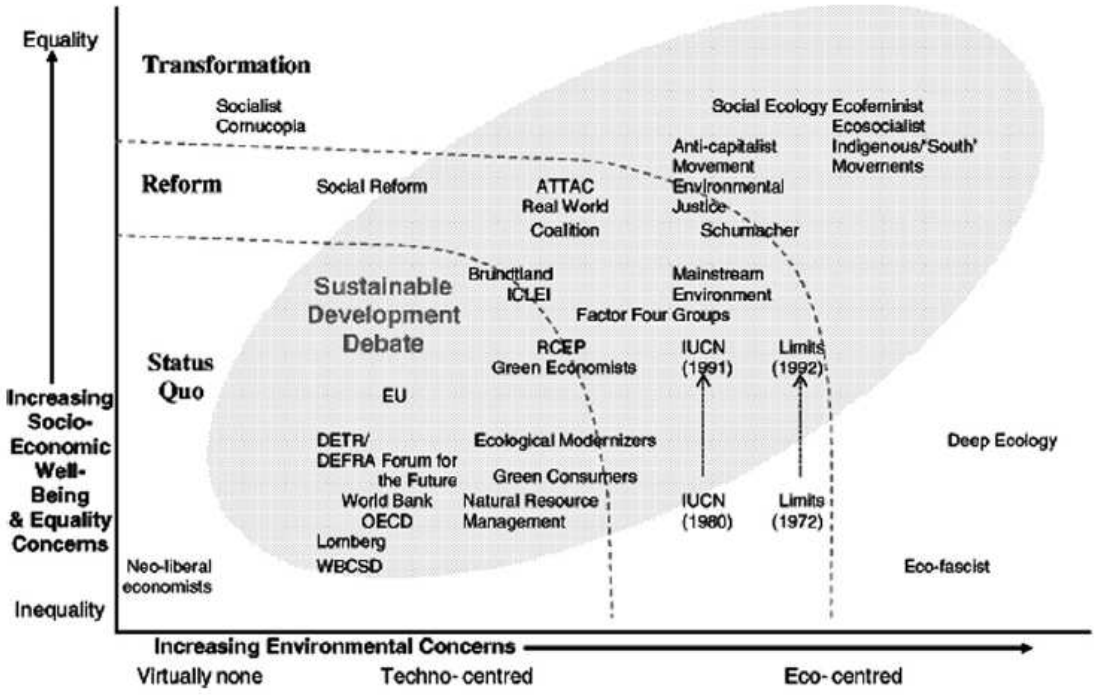
A4.2: A typology of eco-innovations (OECD, 2009)

Figure 4. The typology of eco-innovation



Lombardi et al. (2011) use a classification of Hopwood et al. (2005) to organise various view on sustainable development. Again, the x-axis gives the lever of transformation required, but focuses on the environmental aspect of sustainability only. The y-axes covers the level of importance given to human well-being and equality, and is hence clearly of a socio-economic nature.

Figure A.4.3. Mapping of views on sustainable development from Hopwood et al. (2005, figure 1)



Tukker and Tischner (2006) identify five main intervention points along the production-consumption chain that each can improve the resource-intensity of our economic. In short it concerns (see also Figure A4.4):

1a: End of pipe / reducing emission factors
2a: Greening products and service systems – enhancing productivity
2b: as 1a and 2a, but creating 'Factor X' improvements via system innovation of products and processes;
3: Intensifying the use of products via product-service systems
4: Enhancing immaterial consumption / less impact intensive expenditure;
5: Enhancing quality of life without additional expenditure.

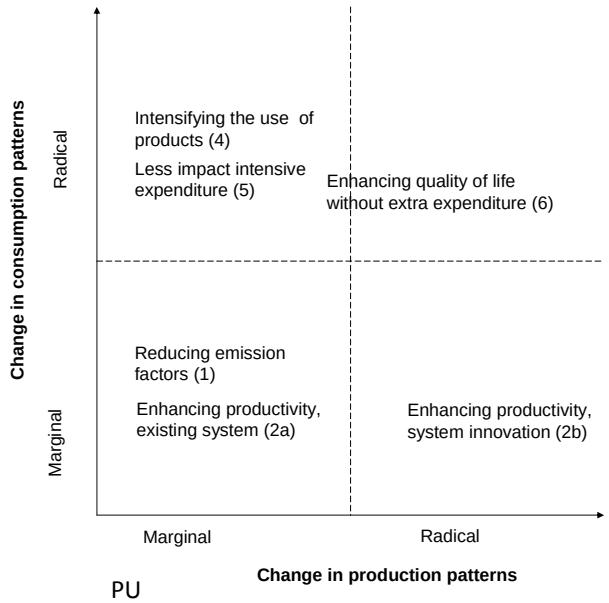
These improvement strategies now can be plotted on two axes: if the address production or consumption and if they are radical or incremental (see Figure A2.5)

Figure A4.4: Intervention points along the production-consumption chain and potential decoupling factors (Tukker et al., 2010)

Production side *Eco-efficiency strategies*		-----	**Consumption side** *Sufficiency strategies*	
Mining and Production	**Products and services**	**Use of products and services**	**Expenditure mix**	**Quality of life realised**
New tech-nology and end of pipe	***Greening products and service systems***	***Intensifying use ('PSS')***	***Enhancing immaterial consumption***	***Improving QoL/Euro spent***
20-50% Factor X	***20-50% Factor x***	***Factor 2***	***Factor 2***	***Factor 2-4***
↑		***Invest green***		←

Close material loops

Figure A4.4: Level of change in production and consumption patterns in relation to different decoupling strategies (Tukker and Tischner, 2006)



Finally, GWS (2013). developed a classification of 'Green Growth' strategies on on the basis of some 16 criteria. They ultimately map all strategies in a three dimensional framework that discerns an economic, environmental, and social axis, and the emphasis that is given to each of this aspects. For the economic axis, interestingly not only emphasis on growth is made visible, but also if a strategy emphasizes negative growth or 'degrowth'.

Figure A4.5: Classification of Green Growth strategies (GWS, 2013).

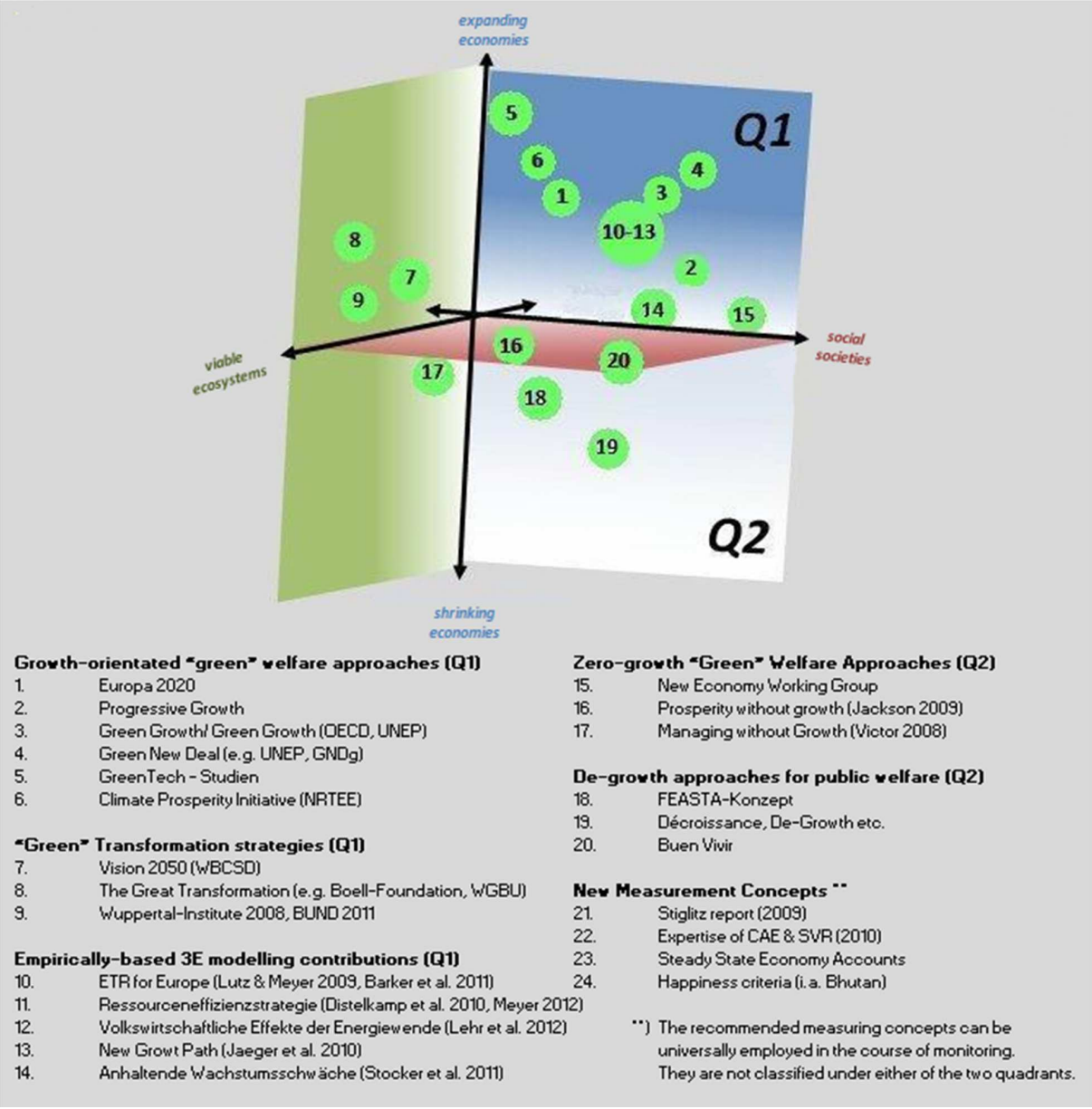


Table A4.1: Criteria used to evaluate green growth models (GWS, 2013).

The systematic evaluation of current reform approaches and "green" growth, steady state or de-growth models was carried out on the basis of a common matrix of questions which contains 16 criteria.

Criteria 1 to 4 are to give indications on the range of the evaluated reform approaches with regard to possible targets.

1. Which environmental targets are addressed?
2. Contribution to problem solving – reduction of physical impacts?
3. Contribution to problem solving – welfare benefits even without growth?
4. Contribution to problem solving – avoiding negative social implications?

Criteria 5 to 7 are related to a possible structural change in the economy.

5. Are the effects on employment and jobs addressed?
6. Is structural change in sectors and/or regions or are specific industries looked at?
7. To what extent are globalisation processes taken into account?

Criteria 8 to 10 contain questions about threats tor the welfare of society which may be concealed or underestimated in many cases.

8. How is the danger to welfare through defensive costs dealt with?
9. How is the danger of increasing resources and energy costs dealt with?
10. How is the danger to welfare taken into account which is caused by "pseudo-welfare" as a result of over-indebtedness?

Criteria 11 and 12 address the measurement of growth and welfare. (Indicator systems are examined more closely in Part 2 of the project where the National Welfare Index has been developed further.)

11. How are the benefits of and damages to welfare discussed on a conceptual level?
12. What is the role of measurement systems and indicators?

Criteria 13 to 16 are intended to offer suggestions concerning institutional foundations and political constellations which could be important for a sustainable welfare concept.

13. Which players and institutions are involved and affected?
14. What is the state of practical implementation of the welfare concept?
15. Which special factors affect its implementation (opportunities, obstacles)?
16. Has the interference with the economic system been addressed?

9.3 Dimensions to be used in this paper

In view of the classifications and dimensions discussed, and the analysis in chapter 1-3, it seems appropriate to use the following parameters to evaluate new sustainability and resource-efficiency concepts.

The Eco-innovation observatory uses as dimensions the Scope of change (system components or systems) and the Degree of change (in terms of incremental and radical). The OECD again uses Scope of change but then different system elements as targets. Tukker and Tischner too use the Scope of change as parameter, by discerning the production and consumption side, next to the Degree of change (incremental and radical). Hopwood et al. use a social and environmental dimension in combination with Degree of change. The GWS classification is somewhat more complex, but ultimately portrayed in a figure with an environmental, social and economic dimension and also a Degree of change.

As the GWS study indicates it is not difficult to end up with dozens of criteria on which new concepts with regard to resource efficiency can be evaluated. A drawback of using many criteria is that one easily loses oversight. We hence prefer to reduce the number of criteria or parameters to at maximum three, allowing to plot concepts in a three-dimensional graph as exemplified in Figure A2.5. We think that for the analysis of concepts in this paper at least the following dimensions are relevant, and propose to use a 3 point scale to define positions on these dimensions:

Scope of change. This plays a role in virtually all researched classification systems, and seems also relevant given the long list of concepts mentioned in chapter 4. Some concepts focus on parts of the value chain, such as responsible mining. Others aim at transforming whole systems. We propose to classify initiatives in one of the following three categories

- Scope is a specific industry sector (e.g. mining)
- Scope is a value chain
- Scope is societal (sub)-systems (e.g. food, energy, mobility)

Ambition with regard to the (paradigmatic) degree of change. This resembles the degree of change found in many of the classification systems listed above, but deliberately adds the adjective ‘paradigmatic’ to it. As discussed in the main report, currently the sustainability discussion is often still framed in the utilitarian, economic rationality that has dominated Western society since enlightenment and the industrial revolution. Many concepts simply still adhere to this existing paradigm. Other concepts however see the existing paradigm as a root cause of the sustainability problem, and hence argues that an upheaval in values, institutions, etc. is essential, towards a direction that some have dubbed ‘Buddhist Economics’. This goes significantly further as the differentiation in incremental and radical change, which often just is focused on technical aspects. We see further that within the existing paradigm of utilitarian, economic rationality of use of nature there is a differentiation between approaches that emphasise predominantly the business opportunities and benefits for being sustainable and resource efficient – the role of authorities then simply is to remove market failures - and approaches that see also a threat to public goods – with authorities then having a role of protecting them. This leads then to the following three categories:

- No paradigmatic change, focus on market-based solutions
- Intermediate paradigmatic change in the sense that there is a recognition of the ‘public good’ character of resource-related problems that need government intervention
- Fundamental paradigmatic change, the concept clearly calls for a revolution in our economic system, related values, institutions, etc.

Explicit attention for drivers and pathways of change. Major historical changes like a ‘resource revolution’ do not happen automatically. Particularly with regard to radical,

paradigmatic changes, Kuhn (1962) already noted that these are not frequent and only happen when the existing paradigm is about to become untenable. Concepts that respond to real life driving forces, or provide a clear pathway or formula how change must come about hence have value over concepts that don't. Some concepts that do not pay attention to this may propose change in directions that are not realistic and at best create a short-lived hype. Drivers for change should not be interpreted as deterministic phenomena: as authors analysing history from a co-evolutionary perspective have convincingly shown, both structure as agency play a role in shaping historical change[12]. Factors that may help or hinder shaping a 'resource revolution' include real (physical or geopolitical) scarcity of resources; technological momentum, social momentum, and institutional momentum. We would propose the following three categories to classify concepts on this criterion:

- The concept ignores important factors that make the proposed change unnecessary;
- The concept only shows vaguely or conceptually why change is needed or could occur
- The concepts is clear in identifying pathways for change

With these dimensions, we do not address explicitly if the concept focuses on the environmental, social or economic aspects of sustainability or resource efficiency or which actors it addresses (industry, government, civil society). A good description of the scope of change and pathways of change will however make the latter clear. Further, particularly concepts proposing radical changes almost inevitably will address environmental, social and economic aspects.

This analysis leads to the suggestion to analyse different concepts for sustainability, eco-efficiency or resource-efficiency along the following lines (about half A4 per concept):

1. The concept in brief: main aim, origins/authors, and history/impact (5-10 lines)
2. Scope of change (2-3 lines)
3. Ambition of change (2-3 lines)
4. Pathway of change (2-3 lines)
5. Actors addressed and if it mainly focuses on environmental, social and/or economic aspects (2-3) lines

Next to this the concept can be scored on the three main aspects discussed by presenting the following table and making the cells most applicable grey.

[12] The concept of "conjunctural contingent meso-history" (CCM) developed by Little (2000) formulates this as follows: "[CCM] recognizes the role of agency—leaders, inventors, engineers, activists, and philosophers are able to influence the course of development in particular historical contexts. It recognizes the multiplicity of causes that are at work in almost all historical settings—thereby avoiding the mono-causal assumptions of much previous macro-history. And it recognizes, finally, that there are discernible structures, processes, and constraints that recur in various historical settings and that play a causal role in the direction and pace of change (…) The presence of certain large-scale factors which are commonly associated with outcome X will not guarantee that X occurs in this circumstance too. Rather, a compelling large-scale explanation will be local in its analysis of circumstance, and large-scale in its recognition of the common workings of certain general factors (population increase, extension of markets, technological change, etc.). At the same time, the CCM view postulates a firm rebuttal to the subjectivist historiography that implicitly asserts the full plasticity of historical process. Given the conjunction of factors in place at a certain time, certain futures are more likely than others, and certain pathways of development are inaccessible".

Table A4.2: Classification dimensions and scoring criteria

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10 Annex 5: Description and classification of concepts

10.1 Industrial Ecology

	Description
Main aim / origins /history	The concept of industrial ecology (IE) proposes a system-oriented view to analyse the interactions between human and natural systems. In an attempt to minimize the impact of production and consumption processes on natural systems, "*IE seeks to optimize the total industrial materials cycle from virgin materials to the finished product to ultimate disposal of waste*" (Graedel, 1994). Generally, the origins of the concept are attributed to Frosch and Gallopoulus (1989) that in their seminal paper Strategies for Manufacturing, allude to what has been later termed as the "*ecological metaphor*", the idea that industrial systems should mirror the efficiently functioning of natural systems, where waste of process becomes a resource for another process or organism. In the same year, Ayres (1989) published a paper on Industrial Metabolism defining some of the key ideas and pillars of the field. IE proposes a profound restructuring of production and consumption systems from a mainly linear design where raw materials are extracted from natural systems, transformed and consumed and then released to the biosphere, to a circular, closed-loop system where resources are cascaded and recycled within the system, "*favouring an industrial metabolism that results in reduced extraction of virgin materials, reduced loss of waste materials, and increased recycling of useful ones*" (Ayres, 1989).
Scope of change	The scope of change proposed is thus high involving all parts of the supply chain and the manufacturing and consumption systems as a whole. However, most of the research in the field has focused on production systems and business actors, while the analysis of consumption systems and individual behaviour has been insufficiently explored.
Paradigmatic degree of change	IE suggests a change of paradigm in the way human systems function and are organised, moving towards a more holistic paradigm where human systems are restructured following the principles that govern biological systems. However, the policy agenda of industrial ecology is underdeveloped and still contains a profound utilitarian-rational pose. Alternatives are mainly based on win-win solutions, where improvements in the efficiency of the system leads to economic gains.
Plausibility of pathways of change	The concept offers some clear guidance with regard to the necessary changes in the technical/production spheres but there is limited discussion of the societal changes this would imply. There have been some attempts to introduce social considerations to the transformation of industrial systems proposed (Binder, 2007). However, aspects such as social justice or equity are rarely addressed. Main actors leading the change are industrial actors and technology. The role of policy makers is set back to defining the appropriate institutional framework to allow for the changes operated in production and consumption system.
Actors addressed (industry, government, civil society) environment/social/economic aspects	Main actors addressed are industry and businesses from different supply chains and to a lesser extend consumers. The role of government is generally secondary to define the general framework for industrial actors cooperation. Environmental and economic dimensions are the focus of the approach, with little attention to the societal dimension.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.2 Industrial Symbiosis

	Description
Main aim/origins/history	Within the field of industrial ecology, industrial symbiosis (IS) is principally concerned with the *"cyclical flow of resources through networks of businesses as a means of cooperatively approaching ecologically sustainable industrial activity"* (Chertow, 2000). Therefore, the emphasis of industrial symbiosis is on the interfirm interface, focusing on ways of resource optimisation based on collaboration among different industries and activities. The approach aims to overcome the traditional boundary of the organisation to achieve better environmental collective performance offered by a more global approach to material and energy flows. A comprehensive definition of the concept is offered by Chertow (2000): "*Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchanges of materials, energy, water and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity*". Kalundborg (www.symbiosis.dk) is generally portrayed as the model of industrial symbiosis. The IS system created in Kalundborg involves a number of public and private companies that exchange waste products and process residuals in a closed cycle. The residual streams traded include steam, gases, heat, slurry, Gypsum, sulphur fertiliser among others. Kalundborg has become an example of how waste material from one company can become a raw material for another, generating substantial economic and environmental benefits. A growing number of examples of both planned and spontaneous IS networks have emerged in the last years contributing to the empirical foundations of the approach. China has launched recently large scale IS networks and eco-industrial parks pilot programmes as part of their circular economy strategy (Geng et al., 2009).
Scope of change	The scope of change proposed under this approach is incremental, affecting primarily the organisation of production systems. Linear production systems need to be transformed into closed loop systems by promoting the recirculation of resources within the system.
Paradigmatic degree of change	The approach maintains a basically utilitarian and rational economic approach to nature, where win-win solutions drive the change towards more closed-loop systems of production and consumption The paradigmatic degree of change can be thus considered as low, where business solutions are preferred though there is recognition of the basic dependence of production systems from the natural systems where they are embedded.
Plausibility of pathway of change	As in the field of industrial ecology, the plausibility of pathways of change is explored for production and technological systems but uncertainty persists regarding necessarily societal changes.
Actors addressed (industry, government, civil society) Environment / social / economic aspects	Industry and businesses are the main focus of the approach. The role of government, as in industrial ecology, is generally secondary, limited to define the general conditions for industrial actors cooperation. Environmental and economic dimensions are the focus of the approach, with little attention to the societal dimension.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.3 Waste prevention / priority waste streams

	Description
Main aim/origins/history	Waste prevention alludes to the reduction in the volume of waste generated at source and its hazardous content and thus the minimization of the impact of waste on the environment. Waste prevention strategy is considered the highest priority of the waste management policy according to the "waste hierarchy" defined in the EU Waste Framework Directive (article 4). There is a direct connection between waste prevention and resource efficiency, as improving the efficiency with which resources are used should lead to reduction in the amount of waste generated. More than a normative concept, waste prevention is largely a legal-policy construct. Waste prevention, understood as waste reduction per capita, is one of the aspirational targets included in the *Roadmap to a resource efficient Europe*. Also, according to the revised Waste Framework Directive, member states should establish waste prevention plans by December 2013. Connected with waste prevention and, as part of the waste management policy, both EU and members states have defined a number of **priority waste streams**. Priority waste streams are selected according to their potential damage to the environment when they are disposed of or the potential energy and material savings associated with their reuse and recycling. Priority waste streams identified by the European Commission include: packaging waste, end-of-life vehicles, batteries, electrical and electronic waste, construction and demolition waste, waste oils and bio-waste. These waste streams are regulated by EU Directives (WFD and Extended Producer Responsibility schemes_ see definition) that establish requirements for their collection, reuse, recycling and disposal.
Scope of change	To be successful, any waste prevention strategy should be pursued at all levels of the supply chain and life cycle of a product or service from its initial design, manufacturing and production, distribution, consumption and final disposal. Strategies such as designing out waste and reuse of products and materials are mainly targeted at waste prevention. Although waste prevention implies changes in manufacturing processes and consumption patterns towards greener products, with less packaging, this strategy rarely implies a profound change or restructuring of manufacturing and consumption systems and thus the scope of change can be considered medium.
Paradigmatic degree of change	The paradigmatic degree of change of waste prevention strategies could be considered medium as well, as although there is an implicit recognition of the right of the governments to act to protect environmental goods and services, they do not provide an alternative to the predominant utilitarian and rational economic approach. Indeed, a combination of market based instruments and bans, targets and prohibitions constitute the bulk of the waste prevention legislative framework.
Plausibility of pathway of change	As an eminently practical approach, waste prevention explicitly identifies specific instruments to incentivise behavioural change by actors (industry, consumers) to influence their choices and promote waste reduction at source both qualitatively and quantitatively. These changes or mechanisms of change, however, do not generally involve paradigmatic changes of values and practices or explicit pathways of societal change but rather incremental changes to behavioural practices.
Actors addressed (industry, government, civil society) Environment/social/economic aspects	Main actors addressed by the approach include industry, consumers and governments. The role of government is to define the framework conditions and create the necessary incentives to waste prevention. Economic and environmental dimensions are the focus of the approach with less attention paid to societal aspects.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.4 Extended Producer Responsibility

	Description
Main aim/origins/history	The concept of extended producer responsibility (EPR) involves a "*shift in the responsibility of the end of life management of products to producers*" (Lifset et al., 2013). A widely used definition of EPR is the one provided by the Organization for Economic Cooperation and Development (OECD, 2001), which refers to it as "*an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle*". From the policy point of view, EPR schemes generally involve two related features (OECD, 2001): *"(1) the shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities, and (2) (…) the incentives to producers to incorporate environmental considerations in the design of their products*". The origins of EPR concept can be found in the early policy developments in Sweden and Germany in the early 1990s of EPR schemes that aimed at providing an integrated strategy to tackle eco-design of products and to internalize the economic costs of end-of-life management, shifting its financial burden from public authorities to producers and consumers. Although in most cases concrete policy manifestations of the EPR schemes have fallen short of the initial aims of the strategy to focus on the expansion and funding of post-consumer recycling, EPR should in principle contribute to advance towards closing the loop of materials and resources and thus to enhance resource efficiency. Currently, the EU has introduced EPR schemes covering the following waste streams: batteries (Batteries Directive 2006/66/EC), packaging (Packaging Directive 94/62/EC), vehicles (end-of-life Vehicles Directive 2000/53/EC), electrical and electronic equipment (WEEE Directive 2002/96/EC). The recast of the waste framework directive (2008/98/EC) also includes a general provision to support the "design and production of goods which take into full account and facilitate the efficient use of resources during their whole life-cycle including their repair, re-use, disassembly and recycling". Article 8 from chapter II (General Requirements) specifically encourages Member States (MSs) to take legislative or non-legislative measures to ensure that producers of products have extended producer responsibility, including measures to accept returned products at the end of their use life and the waste associated with them. Producers should also have the financial responsibility associated with those activities. The directive also encourage MSs to take measures to ensure that design of products incorporate principles of environmental impact and waste minimisation and that, where possible, they are suitable for multiple uses and durable and suitable for proper and safe recovery at the end of their useful life.
Scope of change	EPR schemes, by creating a link between the products and the producers at the end of their use life, introduce significant changes to various parts of the supply chain, including, in some cases, reverse logistics and take back systems, to revert to the manufacturer the product at the end of its use-life. The scope of change can thus be considered medium.
Paradigmatic degree of change	Regarding the paradigmatic degree of change, even though it could be argued that different manifestations of EPR could lead to significantly divergent results in terms of paradigmatic changes operated at the core of the manufacturing system, the concept does primarily rely on the predominant utilitarian and rational paradigm in most of its current manifestations with a focus on internalizing the costs of end-of-life management. Moreover, the way schemes have been implemented at present are too fragmented to achieve a profound widespread effect on the manufacturing system.
Plausibility of pathway of change	The concept addresses real-life driving forces, such as resource scarcity, and provide clear pathways of change through the introduction of reduction targets, materials bans and market-based instruments to improve end-of-life management of products. Different initiatives and schemes tackling a variety of waste streams (batteries, vehicles, electronic waste) exist both at

	the EU and at the international level (Canada), which demonstrate the practical dimension of the concept. The drivers to introduce changes in the responsibility of end of life management are explicitly specified by EPR schemes. Also as a policy instrument, EPR contains prescriptive measures to bring about the change required, detailing aspects of the end-of-life collection, reuse and recycling and disposal. Some schemes also incorporate prescriptive measures upstream at the design stage, such as prohibition to use certain substance or materials or percentage of recycle content. However, as a technical instrument, EPR does not address societal pathways of change.
Actors addressed (industry, government, civil society)	Main actors addressed by the concept include industry, end consumers and government. The role of the government is generally to define the framework conditions in which EPR schemes work, while industry and end consumers have a more active role in defining the operation of those systems.
Environment / social / economic aspects	

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.5 Supply chain management

	Description
Main aim/origins/history	The increasing complexity of supply chains and global scale of sourcing, purchasing, manufacturing and distribution activities explain the growing corporate, academic and policy interest in sustainable supply chain management. According to Handfield and Nichols (1999), "*the supply chain encompasses all activities associated with the flow and transformation of goods from raw materials stage (extraction), through to the end user, as well as the associated information flows. Material and information flow both up and down the supply chain".* Consequently, supply chain management (SCM) can be defined as *"the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage''* (Handfield and Nichols, 1999). Increasing pressure to control and enhance the social and environmental dimensions along supply chains have led in recent years to the concept of green or sustainable supply chain management. Sustainable supply management can be defined as the *"management of material, in- formation and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements"* (Seuring and Mueller, 2008).
Scope of change	As an integrative approach to supply chain management, the concept addresses all stages of the supply chain from the sourcing of the materials to the distribution and sale of the final product/ service. The scope of change can thus be considered medium.
Paradigmatic degree of change	Although, there may be an implicit recognition of the public good character of environmental goods and services that need to be protected and preserved along the supply chain through closer cooperation and interconnection among primarily business actors,, the approach relies on the predominant utilitarian and rational paradigm to nature and resources, where win-win solutions drive the change to existing practices.
Plausibility of pathway of change	Pathways of change and drivers are identified and play a significant role in introducing practical improvements in the management of supply chains incorporating principles of environmental protection and safeguarding and social justice and equity, as the stakeholders' pressure increases.
Actors addressed (industry, government, civil society) Environment /social /economic aspects	The concept thus implies a proactive role of all actors involved in the supply chain, mainly industry, but also consumers and stakeholders as a whole. Economic competitiveness is at the basis of the approach, but environmental and social issues are increasingly being accounted for in the management of the supply chain.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.6 Leasing society

	Description
Main aim/origins/history	One of the important elements of a circular economy is changing the relationships between producers and consumers and the introduction of new business models that rely on fundamental changes to the traditional approaches to ownership and product responsibility in an attempt to move towards more closed loop production and consumption systems. Under this approach, the idea of the leasing society has gained momentum as a way to move towards a more service-oriented economy where resources and products are used efficiently, preserving their value along its use life and where materials are recovered to the the system in a cyclical way. The vision of the leasing society implies a novel way to fulfil consumer needs that puts the emphasises in the production of services rather than products, reducing the environmental impact associated with products disposal at the end of their use life and providing more resource efficient product design, durability and easier dissemble and remanufacturing to optimise resource use and minimize environmental impact over the life-cycle of the product. It has been argued that the concept of the leasing society may contribute to a more resource efficient Europe (see, Marsden, 2012 or Merkies, 2012).
Scope of change	The vision of the leasing society proposes substantial changes in the way manufacturing and consuming systems are organised and structured. The scope of change is thus potentially high, leading to new way of production and consumption based on the fulfilment of the need rather than the acquisition of a material product.
Paradigmatic degree of change	Although emerging from a utilitarian approach to nature, the concept of the leasing society proposes a radical change in the way societies are organised and to some extent a paradigmatic change of values and behaviours associated with production and consumption activities.
Plausibility of pathway of change	Even though the concept is not entirely new and have links to early developments of the concept product-service, there is uncertainty and openness regarding the ways this may operate in the practice and the drivers and factors that may make change possible at present. Further development of the concept is needed to specify possible pathways of change and drivers and barriers to it.
Actors addressed (industry, government, civil society) environment/social/economic aspects	Main actors addressed by the approach include producers and consumers; Government is assigned the role of defining the framework conditions in which the leasing society operates. Environmental and economic aspects are the focus of the approach with less attention paid to societal issues.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.7 Ecological Economics

	Description
Main aim/origins/history	Ecological economics is a transdisciplinary approach that focuses on the interface between natural, social and economic systems and incorporates elements from the natural and social sciences. Although its roots can be traced back to Malthus or Stuart Mill (Martinez Alier, 1990), it is in the last decades of the 20th century when the discipline developed as a response to the acute environmental problems that modern societies were facing and the lack or inadequacy of the responses provided by the mainstream or neoclassical economics, that pointed to prices and perfect functioning markets as the solutions to environmental degradation. The limits to growth (Meadows et al., 1972) and the steady-state economics (Daly, 1977) set the basis and main principles of the discipline. Aspects such as scale of human-economic systems with respect to the natural systems they are embedded in, allocation and distribution of resources have been addressed in the discipline. This approach rejects some of the neoclassical principles such as the perfect substitution between different capital forms (natural, labour and man-made) or perfect allocation of resources and introduces aspects such as minimum threshold levels and life supporting environmental services.
Scope of change	Ecological economics is a holistic approach to the understanding of the functioning of environmental and social-economic systems and thus proposes a restructuration of social systems as a whole to adapt to the constraints and operating principles of the natural systems. The scope of change thus involves the societal systems as a whole.
Paradigmatic degree of change	Ecological economics incorporate aspects of moral justice and reject the positivist, rational utility-maximizing approach that is on the basis of traditional neoclassic approaches. Aspects such as intra- and inter-generational equity or the intrinsic value of nature and natural systems are recognised in the discipline.
Plausibility of pathway of change	Explicit pathways of change and alternative instruments and policies are proposed in the discipline to deal with some of the environmental and social problems faced by modern societies and to substitute existing predominant decision-making structures based on a utility-maximizing approach, which fails to recognise the intrinsic value and operating rules of natural systems. However, the discipline has an eminently theoretical approach and limited empirical basis exist to demonstrate the practicality of the approach.
Actors addressed (industry, government, civil society) environment/ social/ economic aspects	The approach addresses all societal actors including industry, consumers, citizens, NGO's and governments. Environmental, economic and societal dimensions are all considered in an integrative and co-evolutionary way.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of

			change

10.8 Natural step

	Description
Main aim/origins/history	The natural step is a framework to sustainability developed by a non-profit organisation founded by Karl-Henrik Robert in 1989. It proposes a number of system conditions that need to be fulfilled to lead to a sustainable society. The first three conditions are based on the thermodynamic laws, adding a fourth condition that focuses on the socio-economic interface. Regarding the forth condition, the concept of needs is based on the approach proposed by Max-Neef (www.max-neef.cl), which identifies nine fundamental human needs: subsistence, protection, affection, understanding, participation, leisure, creation, identity and freedom. The system conditions can be redefined as sustainability principles, as shown in the table below: **SYSTEM CONDITIONS** / **SUSTAINABILITY PRINCIPLES** **1. Nature is not subject to systematically increasing concentrations of substances extracted from the earth's crust (heavy metals, fossil fuels, etc).** / 1. A sustainable society must contribute to eliminate the systematic increase of concentrations of substances extracted from the earth's crust **2. Nature is not subject to systematically increasing concentrations of substances produced by society** / 2. A sustainable society must contribute to eliminate the systematic increase of concentrations of substances produced by society (dioxins, PCBs, DDT, etc) **3. Nature is not subject to systematically increasing degradation by physical means** / 3. A sustainable society must contribute to eliminate the systematic physical degradation of nature and natural processes **4. People are not subject to conditions that systematically undermine their capacity to meet their needs** / 4. A sustainable society must contribute to eliminate the conditions that systematically undermine people's capacity to meet their basic human needs Source: www.naturalstep.org The framework uses a combination of backcasting and creative visioning as instruments of change towards more sustainable scenarios. The principles provide the framework conditions a sustainability society must comply with and the backcasting method of planning attempts to identify steps and bridges towards that vision (www.naturalstep.org).
Scope of change	The scope of change is high as the concept implies radical changes in the way societal systems operate. The approach proposes a set of limitations derived from planetary constraints that should be on the basis of the operation of social

	and economic systems.
Paradigmatic degree of change	The paradigmatic degree of change is also high as the approach moves away from the utility maximizing models to a society organised around the limitations derived from the ecosystems carrying capacity. Elements of moral justice are also recognised in the fourth of the sustainability principles proposed.
Plausibility of pathway of change	Although the approach aims at providing practical principles for achieving a sustainable society, and a number of guidelines have been developed for household, planners or municipal decision-making, the specific mechanisms to initiate and manage the transition and discussion of adequate pathways of change need further development.
Actors addressed (industry, government, civil society) environment/ social/ economic aspects	All societal actors are addressed by the approach, including industry, consumers and citizens. Governments and NGO's, relying on participatory methods, play a very active role in defining the steps to move towards a sustainable society. Environmental, economic and social aspects are all seen in an integrative way.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.9 Weak, strong and sensible sustainability

	Description
Main aim/origins/history	Although the concept of sustainable development can be traced back to the 1980s, it was the publication of the Brundtland report in 1987 (WCED, 1987), what which contributed to its popularisation and policy resonance, by providing reconciliation between growth and environmental protection. According to the report, sustainable development is a: '*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*'. At a global level, the sustainable development concept and associated goals and principles have been refined over time during the United Nations Conference on Environment and Development at Rio in 1992 and the World Summit on Sustainable Development in Johannesburg in 2002. Most of the concepts suggest an environmental, economic and social dimension. The ambiguity contained in the term has given rise to different interpretations or "plethora of paradigms" (e.g. Fowke and Prasad, 1996; Fischer-Kowalski et al., 1994; WRR, 1994; Gallopín, 2003). Sustainable development has been conceived as a desirable goal for some and as a paradigm shift for others (Downs, 2000), ranging from maintenance of the status quo with small changes, to major structural changes in the way societal and economic system are organised, becoming an umbrella term for a multiplicity of approaches. The range of interpretations of sustainability has been captured in two contrasting views: weak sustainability vs. strong sustainability. These two perspectives have concentrated the academic debate on the assumptions made about the degree of substitutability between natural and manmade or manufactured capital (Ayres and Ayres, 2002). The perspective of weak sustainability assumes that there is a perfect (or quasi-perfect) substitutability between man-made and natural capital (Pearce and Turner, 1990). Therefore, a sustainable society, from this point of view, should aim at maintaining or increasing the total stock of capital over the years. The process of environmental degradation (or diminishing of natural capital) is not critical as long as it is compensated with an increase of manufactured capital, including human capital. This position fits within the neoclassic economics of utility maximisation models, where welfare is equivalent to utility, measured as aggregated consumption. From the perspective of strong sustainability, it is assumed that minimum amounts of different types of capital (technology, human capital, natural capital) are essential for the productivity of the other factors. Therefore, different types of capital can only be substituted to a certain degree, beyond which they become complementary. Natural critical capital refers to this minimum amount of natural capital that needs to be secured to guarantee the production of the other types of capital. Moreover, some forms of natural capital are subjected to irreversible processes of environmental degradation and cannot be substituted by manmade artefacts or systems. The levels of substitutability and complementarity vary according to different authors, as well as the determination of the levels of natural critical natural capital. The right of existence of nature, independently of its "utility" to human societies is also recognised from the point of view of the Deep Ecology (Ayres and Ayres, 1998).
Scope of change	The scope of change both in its weak and strong versions can be considered high, as it involves a restructuring of all societal subsystems by operating a fundamental change in the way social, economic and environmental systems operate, recognising the linkages and inter-dependence between the systems.
Paradigmatic degree of change	The concept of sustainable development strives to overcome the traditional trade-off between economic and social development and environmental protection, looking at ways in which the systems can operate in a mutually supportive way. The paradigmatic degree of change can be considered low in the case of the weak perspective on sustainability that relies primarily on the utility-maximizing paradigm, where market solutions are preferred, and substitutability between different types of capital is assumed. The perspective

	on strong sustainability though involves a radical change in existing values and institutions and the way in which environmental systems are considered and accounted for. Critical environmental system services and thresholds are key for the maintenance of economic and social systems. Also, aspects such as justice and equity, understood as intra- and inter-generational equity are at the centre of the approach.
Plausibility of pathway of change	The concept has materialised in ever-growing number of policy strategies and programmes around the world. From the Agenda 21, proposed at the UN Conference on Environment and Development in Rio 1992, there has been innumerable initiatives and programmes to pursue sustainable development at the global, supranational (EU sustainable Development Strategy), national (see, for example, Sustainable Development Strategy of Canada), regional, sectorial (see, for example, German Sustainability code or the cement sustainability initiative) and local level (see, for example, Local Agenda 21). Although the content and level of ambition of these initiatives varies considerably, they provide specific measures and instruments to move towards a more sustainable path of development.
Actors addressed (industry, government, civil society) environment/ social/ economic aspects	As a holistic approach, all societal actors are addressed, including industry, consumers, citizens, NGO's and Governments. A key pillar of the approach is the interconnection between economic, social and environmental dimensions.

Weak sustainability

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

Strong sustainability

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.10 Small is beautiful / appropriate technology

	Description
Main aim/origins/history	Small is beautiful proposes an alternative approach to mainstream economics, which criticizes the focus on output and technology while ignoring the limited capacity of natural systems and their irreplaceable role in sustaining society. Although the phrase came from Leopold Korh, author of the *Breakdown of Nations* (1957), where he rooted the cause of social misery in the concept of "bigness", it was a collection of essays by economist F.E. Schumacher entitled *Small is Beautiful: a study of economics asd if people mattered* (1973) that championed the idea of small, appropriate technology. Schumacher argues that the modern way of production is unsustainable, generating tensions both in the social and natural systems. This approach challenges the idea that big is better or that growth is good and proposes a new perspective on economics, that he termed Buddhist economics, that tries to overcome the materialist focus and where small, local, decentralised models of work and production are preferred. This approach entails a fundamental restructuring of all societal systems and the values behind them and proposes a vision of development that transcends materialistic realm to focus on the ethical maturity of human beings (Payutto, 1992). Pathways of societal change are rooted in a redefinition of the nature of human labour and the scale and modes of production. The local sphere gains relevance and the idea of maximising profits is substituted by that of minimizing suffering and non-violence to all living and non-living beings. Thus, resource management should focus on a very careful, planned use of resources, avoiding overexploitation of natural resources that is a form of violence that opposes the Buddhist principle of non-violence. Production needs to be locally adapted and where possible self-sufficient. Maximizing consumption is not a true measure of human happiness and thus it advocates for different measures of wealth such as the Gross National Happiness (www.grossnationalhappiness.com).
Scope of change	The scope of change is thus high, calling for an upheaval and restructuring of all societal sub systems and the basic principles of organising society.
Paradigmatic degree of change	The paradigmatic degree of change is also high as the concept seeks an alternative way of organising society and production, moving away from a materialistic focus, to a human-oriented approach, that redefines the nature of human labour and its connection with human dignity and the scale and mode of production, based on local, decentralised systems.
Plausibility of pathway of change	Pathways of change are discussed conceptually, pointing to possible avenues of social change, building around local alternatives of work organisation focused on self-subsistence and sustainability. These small-scale practical initiatives scattered around the world though are of a too limited scale to demonstrate the practicability of the approach at a wider context.
Actors addressed (industry, government, civil society) environment/ social/ economic aspects	The approach addresses all societal actors, including industry, citizens and governments. Decentralized and participatory models of government are though proposed. Environmental, social and environmental issues are considered intrinsically intertwined.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.11 Eco-innovation

	Description
Main aim / origins /history	Traditionally, eco-innovation was understood mostly as a solution to minimise or fix negative environmental impacts from production and consumption activities. These end-of-pipe solutions allowed for the 'cleaning-up' of polluted water and soils, and for reducing harmful emissions. One of the first appearances of the concept of eco-innovation in the literature is in the book by Claude Fussler and Peter James (1996). It is increasingly evident today, however, that the key challenges of the 21st century are not only about reducing pollution, but also about getting a handle on the over-consumption of natural resources (e.g. Rockström et al. 2009, EEA 2010). The understanding of eco-innovation has thus broadened to include a focus on resource and energy efficiency taking into account a full life-cycle perspective. In contrast to innovations in general it brings both environmental and economic benefits. The EIO Report 2010 published by the European Commission defines eco-innovation as "the introduction of any new or significantly improved product (good or service), process, organisational change or marketing solution that reduces the use of natural resources (including materials, energy, water, and land) and decreases the release of harmful substances across the life-cycle".
Scope of change	The scope of change ranges from incremental to disruptive. It is assessed as high, as it addresses all parts of the value chain. As such, the concept tries to achieve a "systemic change" in the economy, which represents one of the societal sub-systems.
Paradigmatic degree of change	While eco-innovation traditionally focused on market-based solutions and emphasizes the business opportunities and benefits for being sustainable and resource efficient, the recent Annual EIO Report 2012 "Europe in transition" points out that "the importance of new technologies goes beyond displacing established products; it can also be a powerful means for enlarging and broadening markets and providing new functionality". The argument is that, from a historical perspective "waves of innovation" have been accompanied by shifts in behaviour, shifts in policy, and shifts in structure that converge with the occurrence of technological innovation. Thus, the paradigmatic degree of change is considered medium, since the extent of paradigm change differs according to the perspectives of different actor groups.
Plausibility of pathways of change	Analyses "discontinuities" of trends, tries to overcome the risks (Horizon Scanning and Foresight Reports) and thus responds to real-life driving forces. The concept is explicit and plausible in identifying pathways of change. The EC has launched an Eco-Innovation Action Plan in 2011 (EcoAP) defining measures that have to be taken in order to promote the further development and use of environmental technologies in the EU. However, most political advocates of eco-innovation in the EU are still focusing on making the concept attractive for the businesses. Thus, the concept is implemented rather incrementally, not taking into account the radical innovations needed to bring the EU on the track of strong sustainable development. According to this analysis, the concept's plausibility of pathways ranges between medium and high, depending on the viewpoint from which it is evaluated.
Actors addressed (industry, government, civil society) environment/social/economic aspects	Actors addressed by the eco-innovation concept are mainly business and government. It focuses on environmental and economic aspects of sustainability, by arguing that "when business meets environment" win-win-solutions are created, and views social benefits as a by-product.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.12 Transition management

	Description
Main aim / origins /history	"Transition management has rapidly emerged over the past few years as a new approach dealing with complex societal problems and the governance of these problems. In the Netherlands, UK and Belgium, serious efforts have been and are being undertaken to develop transition policies in areas such as energy, building, health care, mobility and water management. This is the result of a much broader scientific development of transition research as an interdisciplinary field of study in which innovation studies, history, ecology and modelling are combined with sociology, political and governance studies and psychology. Because of the focus on integrated sustainability problems and the applied nature of transition research, the natural interaction between science and policy has led to a continuously coevolving theory and practice of transition management, following the tradition of post-normal and sustainability science". (Wittmayer et al. 2011) "The importance of social actors for achieving sustainability and the critical role of innovation are at the core of transition management. More specifically, all the transition management tools include both stakeholder and community engagement elements (e.g., participation as the way for vision-building, knowledge-creation and scenario-drawing) and innovation-stimuli elements" (Frantzeskaki et al, 2012). Transition management as a governance approach can facilitate programmes and policies that have a direct link to resource efficiency. Since the underlying rationale of the management approach and the design of the transition management instruments follow the basic principles of sustainable development (integration, plurality of interests, intergenerational justice, and importance of scale), it is well suited to support socially-rooted and thus successful transition processes to a resource efficient Europe. For example, between 2004 and 2006, a transition arena and network were developed in Flanders, Belgium (Loorbach and van de Lindt, 2007). A main objective was to apply the transition management approach to sustainable living and housing. The transition arena defined criteria for a sustainable living and housing that included closed material cycles and an integrated policy approach thus demonstrating the relevance of this approach for resource efficiency. "Numerous transition experiments have been initiated in the fields of sustainable agriculture, mobility, construction, energy, spatial planning, and health care. The interest in transition processes is growing, e.g., in the UK, Germany, Austria, Finland, and—most concretely—Belgium, where two transition processes are being attempted at the national level, one on waste management and one on sustainable housing and construction in Flanders" Fischer-Kowalski and Rotmans (2009)..."Studies about transitions and its main drivers have been done regarding resource and land scarcity, climatic variations, or specific colonial and trade relations" (Fischer-Kowalski and Rotmans, 2009).
Scope of change	The concept focuses on persistent problems of unsustainability and aims at transforming whole sub-systems (institutions, regulations, physical, infrastructures, financial infrastructures, etc.). As such its scope of change can be considered high.
Paradigmatic degree of change	The concept clearly calls for a revolution in the economic system, related values, institutions, etc. and as such initiates a fundamental paradigmatic change. The goal of this concept is to reframe existing societal issues at the various levels of the societal sub-systems in terms of their underlying problems to go beyond obvious and partial problems. The premise is that sustainability transitions require a new way of thinking and acting, which are intertwined. While the ambition of transition management is to achieve systemic change, the experience so far generally does not meet this goal, so the paradigmatic change is ranked as medium.
Plausibility of pathways of change	An explicit part of the transition management process (see Wittmayer et al. 2011) is backcasting from a vision to develop pathways. These pathways are then implemented through measures decided by the participants in the transition process, accompanied by monitoring and evaluation. Although, the plausibility is grounded in the process design, there are only few real life examples for how transition management can be put into practice successfully, initiating change towards sustainable development
Actors addressed	The concept acknowledges the integrated nature of sustainability problems. It thus it tries to integrate various societal actors, such as the civil society, scientific community, government

(industry, government, civil society) environment/social/economic aspects	and industry, and engage them into joint-learning processes. Transition Management takes into account the environmental, social and economic dimension of sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.13 Green growth

	Description
Main aim / origins /history	Green Growth describes an alternative path to growth in contrast to the conventional paradigm of economic growth. The idea is that the environmentally necessary restructuring of the economy to include greater energy and resource efficiency and better management of natural capital can be a strong driver for growth. The thesis suggests that the inclusion of new green markets, the development of eco-innovations and the management of ecosystem services create both improved competitiveness and new business opportunities. The concept of green growth was coined in Asia and the Pacific. In 2005, at the Fifth Ministerial Conference on Environment and Development in Seoul, 52 Governments and other stakeholders from the region agreed In a Ministerial declaration to pursue a path of "green growth". They also adopted an implementation plan. This provided the starting point for the UNESCAP vision of green growth as a regional initiative to achieving sustainable development and the Millennium Development Goals (United Nations Department of Economic and Social Affairs). The Green Growth concept is also anchored in the OECD. The OECD (2011) defines Green Growth as “fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies”. In 2009, government ministers from 34 countries signed a Green Growth Declaration and thus gave the OECD a political mandate to develop a Green Growth strategy. The strategy was published in 2011 under the title “Towards Green Growth” as the starting point for a long-term Green Growth Agenda. The World Bank (2012) defines green growth as “growth that is efficient in its use of natural resources, clean in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters. “ Each institution places a different emphasis on the green economy. For example, the World Bank places an emphasis on the role that nature plays in preventing physical disasters, and emphasises the role of resource use efficiency while the OECD places importance on the role of sustainability of natural resources as the basis of existence.
Scope of change	high, because it covers not only the economic sub-system, but the whole society.
Paradigmatic degree of change	The concept’s degree of paradigmatic change is low, since it is still framed in the conventional economic paradigm. It provides market-based solutions that adhere to the existing utilitarian economic rationality. Rather than initiating radical change and an upheaval in existing values and institutions, the Green Growth concept provides solutions to the crisis and demonstrates a commitment to the belief that growth and environmental protection can go hand in hand.
Plausibility of pathways of change	The concept addresses real life driving forces, such as resource scarcity and provides clear pathways for change e.g. through measures in the areas of education, research, innovation and ICT. The fact that many initiatives (OECD, UNEP, World Bank*) already exist, demonstrate the concept’s high level of practicability. *http://www.unep.org/greeneconomy/Portals/88/documents/partnerships/GGKP%20Moving%20towards%20a%20Common%20Approach%20on%20Green%20Growth%20Indicators.pdf
Actors addressed (industry, government, civil society) environment/social/economic aspects	Green Growth centers around environmental aspects, but always in the economic context: environment should be used sustainably in order to create win-win-situations. As such it does to feature full commitment to social and environmental sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.14 Green economy

	Description
Main aim / origins /history	The Green Economy is a concept that UNEP has taken the lead in promoting. UNEP sees the Green Economy as an economic approach that "results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011). To implement this vision, UNEP created the Green Economy Initiative, the first results of which were published in the report Towards a Green Economy in 2011. The initiative aims to support decision makers in moving towards a more resource efficient, low carbon and socially inclusive economy in practice. The Green Economy was one of the two key themes forming the focus of UN Conference on Sustainable Development Rio+20 in Rio de Janeiro. While the concept of a green economy has human development at its center, the concept of green growth is often seen as one that is more profoundly economics oriented. Its paradigm does not imply the necessity of growth in all economies but recognizes that there is growth potential in greening economies.
Scope of change	high, because it covers not only the economic sub-system, but the whole society.
Paradigmatic degree of change	The concept's degree of paradigmatic change is medium. While it is still framed in the conventional economic paradigm and provides market-based solutions that adhere to the existing utilitarian economic rationality, the Green Economy Initiative of UNEP has the ambition to develop a green economy in which growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. It is recognized that these investments will require policy reforms and regulation changes.
Plausibility of pathways of change	The concepts addresses real life driving forces, such as resource scarcity, climate change or social exclusion and provides clear pathways by bringing together and analysing best practice examples from all around the world, to illustrate the positive impacts of green investments and policies. Ultimately, this involves embedding individual measures, based on robust economic research and policy analysis, in a coordinated way within a comprehensive strategy, in order to make quick progress towards the goal of a green economy.
Actors addressed (industry, government, civil society) environment/social/economic aspects	The green economy concept focuses on the industry and the government as the main driving forces behind sustainable development. Thus the societal benefit is rather viewed as a by-product of the synergy that results from increasing the economic and environmental dimension of sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.15 'Beyond GDP'

	Description
Main aim / origins /history	The aim of this initiative developed by the European Commission (2009) is to identify which indicators are best suited to measure societal progress. Usually societal progress is measured and compared using GDP, but is has been increasingly recognized that GDP does not capture whether well-being or prosperity (assets over and above financial assets such as health, social capital and security) has improved (see, for example, Jackson (2009)). Further the initiative identifies pathways for integrating these indicators into decision-making processes and public debate. The second key milestone after the Beyond GDP conference that took place at the end of 2007 is the communication entitled GDP and Beyond from August 2009. The communication sets out a concrete roadmap in the form of five key actions for the development of a new set of indicators for progress that can be used alongside GDP. The Sofia Memorandum on Measuring progress, well-being and sustainable development (2010), adopted at the 96th conference of the Directors General of the National Statistical Institutes considers that sustainable development and well-being are fundamental objectives of the "Treaty on European Union"(Article 3) (Directors General of the National Statistical Institutes, 2010). While there is growing demand by societal actors and policy makers to measure progress towards well-being and sustainable development in a more comprehensive way the European Commission Communication "GDP and Beyond: Measuring progress in a changing world" (2009) can be seen as a commitment to pursue the further development of measurements in this areas. The "Europe 2020" strategy adopted by the heads of EU States and Governments includes measurable targets for several indicators that go beyond GDP.
Scope of change	This initiative only indirectly aims at changing the existing societal sub-systems by driving a fundamental change in the way in which societal well-being and progress towards sustainable development is measured and reported. As an awareness-raising tool for indicating that progress cannot be measured by GDP alone and that prosperity does not just depend on money, its potential for stimulating systemic change is high.
Paradigmatic degree of change	This concept clearly strives for an upheaval in existing values, institutions, etc. It tries to overcome the current paradigm of evaluating societal progress according to economic growth and material prosperity. To go beyond this traditional paradigm of measuring progress, the concept proposes the inclusion of environmental and social parameters.
Plausibility of pathways of change	Since the concept works indirectly through awareness raising, it does not provide concrete pathways of change but the process of developing new indicators recognizes the need for change.
Actors addressed (industry, government, civil society) environment/social/economic aspects	The Beyond GDP concept mainly addresses governments and their willingness to measure progress with alternative indicators. However, Beyond GDP indicators take into consideration environmental, social and economic progress towards sustainable development.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.16 Cleaner production

	Description
Main aim / origins /history	"The continuous application of an integrated preventive environmental strategy to processes, goods, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to goods themselves, and to various services provided in society" (UNEP 2013). Cleaner Production is seen as a tool that can contribute to the sustainable forms of economic development, as endorsed in Agenda 21 adopted by the United Nations Conference on Environment and Development (UNIDO 2002). This holistic approach of Cleaner Production aims to: • "Increase productivity by ensuring a more efficient use of raw materials, energy and water • Promote better environmental performance through reduction at source of waste and emissions • Reduce the environmental impact of products throughout their life cycle by the design of environmentally friendly but cost-effective products" (UNIDO 2002). Cleaner production does not only relate to costly technologies but identifies a range of measures to achieve the above objective.
Scope of change	The scope of change of this concept can be considered medium, as it is only targeted at one part of the value chain, namely the production. Cleaner production centres in about 40 countries supported by governments and UNIDO and UNEP have been supporting a wide range of industries on the transformation of production processes. The approach has moved from end of pipe to a more input oriented approach but does not look at the whole economic system and consumption side.
Paradigmatic degree of change	ambition to initiate a paradigmatic change is low, since it predominantly stresses the business opportunities and benefits of sustainability for producers.
Plausibility of pathways of change	UNIDO (no date) already identified a range of concrete measures to reach the objective of a cleaner production without the need to make huge investments in new technologies. Amongst these are for example: • On-Site Recovery/Reuse: the reuse of the wasted materials in the same process or for another useful application within the company; • Production of Useful By-Products: the transformation of previously discarded wastes into materials that can be reused or recycled for another application outside the company; or • Product Modification: the modification of product characteristics in order to minimize the environmental impacts of the product during or after its use (disposal) or to minimize the environmental impacts of its production. (UNIDO no date)
Actors addressed (industry, government, civil society) environment/social/economic aspects	The concept only addresses governments and the industry as major the actors supposed to drive the change to more sustainable and "clean" production processes. Since it is structured around the business opportunities of resource efficiency, the cleaner production mainly addresses the economic and environmental dimension of sustainability. Benefits for the society come as a side effect.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.17 Eco-efficiency

	Description
Main aim / origins /history	"Eco-efficiency is a management philosophy that encourages business to search for environmental improvements that yield parallel economic benefits. It focuses on business opportunities and allows companies to become more environmentally responsible and more profitable. It is a key business contribution to sustainable societies. Eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity." (UNEP 2010) The term was coined by Stephan Schmidheiny, founder of the World Business Council for Sustainable Development (WBCSD), in his 1992 publication "Changing Course". Further, at the 1992 Earth Summit, eco-efficiency was endorsed as a new business model and means for companies to implement Agenda 21 (UN 1992) in the private sector.
Scope of change	Eco-efficiency is a concept that is targeted at changing various parts of the value chain to become more environmentally responsible. However, it does not aim at transforming the whole economic system. Therefore, its scope of change is medium.
Paradigmatic degree of change	The concept mainly focuses on business opportunities and related economic benefits and thus adheres to the existing paradigm. Rather than escaping from the utilitarian, economic rationality that is currently dominating our Western society, it reproduces them by providing market-based solutions to sustainable development.
Plausibility of pathways of change	The concept has managed to show why becoming eco-efficient is economically profitable, but failed to provide a clear pathway for radical change to social and environmental sustainability. However, it can be argued that the concept presents plausible pathways within the current economic paradigm. Thus it can be rated high.
Actors addressed (industry, government, civil society) environment/social/economic aspects	Business is the only actor addressed by the concept. Hence, it is primarily tailored to meet the economic challenges of sustainability, rather than the environmental or social ones.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.18 Resource-efficiency aimed at reducing the impacts of industrial processes

	Description
Main aim / origins /history	Resource efficiency is defined by Dahlstrom and Ekins (2005) as a basic ratio of two resource variables of the same kind, that is, the ratio is dimensionless. For example, material efficiency is measured as a ratio between useful material output, Mo, and material input, Mi, such as useful material output per total material input: Mo/Mi = material efficiency And energy efficiency is useful energy output, Eo, per input of energy, Ei: Eo/Ei = energy efficiency These definitions of resource efficiency are therefore consistent with the definition of efficiency used in engineering. It is also consistent with the economic concept of efficiency, which relates to economic outputs and inputs, Yo/Yi, although one difference is that engineering efficiencies are always less than 1 (e.g. Mo < Mi), whereas for a profitable company Yo/Yi > 1. Other definitions are given by: • Wuppertal Institute: Resource efficiency means in general the relation of a desired output of a process to the related resource requirement or -input. If the output is an economic measure, e.g. value added or GDP, we speak in the context of whole economies of "resource productivity". Resource efficiency of processes, however, can also refer to physical relations, e.g. the relation of used raw material extraction to the total extraction of primary materials. • EU DG ENV (2011): Resource efficiency means producing more value using less material and consuming differently, to limit the risks linked with scarcity and for less environmental impacts, within our planet's natural limits. It concerns the sustainable management and use of resources throughout their life cycle - from extraction, transport, transformation, consumption to the disposal of waste. Resources include all material and natural resources, from food, timber, and biodiversity in the widest sense, to energy, metals, soil, water, minerals, our atmosphere and land.
Scope of change	The scope of change of this concept can be considered medium, as it is targeted at various parts of the value chain in industrial processes, yet does not look at the economic system as a whole.
Paradigmatic degree of change	The concept sees an unsustainable development path not only a threat to economic profitability, but also to public goods. As such it can be argued that it drives an intermediate paradigmatic change, in the way that it recognizes the need for government intervention in order to safeguard also social interests.
Plausibility of pathways of change	The concept responds to real life driving forces such as poverty, environmental degradation and resource scarcity. UNEP (2010) is strengthening the scientific knowledge base, building capacity for government interventions by developing national and local policies and stimulating demand by providing market incentives. Thus, the concept identifies clear pathways of change. However, it can be argued that in reality the concept has not been implemented very successfully and thus not driven any real life change towards sustainable development so far.
Actors addressed (industry, government, civil society) environment/social/economic	UNEP (2010) addresses governments, businesses and the scientific community as the major actors that should be driving the change. However it also gives attention to the importance of changing lifestyles. As such, it addresses all three pillars of sustainability.

aspects	

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.19 Pollution prevention pays

	Description
Main aim / origins /history	Pollution prevention focuses on the source reduction of pollution and environmental impact. Waste is eliminated and reduced within the process and not end-of-pipe. Therefore waste treatment is not part of the concept. Pollution prevention pays addresses those pollution prevention which additionally saves money through avoidance of pollution and reduction of operating costs. The concept was first introduced in the US by the 3M company in their pollution prevention pays (3P) programme in 1975. Nowadays the terms pollution prevention, cleaner production and resource efficiency are often used synonymously while pollution prevention is more common in North America (UNEP 2013).
Scope of change	Pollution prevention focuses on parts of value chain: reducing waste within the process/at the source, not over the whole lifecycle. waste treatment is not part of the concept because it doesn't prevent the creation of waste.
Paradigmatic degree of change	Pollution prevention focuses on market based solutions. Depending on the country context the concept is applied voluntarily or on a legal basis. It also focuses on business opportunities to reduce cost while reducing harmful or wasteful inputs.
Plausibility of pathways of change	The plausibility of pathways is high, as governmental laws have been adopted in many countries on pollution prevention, yet the definition and adoption of laws regarding harmful chemicals lags behind the ever new appearance of chemicals on the market. However, leading companies such as 3M have adopted Life Cycle Management reviews with the aim of systematically and holistically address the environmental, health and safety (EHS) and energy opportunities and issues from each stage of their product's and more concretely to reduce or eliminate toxic emissions during manufacturing, reduce or eliminate toxic releases for the customer, or introduce a new product that has no toxic releases.
Actors addressed (industry, government, civil society) environment/social/economic aspects	Pollution prevention is mainly targeted at industrial and commercial business and covers less less social aspects apart from health and safety issues. It predominantly addresses the economic dimension of sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.20 Sustainable Consumption and Production

	Description
Main aim / origins /history	The most widely accepted definition of SCP, as developed at the multi-stakeholder workshop hosted by the Norwegian Ministry of Environment at the Oslo Symposium on Sustainable Consumption in 1994, is "the use of services and related products, which respond to basic needs and bring a better quality of life while minimising the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardise the needs of future generations" (UNEP 2010). However, global recognition of the need for sustainable consumption and production (SCP) dates back to the United Nations Conference on Environment and Development (UNCED) held 1992 in Rio de Janeiro. Agenda 21, the action plan for sustainable development adopted at the summit, called for "action to promote patterns of consumption and production that reduce environmental stress and will meet the basic needs of humanity" (UN 1992). Ten years later, the World Summit on Sustainable Development (WSSD 2003) in Johannesburg reaffirmed at the highest political level in the Johannesburg Plan of Implementation (JPOI) that "poverty eradication, changing unsustainable patterns of production and consumption and protecting and managing the natural resource base of economic and social development are overarching objectives of, and essential requirements for, sustainable development". In order to accelerate the shift to SCP, the WSSD encouraged the development of a 10-Year Framework of Programmes on SCP. The multistakeholder Marrakech Process, launched in 2003, has supported the implementation of SCP and provides inputs for the development of the 10-Year Framework (UNEP, 2012b). The 10 FYP on SCP was finally adopted at Rio+20.
Scope of change	The scope of change of this concept can be considered high. While it is targeted at parts of the value chain (consumption and production), its implementation through product services and other measures would have system-wide implications.
Paradigmatic degree of change	Sustainable consumption and production aims at maximizing business' potential to transform environmental challenges into economic opportunities and provide a better deal for consumers. Since it addresses both consumers and producers, and views resources as public goods, the paradigmatic degree of change is medium.
Plausibility of pathways of change	The EC has outlined a Sustainable Consumption and Production Action Plan (2008), proposing the introduction or expansion of a range of policies at EU and national level that are targeted at resource efficient and eco-friendly products and raise consumer awareness. However, the pathways proposed by the EC have not been far-reaching enough to trigger considerable change towards sustainable development in real life. Thus plausibility can be rated medium.
Actors addressed (industry, government, civil society) environment/social/economic aspects	The concept addresses the importance of government- as well as industry actors and the civil society likewise. It clearly states that, only by viewing sustainability as an integrated phenomenon the multiple challenges resulting from our currently unsustainable development path can be met. Hence sustainable consumption and production takes into consideration all three dimensions of sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways	Ignores factors making	Explains at best	Explicit and plausible

of change	change un-necessary	conceptually factors supporting change	discussion of pathways of change

10.21 Product-service systems

	Description
Main aim / origins /history	Product-service systems are a company related approach. The idea is to sell the service of a product rather than the product itself (Jasch et al. 2006). Consumers are interested in the comfortable warmth and not in the technical heating system. The concept has been developed in academic circles and some initiatives tried to transfer the PSS concept to industry but it is still not implemented widely. A product-service system represents the change from a focus on producing and consuming products to consumption approach, where the service components are increasingly replacing the more traditional material intensive ways of product manifestation (Jasch et al. 2006). A focus on service provides individuals and organisations with the possibility to fulfil needs through the provision of more dematerialised system solutions (Mont, 2000). Baines et al. (2007) explains that a product-service system proposes to extend the traditional functionality of a product by incorporating additional services. Here the emphasis is on the "sale of use" rather than the 'sale of product'. The customer pays for using an asset, rather than its purchase. The definition of product-service system reflects the development of the production systems in the society. The society went from focusing on products to discovering the surrounding factors of a product and its production system e.g. other products and services, drivers, stakeholders, factors that influence a product's performance, friendliness to the customer and environment, price, reparability, and all other parameters of the product's life cycle. The concept of product-service system indicates that society buys services instead of products, and that the service plays a very important role in customer satisfaction and again in product performance (Mont 2000).
Scope of change	The scope of change resulting from the increasing importance of product-service system can be considered high, as it significantly drives dematerialization and the change to a more service oriented economy.
Paradigmatic degree of change	The PSS concept is much related to the vision of a leasing society, in which people have acquired a new mind set. This society takes a different approach to consumption. Instead of satisfying human needs though material goods and services, they are now met by "functions". As such, PSSs call for a paradigmatic change of our values and behaviours that are currently rooted in the material foundation of our economy. It seems appropriate to argue that the idea of a service oriented economy calls for a revolution of the basic parameters that our economic system is built upon.
Plausibility of pathways of change	The PSS concept is conceptually valuable and there is an substantial amount of literature (e.g. Jasch et al 2006) providing companies with pathways for how to put theory into practice, however, despite several singular initiatives, PSS have still not been implemented widely. Possible reasons for this failure to disseminate the concept are (a) the lack of inappropriate supporting methods and tools for the companies and (b) the lack of acceptance of consumers. Ownership is an important factor for consumers and there appears to be a psychological barrier which prevents consumers from turning away from possessing things towards their common use (Hrauda 1999, 4).
Actors addressed (industry, government, civil society) environment/social/economic aspects	This concept addresses business actors and their consumers. It leaves sustainability up to market-forces. However, due to its far reaching implications PSSs address all dimensions of sustainability likewise.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.22 Circular economy

	Description
Main aim / origins /history	"A Circular Economy is an economy that balances economic development with environmental and resource conservation. It puts emphasis on environmental protection and the most efficient use of and recycling of resources. A Circular Economy features low consumption of energy, low emission of pollutants and high efficiency. It involves applying Cleaner Production in companies, eco-industrial park development and integrated resource-based planning for development in industry, agriculture and urban areas. The Circular Economy was adopted by the Chinese Government in the last five year plan (2001-2005) as the development model for China to follow" (UNEP 2010). The Ellen Macarthur Foundation defines the circular economy referring to an industrial economy that is restorative by intention. It aims to rely on renewable energy; minimises, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design. The concept of the circular economy is grounded in the study of non-linear systems, particularly living ones. It involves a careful management of materials flows, which, in the circular economy, are of two types as described by McDonough and Braungart (quoted by Ellen Macarthur Foundation 2013): "biological nutrients, designed to re-enter the biosphere safely and build natural capital, and technical nutrients, which are designed to circulate at high quality without entering the biosphere". A core principle of the circular economy is the concept of 3Rs (reduce, reuse and recycling), which is used for defining the waste management hierarchy. Essentially, the circular economy defines an ecological economy that follows the principles of 'reducing resource use, reusing, and recycling', with the objectives of reducing the resources that enter the production process, effecting multiple use of the same resources in different ways, and reusing waste from one facility as a resource for other facilities.
Scope of change	The scope of change intended by the circular economy is high. It proposes a fundamental transformation of the whole economic system from a linear model to a circular one.
Paradigmatic degree of change	circular economy (e.g. EU, McKinsey) predominantly emphasize the business opportunities and economic benefits entailed in this concept. With a focus only on economic aspects, the degree of paradigmatic change is low.
Plausibility of pathways of change	The concept responds to real life driving forces like environmental pollution and resource scarcity and brings up plausible pathways to deal with these challenges. China for example was the first country to implementing the Circular Economy at an Industrial level, with the development of 30 Eco-Industrial Parks based on circular economy principles. Also the EU has developed policies based on the concept of transforming the economy into a circular model (UNEP 2010). Since the experiences with implementation of a circular economy have shown deficits in the pathways , the plausibility is ranked medium.
Actors addressed (industry, government, civil society) environment/social/economic aspects	This concept mainly addresses industry-actors, but also governments, since they are supposed to incentivise industries to become circular. It emphasizes the economic and environmental dimension of sustainability, while viewing social benefits as positive side-effects.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.23 3R

	Description
Main aim / origins /history	The 3R concept is a core principle of the circular economy. It aims at promoting the "3 Rs" (reduce, reuse and recycle) globally so as to build a sound-material-cycle society through the effective use of resources and materials. Agreed upon at the G8 Sea Island Summit in June 2004, it was formally launched at a ministerial meeting in Japan in the spring of 2005 (UNEP 2010). Reducing means choosing to use things with care to reduce the amount of waste generated. Reusing involves the repeated use of items or parts of items which still have usable aspects. Recycling means the use of waste itself as resources. Waste minimisation can be achieved in an efficient way by focusing primarily on the first of the 3Rs, "reduce," followed by "reuse" and then "recycle" (UNEP 2010). Japan has embarked on continuous development of a legislative structure geared towards 3Rs, with the emphasis moving to the "front of pipe" or preventative, rather than "end of pipe" solutions to its waste problem. The development of a "Recycling Oriented Economic System" has created new policies and legislation aimed at overcoming the country's severe landfill shortage. Japan is revising from a sole focus on hazardous substances management to new phases of greening, especially in the home appliance and electronic sectors. The 3R Project is to be completed in three phases: • Phase 1: Elimination of hazardous chemical substances • Phase 2: Recycling • Phase 3: Green new product development
Scope of change	The 3R concept aims at transforming the economic system as a whole, initiating fundamental changes in other societal subsystems. Thus, its scope of change is considered high.
Paradigmatic degree of change	The focus is on business opportunities and economic benefits, so the degree of paradigmatic change is low.
Plausibility of pathways of change	enactment or amendment of various laws relating to waste management and recycling. Experience with this approach suggests that the pathways do not always address central issues, so the plausibility is ranked medium.
Actors addressed (industry, government, civil society) environment/social/economic aspects	The 3R concept addresses mainly businesses, consumers and governments. Its systemic approach makes the 3R concept consider all three pillars of sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.24 De-Growth

	Description
Main aim / origins /history	De-growth denotes economic downsizing. The vision of a degrowth society comprises a relocalisation of the economy, a fairer distribution of income and resources, new and more democratic institutions, sufficiency, and social and technical innovations that support a convivial and frugal way of life. Nicholas Georgescu-Roegen, who published numerous essays on economics and degrowth in the 1970s, is viewed by proponents of the degrowth movement as one of the leading pioneers of the concept. The Club of Rome Report "Limits to Growth" and E.F. Schumacher's book "Small is Beautiful" are also seen as early calls for degrowth. Nonetheless, it is only in recent years that the movement has obtained momentum. The first international conference in Paris in 2008 marked the beginning of the academic debate and civil society movement that exist today. Since then, two further international conferences have taken place: 2010 in Barcelona and 2012 in Venice (Pirgmaier 2012). Continuous environmental and economic crises compounded by a growing disjuncture between the real economy (in which the value of natural capital is seldom recognised) and the fictitious paper economy of finance have provoked renewed calls to depart from the promethean economic growth paradigm and to embrace a vision of sustainable de-growth. De-growth proponents recognize that the natural limits to growth have already been surpassed and we are now entering an overshoot phase which may not be but a transition leading to a more or less prolonged period of decline. The concept of sustainable de-growth is understood as an equitable and democratic transition to a smaller economy with less production and consumption. Such a system, in the eyes of its proponents, would allow a prosperous way down or at least a soft landing rather than a crash due to environmental collapse (Martínez-Alier et al. 2009).
Scope of change	The de-growth concepts foresees the necessity to change the economic system and accept a no growth policy as its basis. This idea transcends all societal systems and therefore, its scope of change can be considered high.
Paradigmatic degree of change	The degrowth idea arises from the debate surrounding critiques of growth. Economic growth is characterised as a problem and not as a solution for social and ecological problems. Technological innovations and greater resource and energy efficiency are not enough in themselves because rebound effects occur that increase production and consumption and thus lead to yet more environmental consumption. In its critique of neoliberal economic theory and practice, degrowth stands in opposition to the concept of sustainable development. Any form of additional economic growth, whether it be sustainable, green, or social, is seen as legitimising the continuation of the status quo and as a distraction from the contradiction that GDP growth and renaturation on a sustainable level are mutually incompatible. For degrowth adherents, the necessity for degrowth—as soon and in as democratic a form as possible—is the logical conclusion of critiques of orthodox economic systems and the awareness of social and ecological problems (Pirgmaier 2012). Therefore de-growth calls for a fundamental paradigmatic change – a revolution in our economic system, related values and institutions.
Plausibility of pathways of change	The discussion on degrowth has engaged with possible pathways. For example, Paech (2009) discusses 5 pathways of change. The Barcelona Degrowth Conference in 2012 developed concrete proposals for future actions, for example introduction of local currencies, co-housing and a guaranteed basic income. plausible pathways for political action that can be taken in order to strive towards downsizing the economy do not fit with this concept, which is based on a bottom-up approach that is not primarily driven by policy. Plausible pathways are therefore available but are not policy-driven, so the plausibility is ranked medium.
Actors addressed (industry, government, civil society) environment/social/economic aspects	Supporters of degrowth come from diverse fields, although most are scientists or activists. They pursue very different strategies in promoting the idea of degrowth. Some constitute protest movements against new large-scale infrastructure projects (e. g. motorways, nuclear power stations), others attempt to promote alternative infrastructures (e. g. solar energy, cycle transport); some focus on individual actions (e. g. —voluntary simplicity), others on collective measures (e. g. cohousing); some wish to replace existing institutions, while others wish to see their adaptation; some work in research fields, whereas others insist that action at local level is of primary importance. It mainly addresses consumers, civil

	society and scientists, viewing businesses and governments as barriers to change, which have to be overcome Degrowth pose the question of how the upcoming degrowth can be managed in order to avoid social and ecological collapse. As such it addresses all three pillars of sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

Resilience & safe operating space

	Description
Main aim / origins /history	Resilience is often described as the ability of systems to adapt to unforeseen changes. The concept is used in different disciplines, first in psychology, later in ecology and economics. The resilience approach focuses on the dynamic interplay between periods of gradual and sudden change and how to adapt to and shape change (www.stockholmresilience.org) Rockström and colleagues introduced the term "safe operating space" in 2009. It identifies biophysical thresholds which shouldn't be crossed in order to prevent "eroding the resilience of major components of Earth-system functioning." Several of the thresholds (e.g. freshwater, chemical pollution, phosphorous) deal directly with resources and their use, others deal indirectly with resource use (e.g. climate change and stratospheric ozone depletion).
Scope of change	If humanity seriously decided to live within the so-called planetary boundaries the scope of change would be system wide, since it would mean drastic reductions of emissions, new agricultural practices, reducing chemical pollution etc. Shaping change for a resilient system is carried out using an adaptive management approach that has similarities to the transition management approach discussed above. See also http://www.wachstumimwandel.at/wp-content/uploads/Policy-Paper-Resilienz-_makro__final.pdf
Paradigmatic degree of change	The adaptive management approach is a major paradigmatic change, since it adopts a participatory and experimental process. Planetary boundaries represent a paradigmatic change, acknowledging that the Earth System is complex and abrupt, non-linear regime shifts are possible and should be avoided. The paradigm change is largely within the scientific community and not really considered within the policy arena.
Plausibility of pathways of change	The pathways of change are not defined for planetary boundaries. The adaptive management approach does not define pathways, it relies strongly on processes of experimentation and learning. Thus, the plausibility can be rated medium.
Actors addressed (industry, government, civil society) environment/social/economic aspects	"Safe Operating Space" and "resilience" are becoming widely used in the scientific community and were introduced in UNEP's Global Environmental Outlook (UNEP 2012a), which addresses policy-makers. Governments were addressed by the Stockholm Memorandum in 2012 and many case studies on resilience have involved a broad range of societal actors.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.25 Hannover principles

	Description
Main aim / origins /history	The Hannover Principles are design principles for sustainable buildings and objects. They were formulated by William McDonough and Michael Braungart (1992) as principles for the design competition for the EXPO 2000 in order to guarantee design and construction in the understanding of sustainability. McDonough and Braungart propose that "designing for sustainability requires awareness of the full short and long-term consequences of any transformation of the environment. Sustainable design is the conception and realization of environmentally sensitive and responsible expression as a part of the evolving matrix of nature". The nine principles are: 1. Insist on rights of humanity and nature to co-exist in a healthy, supportive, diverse and sustainable condition. 2. Recognize interdependence. The elements of human design interact with and depend upon the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects. 3. Respect relationships between spirit and matter. Consider all aspects of human settlement including community, dwelling, industry and trade in terms of existing and evolving connections between spiritual and material consciousness. 4. Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems and their right to co-exist. 5. Create safe objects of long-term value. Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creation of products, processes or standards. 6. Eliminate the concept of waste. Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems, in which there is no waste. 7. Rely on natural energy flows. Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporate this energy efficiently and safely for responsible use. 8. Understand the limitations of design. No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not as an inconvenience to be evaded or controlled. 9. Seek constant improvement by the sharing of knowledge. Encourage direct and open communication between colleagues, patrons, manufacturers and users to link long term sustainable considerations with ethical responsibility, and re-establish the integral relationship between natural processes and human activity (McDonough 1992). http://www.c2c-centre.com/sites/default/files/The%20Hannover%20Principles_1.pdf http://www.mcdonough.com/speaking-writing/the-hannover-principles-design-for-sustainability/
Scope of change	The Hannover Principles are only targeted at one specific industry, namely design and construction. Considering that the principles focus only on design and construction, the scope of change is low.
Paradigmatic degree of change	The paradigmatic degree of change seems to be high. The principles are based on a holistic concept, where humanity as well as nature has the right to live in a healthy, sustainable condition. Besides, inter-generational aspects are considered (create safe objects of long-term value) .

Plausibility of pathways of change	The concept has so far failed to provide clear pathways of change such as new legislations providing incentives for the design and construction industry to incorporate the Hannover Principles to their core business-activities.
Actors addressed (industry, government, civil society) environment/social/economic aspects	The Principles are to be considered by designers, planners, government officials and all involved in setting priorities for the built environment. They mainly focus on the environmental aspect: the rights for nature and interdependencies between human design and nature. However also the social and the environmental dimension of sustainability is incorporated in the 9 Hannover Principles.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.26 BoP business models

	Description
Main aim / origins /history	BoP business models aim at reducing poverty through profitable business opportunities. The base of the Economic Pyramid (BoP) is the largest but also poorest socio-economic group. However, together they have significant purchasing power. The idea is to use this potential. Private firms explicitly address the needs of the bottom of the economic pyramid and improve the quality of life of these people (WRI no date).
Scope of change	The BoP business models scope is focused on transforming the system of informal dysfunctional markets of the poorest socio-economic group. As such it aims at transforming an entire system.
Paradigmatic degree of change	The BoP model stays within the logic of the market. It develops business strategies and adopts a market based approach to poverty reduction. It is a pro-growth concept which considers that there is a market of 4 billion people yet unaddressed. The meeting of their needs and the involved business-models entail growth.
Plausibility of pathways of change	The BoP model is based on the awareness that some business models work, others not. Hence, there are concrete strategies for successful business models (e.g. Gollakota et al. 2010) providing plausible pathways for change. However, there is not much evidence that these strategies have been implemented successfully in real life and shown the potential to trigger radical change towards sustainable development. Thus, the plausibility of pathways is rated medium.
Actors addressed (industry, government, civil society) environment/social/economic aspects	It addresses business showing opportunities for addressing people with lowest income and enabling them to become consumers. It focuses on social and economic issues of sustainability, in the sense of allowing consumption for the poorest socio-economic groups. In the BoP model, environmental issues are of minor importance.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.27 Leapfrogging

	Description
Main aim / origins /history	Leapfrogging is a term used to describe the possibility for developing countries to bypass inefficient, polluting, and ultimately costly phases of development by jumping straight towards sustainable human development and a better quality of life. In other words, is the concept demonstrates an opportunity to avoid the inefficient and polluting phases of development that industrialised countries have gone through. The term "leapfrogging" describes the rapid change made by a society or a company to a higher level of development without going through the intermediate stages observed in other cases. This connects with the idea that economic resources for unsustainable, outdated and polluting technologies can be saved and instead invested directly in a sustainable future. Ecological leapfrogging can be an alternative to development-as-catching up. It provides strategies to directly enter the phase of sustainability without going through the resource-intensive production and consumption models of industrial societies (UNEP 2010).
Scope of change	medium as it is often only related to specific industries in the developing world or certain parts of the value chain. It does not focus on changing the societal system as a whole.
Paradigmatic degree of change	The concept ambition to initiate a paradigmatic change is medium. It adheres to the existing paradigm of utilitarian use of nature, yet acknowledges that nature is a public good. Hence, in the leapfrogging concept government intervention is an essential precondition for solving resource related problems.
Plausibility of pathways of change	There is a discussion about pathways to change in some industries, such as the promotion of ICTs in developing countries (e.g. Steinmueller 2001), however, the concept has not been implemented on a broader scale. Hence, there is no evidence that leapfrogging is a plausible concept for triggering radical change towards sustainable development so far. countries
Actors addressed (industry, government, civil society) environment/social/economic aspects	This concept addresses all societal actors including governments, businesses and international development and trade agencies as well as the civil society in developing countries. Leapfrogging takes into account all three dimensions of sustainability.

	Low	**Medium**	**High**
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

10.28 Slow food, transition towns

	Description
Main aim / origins /history	The transition movement comprises groups of committed citizens who join together in cities and smaller communities to respond to climate change and Peak Oil by minimising their carbon footprint and increase their resilience to supply deficits triggered by oil shortages (Pirgmaier 2012). In the search for responses to climate change and Peak Oil, Transition Communities aim to actively manage the transition to a resilient, self-sustaining society. Their goal is to free themselves from a dependency on fossil energy carriers and to practice a low carbon lifestyle. They view themselves as a form of "social experiment" and as being on a learning path. The term —Transition Movement originated in Ireland and Great Britain, where the idea of transition as the futher development of the permaculture concept was born. The first Transition Towns were established in Kinsale (Ireland) und Totnes (England) in 2005, at the initiative of Rob Hopkins. In 2008, Hopkins published the Transition Handbook as a 12-step guide to support further Transition Initiatives. Supported by the Transition Network founded in 2007, the movement spread throughout the world. As of November 2011, a total of 406 local communities had officially joined, mostly in Europe, North America, and Australia, with a few participants elsewhere (Pirgmaier 2012). Slow Food is an international grassroots movement as alternative to fast food chains and industrial agriculture. Its aim is to preserve regional cuisine and culture as well as the environment and biodiversity. It was founded by Carlo Petrini in Italy in 1986 and expanded from a gastronomic association to a social and political movement. “Slow Food believes that everyone has a fundamental right to the pleasure of good food and consequently the responsibility to protect the heritage of biodiversity, culture and knowledge that make this pleasure possible” (Slow Food Website 2013).
Scope of change	The scope of change is high, since transition towns aim to change from being energy-dependent to being locally-oriented and resilient communities. Likewise, the slow food movement brings a high scope of change, given the aim of shifting from large agro-industries to locally produced and consumed food.
Paradigmatic degree of change	At the local level these initiatives aim for a change of paradigm.
Plausibility of pathways of change	The Transition movement does not provide readymade answers. It sees itself as providing both the inspiration and catalyst for change. Concrete ideas and projects are developed at community level in open and creative consultation processes. The Transition Handbook of Rob Hopkins 2008 provides concrete pathways for change. Both types of initiatives depend on bottom-up processes of engagement, which means that explicit pathways cannot be defined in a top-down manner. The plausibility is therefore medium, since the initiatives do show how change can be supported (Pirgmaier 2012).
Actors addressed (industry, government, civil society) environment/social/economic aspects	The transition movement comprises groups of committed citizens who join together in cities and smaller communities to respond to climate change and Peak Oil by minimising their carbon footprint and increase their resilience to supply deficits triggered by oil shortages (Pirgmaier 2012). Transition Towns mainly address environmental aspects of sustainability but also take into consideration the organisation of communities. Thus, it can be argued that also social aspects are covered. Slow Food believes that food is tied to many aspects of life, including culture, politics, agriculture and the environment. This is why we are an active player in a wide variety of areas, from education to agricultural policy. To work across this broad sphere, Slow Food defends biodiversity in our food supply, promotes food and taste education and connects sustainable producers to co-producers through events and building networks“ (Slow Food Webpage 2013). This clearly indicates the holistic approach the slow food movement takes on sustainability.

	Low	Medium	High
Scope of change	One specific industry	Various parts of value chains	Societal (sub) systems
Paradigmatic degree of change	Focus on market-based solutions	Recognition of 'public goods' and related right of government to act in public interest	Seeks an alternative for the utilitarian and rational economic approach to life and nature
Plausibility of pathways of change	Ignores factors making change un-necessary	Explains at best conceptually factors supporting change	Explicit and plausible discussion of pathways of change

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