Chapter 2
The Scientific Sustainability Approach

Abstract Read, rethink, refine, reform. In this chapter, you will learn that sustainability is the next big thing. For you, for your company, and for society. After reading this chapter, you will be able to rethink your world, be able to refine it, and ultimately reform it. First, however, you need to understand sustainability, and you have to recognise that it is a holistic and trans-disciplinary matter. Especially considering that the topic of plastics recycling in the automotive sector is associated with a large number of different disciplines, it can and should be analysed from several scientific and non-scientific points of view, including various approaches and their respective tools and methods. As a consequence, it is a prerequisite to understand the related fields such as systems sciences, sustainable development, ecology, economy, geography, as well as environment research, society, ethics, psychology, politics, and technology, which are briefly depicted in this chapter. Through this approach, it is possible to analyse a variety of aspects of the automotive sector resulting in a holistic understanding of the system, the subsystems, and related influences. This approach generates the broad and at the same time deep knowledge foundation required for the empirical analysis in the subsequent chapters offering the holistic basis for corporate sustainability management concerning automotive plastics and recycling.

2.1 Transdisciplinarity

As this book is dedicated to looking at automotive plastics recycling as a whole, and following the definitions of multi-, inter-, and transdisciplinarity by Choi and Pak (2006), a holistic and transdisciplinary approach was selected to mark the basis of this book in order to generate more value, because according to Klein et al. (2012), transdisciplinarity offers an optimised approach to overcome challenges by combining know-how from multiple sources, as required in the field of sustainability. However, because transdisciplinarity can be defined in various wide and narrow ways (Lang et al. 2012) such as including scientific experts from other disciplines in the research team, which is not the case in this book, and to circumvent possible unclear definitions, it is to be highlighted that the notion of transdisciplinarity in this book is implemented in the sense of an intensive and consecutive inclusion of assorted relevant

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insights from diverse disciplines, sources, and actors in this book, following the notion of Jahn et al. (2012). The chosen transdisciplinary setting focusses on human ecology within geography in close collaboration with systems sciences, sustainability and innovation research. The issue concerning specific disciplines which are relevant for this book to varying degrees is that those are focussed solely and understandably on merely one aspect of the topic of plastics recycling in the automotive sector. Of course, these disciplines are vital to understand and ultimately analyse this field of research, but it remains highly important to take a holistic approach in order to combine the knowledge generated by each of the mentioned disciplines. With this broad transdisciplinary approach implemented in the sense of including different relevant insights from various related disciplines and sources in this book, this research can conceive of the countless relations including cause and effect across disciplines within the globalised automotive branch.

For these reasons, the most significant sciences relevant to this research and their interrelations are briefly outlined on the subsequent pages. The disciplines refer to academic disciplines and are arranged from meta- to specific levels, resulting in an investigation of varying intensity into human ecology, systems sciences, sustainable development, ecology, economy, society, ethics, psychology, politics, and technology.

2.2 Human Ecology

Besides the declared approach of transdisciplinarity in Sect. 2.1, it is of great importance to find scientific fields which are capable of managing the various additional required disciplines from a meta-position. Through this approach, is it possible to further increase the substantial value and relevance of this research. The chosen scientific fields capable of this task of taking the meta-position, of serving as a superstructure, are first of all, the human-environment geography (see Gebhardt 2011; Knox et al. 2008; Turner 2002; Weichhart 1993) with human ecology as well as systems sciences and sustainable development, which will be dealt with within Sects. 2.3 and 2.4.

Geography and sustainable development are to date pursuing similar goals in their respective sub-areas. Their difference lies mainly in their differing history and their approach, which is the reason for choosing geography as the first science for the meta-position. Human-environment geography emerged largely from academic scholars limited by the institutions, while environmental studies, including the notion of systemic sustainability, evolved through the driving force of occurrences and stakeholders within large sections of society (Sneddon 2009, p. 559). However, geography is experienced in managing the interaction between humanity and the environment, and not to forget, geographers have successfully empirically verified the influence of industrial production on the natural environment (Braun 2003, p. 1). Recent scholars state that the multiple sciences of geography (physical and human) render the geographer capable of taking on the role as a valuable link vital to achieving a

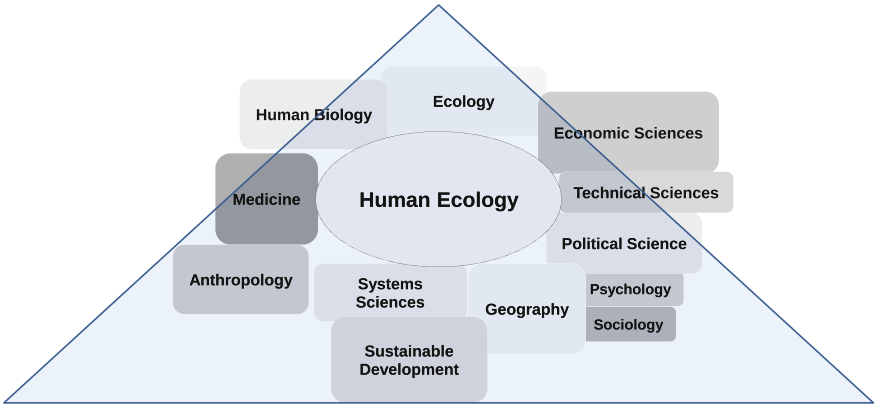


Fig. 2.1 Human ecology—a transdisciplinary approach, adapted with kind permission from Weichhart (1995)

connection between the natural environment and humanity for the purpose of understanding complex issues arising from this relation (see Knox et al. 2008, p. 755). This meta-approach is entitled 'human ecology' and serves as the main transdisciplinary meta-approach for this book. However, despite subtleties of the definition due to different approaches, human ecology in the geographical context is predominantly concerned with sustainability in terms of the relationship between society and the environment which renders human ecology perfectly suitable as a meta-position to answer the research questions in this book (see Sect. 1). Human ecology in this book is primarily based on Peter Weichhart's explanations (Weichhart 2011), alongside Weichhart (1993), Meusburger and Schwan (2003), Glaeser (2013) and Nentwig (2013). Generally, human ecology can be seen as a field of sustainability research focused on transdisciplinarity and the relationship between the global stakeholders as defined below, without a predefined structure as it is basically not an independent science but is a meta-approach managing and accessing diverse human sciences. Human ecology is a new scientific discipline researching the interrelationships and interactions between society, the environment and humanity. Its core is a holistic approach that incorporates physical, cultural, economic and political aspects (Deutsche Gesellschaft für Humanökologie e.V. 2013).[1] Although human ecology emerged from the geographic discipline, it emancipated itself and became a firmly established, transdisciplinary area of research far-reaching across multiple sciences (see Fig. 2.1).

This transdisciplinary approach of human ecology (Fig. 2.1) is an attempt to connect the various disciplines which represents the theoretical foundation of this

[1] Translated and paraphrased original German passage: "Die Humanökologie ist eine neuartige wissenschaftliche Disziplin, deren Forschungsgegenstand die Wirkungszusammenhänge und Interaktionen zwischen Gesellschaft, Mensch und Umwelt sind. Ihr Kern ist eine ganzheitliche Betrachtungsweise, die physische, kulturelle, wirtschaftliche und politische Aspekte einbezieht" (Deutsche Gesellschaft für Humanökologie e.V. 2013)

book. Human ecology and its transdisciplinarity offer the idea of coupled knowledge, although this is often not the case in reality. The most important sciences connected through human ecology which are relevant to plastics recycling in the automotive sector are geography, systems sciences, and sustainable development, followed in a descending order by ecology, economic sciences, sociology and ethics, psychology, political science, and technical sciences. Following this notion of human ecology, the interaction between the two main participants, namely the physical-material world and society, is of especially high importance. In this 'model of interaction', the physical-material world (nature) and society (culture) overlap and this area is defined through 'hybrid systems' [see Weichhart (2008, p. 65), adapted from Fischer-Kowalski and Weisz 1999].

Returning to the paramount topic of geography (Knox et al. 2008, p. 730), further proposes that numerous aspects of future geographies will depend almost certainly on the demand for particular resources and the utilisation of new technologies. Reconsidering the facts about the high demand for oil necessary for the production of virgin plastics and the "end of cheap oil" as stated by Campbell and Laherrère (1998) and outlined in Sect. 3.1, Knox's statement highlights the necessity of geographic approaches toward the current and future plastics production due to the high dependency on a particular resource - oil. Furthermore, the utilisation of new technologies, such as new materials, and technological changes in a globalised economy have global effects (see Malecki 1997).

Taking a brief look on the life-cycle of products, as outlined in Sect. 3.1.2, it becomes clear that geographic factors are essential in a globalised economy. Focussing on the automotive sector, on the required resources for production, the automotive components, and ultimately the car itself as outlined in Sect. 3.2, the life-cycle of those is characterised through numerous spatially relevant features and is a reflection of the relationship between society and the environment:

- The geographic location of the source of the natural resources (e.g., determines the work environment and is relevant for the ecological impact).
- The geographic location of production (locations can be at different stages of development and can have different laws leading to different environmental impact).
- The geographic location of the usage (determines to a great extent where and how the ELVs are treated, causing varying ecological impacts).
- The geographic location of the final destination of untreated end-of-life vehicles.

The relationship of the above-mentioned geographic locations of stages throughout the life-cycle of products, or in this case cars, underlies the basic relations within economic geography according to Ritter (1991, p. 24). This model shows that the resources of the natural milieu and resources of the societal and cultural milieu are used to satisfy human needs, which are modified by ethics and morality. These resources are situated at a geographic position. Finally, the resources, their geographic location and the human needs define the functional relations of economy. Additionally, the relationship between the actors comprised of the consumer, the politicians, and the supplier company is relevant in an economic systems such as

the automotive and plastics industry, which is called 'group of actors approach' according to Kulke (2013, pp. 18–20). In this approach, the financial and work trade between the supplier and the consumer, the power distribution between the consumer and politics, the lobbying and structural policy between politicians and the supplier, and finally the sharing of information establish a system of actors which is influencing the structure and dynamics of location systems and areas as well as spacial systems of economic activities. This approach highlights that in an economy, several actors or actor groups are interconnected significantly. In short, environmental issues and their geographic research are generating a huge momentum within the field of sustainability concerning materials in the economy, regardless of varying definitions of scientific (sub-)fields. However, there are more disciplines besides geography that are investigating environmental issues.

2.3 Systems Sciences

Because this research in the automotive sector deals with a complex system regarding a vast number of elements and disciplines as outlined above, it is advisable to take a systemic approach for improving our understanding of the inherent complexity of the topic. The principles of systems science are relationships between elements including cause and effect, as illustrated in the following example linked to sustainability by OECD (2003, p. 21), which states that "human activities exert pressures on the environment and affect its quality and the quantity of natural resources ('state'); society responds to these changes through environmental, general economic and sectoral policies and through changes in awareness and behaviour ('societal response')" (see Fig. 2.2).

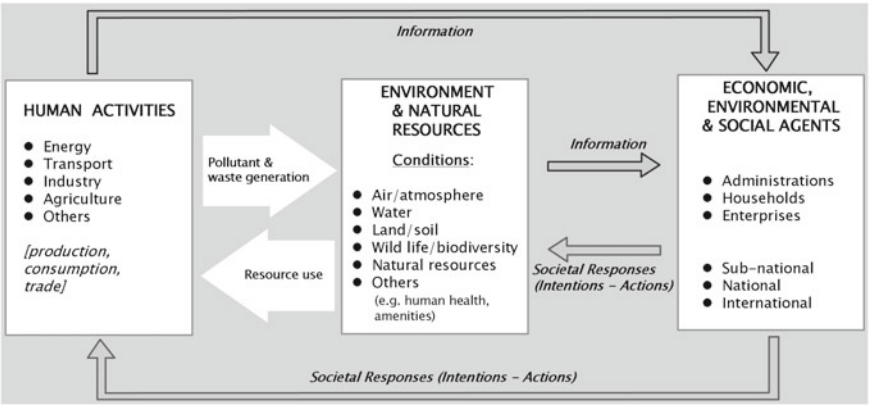


Fig. 2.2 The "Pressure-State-Response Model" highlighting the systemic relationships of sustainability, used with kind permission from OECD (2003, p. 21)

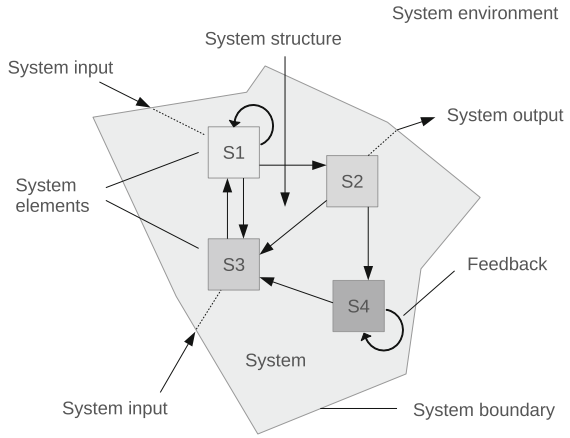


Fig. 2.3 The basic principles of a system, adapted from Mrotzek (2012) and Ossimitz (2000, 1997)

With systems sciences, it is easier to comprehend the system elements and the structure of effects related to automotive plastics when following the principles developed by authors such as Bertalanffy (1968), Checkland (1999), Rosnay (1979) and Willke (2006). Thus the necessary insight to discover the most promising system elements, which can be altered to enhance economic and ecological performance, can be achieved. This notion was also followed by Graedel et al. (1998) who claimed that the automotive industry had to be understood as a system including its surrounding elements and other systems. The principle of systems science is defined as follows: "A system is a set of objects together with relationships between the objects and between their attributes" (Hall and Fagen 1956, p. 18). Consequently, a system consists of system elements, which are structured through connections thus creating relationships, and possibly feedback. In general, the elements of a system are situated within a certain boundary, which should be created in order to achieve a high level of autonomy of the system within the system environment. This system environment influences the system (input) and vice versa (output). Furthermore, feedback is possible within the system, even without input from the environment (Mrotzek 2012). The basic principles of a system are illustrated in Fig. 2.3.

By thinking in terms of such systems, it is possible to perform analysis right down to the last detail as well as regarding the far-reaching synthesis of causal relations (Ropohl 2009, p. 77). Furthermore, this 'systems thinking' is, according to Ossimitz (1997, 2002) defined by four essential dimensions, which were adapted by the author:

- Model thinking: explicitly comprehended modeling, and awareness of the real-world the model is referring to
- Interrelated thinking: thinking in interrelated, systemic structures.

- Dynamic thinking: thinking in dynamic processes (delays, feedback loops, oscillations).
- Systemic action: the ability for practical system management and system control.

These dimensions are considered key to practical systems thinking as performed in this book. Now that the basics of systems thinking are outlined, we can apply this essential systemic knowledge to the science of 'sustainable development'.

2.4 Sustainable Development

The science of sustainability[2] is obligatory to fully understand the ecological dimensions of automotive plastics along the whole life-cycle of cars. For this reason, scientific exploration of sustainable development figures into the theoretical concepts of this book as it facilitates strategic thinking and taking action to overcome urgent challenges (see Baumgartner and Korhonen 2010; Carroll and Buchholtz 2011; Kates and Clark 2001).

Defining sustainable development is difficult, although the term is to date widely used, eliciting a variety of responses. According to Hopwood et al. (2005, p. 38), "the concept of sustainable development is an attempt to combine growing concerns about a range of environmental issues with socio-economic issues." Another and probably the most famous definition is from the report "Our common future", also known as 'Brundtland report': "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Gro Harlem 1987, p. 41).

2.4.1 Levels, Types and Principles of Sustainable Development

In this section, a brief outline of the goals of sustainability and sustainable development will be provided. Following the idea of the 'Framework for Strategic Sustainable Development' (FSSD) by The Natural Step (2013),[3] we must "eliminate our contributions to ...

- ... the systematic increase of concentrations of substances extracted from the Earth's crust (for example, heavy metals and fossil fuels),
- ... the systematic increase of concentrations of substances produced by society (for example, plastics, dioxins, PCBs and DDT),

[2] A detailed up-to-date outline on sustainability is provided by Zimmermann (2016) (in German).

[3] These goals are a reformulation of the initially developed goals by Robèrt (2002) and Robèrt et al. (2002, pp. 198, 199)

- ... the systematic physical degradation of nature and natural processes (for example, over harvesting forests, destroying habitat and overfishing); and ...
- ... conditions that systematically undermine people's capacity to meet their basic human needs (for example, unsafe working conditions and not enough pay to live on)."

Besides these goals for a sustainable society which do not incorporate certain aspects, five principles for sustainable development of which some are linked to the goals mentioned above expand this notion (Deutscher Bundestag 1998):[4]

- "The degradation rate of renewable resources should not overcome their regeneration rate. This rule requires the maintenance of ecological productivity."
- "Non renewable resources should only be used to the extent to which a physically and functionally equivalent replacement in the form of renewable resources or of higher productivity of renewable as well as of non-renewable resources is achieved."
- "Element inputs into the environment should not overcome the absorption capacity of the environmental medium, considering all functions of the environmental medium."
- "The period of time in which anthropogenic inputs or interferences in the environment occur must be in a balanced relation with the period of time needed by the natural processes related to the reaction capacity of the environment."
- "Dangers and unjustifiable risks for human health due to anthropogenic interferences have to be avoided."

Additionally, sustainability contains economic, ecological, and social dimensions that are not separate, but create via an integrated view the three pillars or dimensions of sustainable development (see Adams 2006), illustrated in Fig. 2.4. The dimensions of sustainability with respect to this research will be dealt with in detail subsequently to this section.

Taking the pillars of sustainability, it becomes obvious that one is missing: the institutional pillar. Through this approach, initially developed by Valentin and Spangenberg (2000, p. 383), the institutional aspect of sustainability (which strengthens participation) as well as the linkages between the certain points of sustainability and their imperatives are taken into consideration, as illustrated in the following tetraheder (see Fig. 2.5). Additionally, Janschitz and Zimmermann (2010, p. 137) incorporated logical levels to achieve a concept originally developed for sustainable regional development, but is perfectly suitable for various research in the field of sustainability. The core of the logical levels is to consider the fields in need of change from identity to the environment, which are relevant according to the respective pillar or in this case the vertices of sustainability, and to achieve solutions ranging from visions to concrete actions. The main aim of the concept is to integrate a holistic strategy in sustainable development with the focus on the ecological aspect for the

[4]Translation from German passage in Umweltbundesamt (2010, p. 15), additional translation available from Gleich et al. (2006, p. 355)

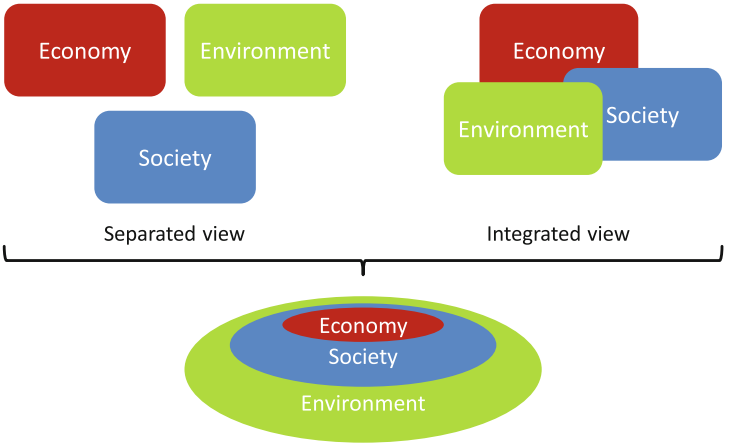


Fig. 2.4 The dimensions of sustainability, adapted from Adams (2006)

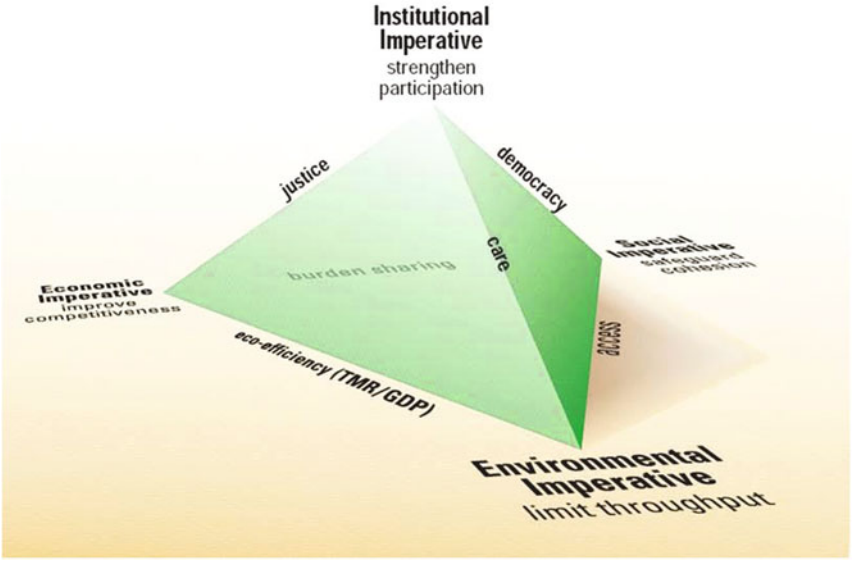


Fig. 2.5 The prism of sustainability (Valentin and Spangenberg 2000, p. 383), used with kind permission. All rights reserved

reason to develop valuable and practicable solutions for transdisciplinary challenges, which is key to this book primarily concerned with ecology.

Because one pillar of sustainability is concerned with economy, it is necessary to first investigate corporate sustainability and secondly, the relationship between sustainable development and corporate sustainability. In this case, the macro-level

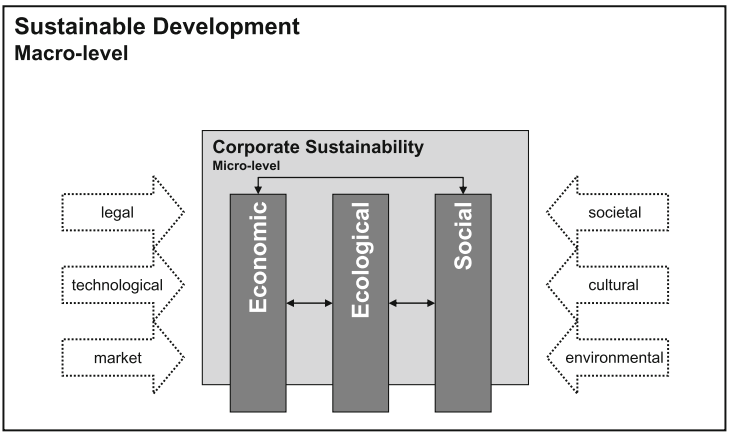


Fig. 2.6 Levels and relationships of sustainability, used with kind permission from Baumgartner and Ebner (2010, p. 77)

(sustainable development) influences the micro-level (corporate sustainability, see section "Corporate sustainability and CSR") through legal, technological, market, societal, cultural, as well as environmental factors (see Fig. 2.6). The micro-level is again based on the three pillars of sustainability. Additionally, society can benefit from corporate sustainability as illustrated by the columns in grey extending from the micro-level into the macro-level (Baumgartner and Ebner 2010, p. 77).

On a holistic examination of sustainability science, four aspects are vital of importance, creating a full outline of the notions of sustainability, which was adapted from Baumgartner (2011, p. 785) and Ömer-Rieder and Tötzer (2004, pp. 6, 7): Sustainability...

- ... is about achieving adequate living for all people on earth within the planetary boundaries, still enabling tomorrow's society to do so likewise.
- ... is dynamic with constantly shifting short-term goals in the course of less dynamic long-term goals.
- ... has to develop strategic contributions (thinking+action) for constructive improvement for society and nature.
- ... contributions have to be rigorous in terms of approaches and strategies.
- ... is to be dealt with in traditional disciplines, and holistic disciplines (such as sustainability science) to achieve an integral way of viewing things.
- ... is about sustainable innovation through new products, as well as institutional, societal and system innovations

Continuing with the approach 'from holistic to specific', we will move on to outline the pillars of sustainability. First of all, the ecological aspects will be dealt with, followed by the economic and the societal aspect including ethics, psychology, politics and the technical theory regarding automotive plastics recycling.

2.4.2 Ecological Aspects

The most important aspect of sustainability in this research is ecology. Essentially, the connection between geography, sustainable development, and ecology is highlighted by Siebert (2008, pp. 99, 283) and Siebert (2007, p. 378) because they state that human activities are always linked to the environment, which is still considered a free good marked by overconsumption to date. It is for these reasons that the environmental impact by human and especially corporate activities has been growing ever since, leading to unsustainable practices (IPCC 2007; Labuschagne et al. 2005; Pachauri et al. 2014) which are measured and compared, for example by DJSI (2013), FTSE (2006) and GRI (2011). Due to this impact of humanity on the environment, the era succeeding the Holocene from the late eighteenth century until today can be labelled as the 'Anthropocene' (Crutzen 2002; Steffen 2007). However, the term Anthropocene has a variety of definitions, depending on the educational and professional background of the respective author (Ruddiman 2012; Zalasiewicz et al. 2008). Crutzen's definition was considered the most suitable, because of his atmospheric chemistry approach, which considers the industrial revolution and the usage of fossil fuels as the beginning of the 'Anthropocene' era. In that era, humanity has been transgressing the planetary boundaries which "define the safe operating space for humanity with respect to the Earth system and are associated with the planet's bio physical subsystems or processes" (Rockström et al. 2009, p. 472).

With this background of the environmental impact of human activities, and the principles of sustainability provided above, we now have to assess the practical ecological aspects or impacts regarding life within the planetary boundaries based on Baumgartner and Ebner (2010, p. 79): The ecological aspects of sustainability include "Resources (materials, energy) including recycling", "Emissions into the air", "Emissions into the water", "Emissions into the ground" as well as "Waste and hazardous waste", impact on "biodiversity" and "Environmental issues of the product" over the whole life-cycle. These ecological aspects are diversely applicable to investigate adverse environmental impacts. In fact, especially the link between global warming and humanity has been confirmed by extensive research on 11,944 papers by Cook et al. (2013, p. 1) which showed that "97.1% endorsed the consensus position that humans are causing global warming", although this number is being debated and challenged in the scientific community. However, to provide countermeasures against the human-caused environmental degradation, one can deduce rules for sustainability, as outlined in Sect. 2.4. When considering the rules and the ecological aspects of sustainable development, it is to be highlighted that during the investigation of ecological impacts of, for example, a product, a life-cycle approach is necessary in order to achieve a holistic view. This life-cycle is defined through three phases: the production phase, the life phase, and the end-of-life phase (Maudet et al. 2012, p. 23), see Sect. 3.2.3. During these phases, certain environmental impacts have to be considered, for example demand for raw materials and energy, the production of waste, and the release of emissions (for more details see Sect. 3.1.3).

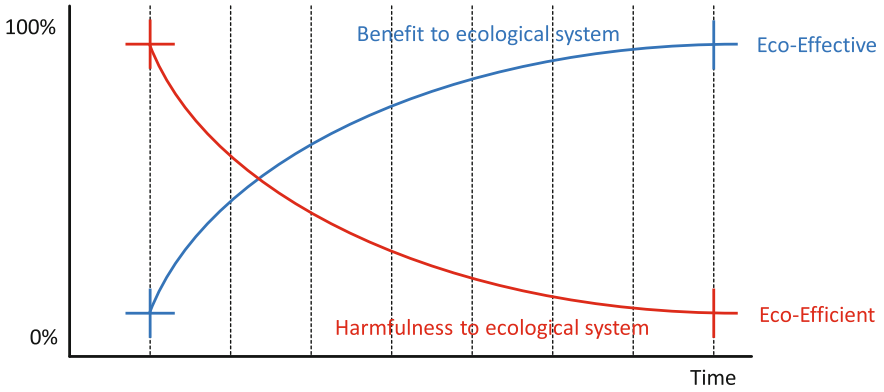


Fig. 2.7 Eco-effectiveness and eco-efficiency, adapted with kind permission from Braungart et al. (2007, p. 1343)

Sustainability science has developed two levels of sustainability, namely 'weak' and 'strong' sustainability. Weak sustainability suggests that natural capital can be replaced by manufactured capital, that depleting natural resources is justifiable if human-made capital is generated in exchange. For example, extracting oil, thus extracting green house gases whose emissions are measured in CO_2 equivalents (CO_2e) (Pachauri et al. 2014), is acceptable if enough plastic products are being produced. In contrast, strong sustainability suggests that natural capital is irreplaceable, that natural capital is finite and certain natural functions are irreversible (Neumayer 2010, pp. 1, 2).

The idea of sustainability leads to additional concepts, such as eco-efficiency and eco-effectiveness. According to Braungart et al. (2007), eco-efficiency sees the economic flow in a linear way, from raw material extraction, to the production of goods and finally to waste (cradle-to-grave). In this linear succession, it is possible to enhance efficiency through, for example, a decrease of raw-material and energy consumption for the production, or little recycling. In fact, only downcycling[5] is possible, since the linear economy does not implement design-for-recycling strategies. In contrast, eco-effectiveness sees the economic flow not as linear but as circular (cradle-to-cradle). With this approach, materials do not end up as waste, as their status as a valuable resource is never lost, through design-for-recycling and actual recycling strategies (upcycling[6]) (Braungart et al. 2007). Moreover, eco-efficiency is intended to decrease the harmfulness to the ecological system, whereas eco-effectiveness is intended to increase the benefit to the ecological system (see Fig. 2.7).

[5]Downcycling describes the process when the recycled product is of inferior value than the initial product, for example, if high-tech automotive plastics is being downcycled to become a waste paper basket.

[6]Upcycling describes the process when the recycled product is of equal or superior value than the initial product, for example if high-tech automotive plastics is being recycled to become high-tech automotive plastics again.

However, a critical analysis reveals that the concept of cradle-to-cradle has to be seen from a holistic life-cycle viewpoint. Thus, the hierarchy of aims might conclude that recycling is deemed unworthy because it is too energy-consuming and the recovery of energy through incineration might be preferable. However, this has to be analysed in each individual case. The next relevant scientific field of sustainability is concerned with the economic aspects related to this research.

2.4.3 Economic Aspects

Research on plastics recycling in the automotive sector is heavily dependent on economic factors, simply due to the fact that it is the economy that drives the world. With this in mind, it is clear that "... the resolution of environmental issues has to proceed alongside the many economic challenges currently facing the automotive industry: notably over-capacity; saturated and fragmenting markets; capital intensity; and persistent problems with achieving adequate profitability" (Orsato and Wells 2007, p. 989). This notion refers to firstly, 'impact decoupling', which "requires increasing economic output while reducing negative environmental impacts" and secondly, 'resource decoupling', which is defined as "reducing the rate of use of (primary) resources per unit of economic activity" (Fischer-Kowalski and Swilling 2011, p. 4). As illustrated in Fig. 2.8, resource decoupling refers to the idea that the intensity or success of economic activity is to be decoupled from resources. And impact decoupling refers to the notion that the economic activity is to be decoupled from the environmental impact. Moreover, the aim is to decouple human well-being, which is presently coupled to economic growth, from environmental impact and resource use.

Additionally, Deutscher Bundestag (2013, p. 156) points out that 'green growth' will not be defined by high growth rates. The benefit lies in the stability and

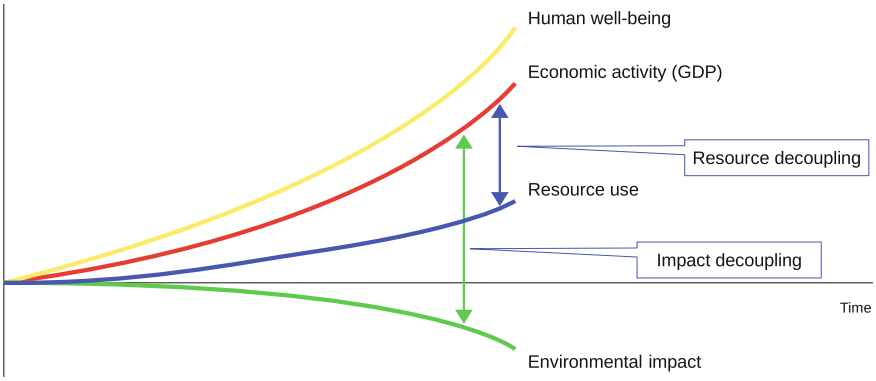


Fig. 2.8 Two aspects of 'decoupling', adapted from Fischer-Kowalski and Swilling (2011, p. 15)

long-term sustainability of economic development. Despite these notions of green growth and decoupling, several additional economic aspects have to be considered as well. According to Deutscher Bundestag (1998, pp. 26, 27), the following aspects[7] have to be taken into account:

- *The economic system is to meet individual and social needs efficiently. For this, the economic system must be so designed that it promotes personal initiative (self-responsibility) and the self-interest in the service of the common good (usually responsibility) is to secure the well-being of current and future society.*
- *Prices must permanently perceive the essential guiding role in markets. They are to reflect to a large extent the scarcity of resources, lowering, factors of production, goods, and services.*
- *The conditions of competition are to be designed so that functioning markets emerge and are sustained, and innovations stimulated in order to achieve a state in which a long-term orientation is worthy and that the social change necessary to adapt to future needs is encouraged.*
- *The economic efficiency of a society and its productive, social, and human capital must be at least maintained over time. These should not only be increased in terms of quantity, but also constantly improved in terms of quality.*

Corporate Sustainability and CSR

The aspects above now have to be implemented within companies through corporate sustainability, which is "Sustainable development when incorporated by the organisation ... and it contains, like sustainable development, all three pillars: economic, ecological and social" (Baumgartner and Ebner 2010, p. 77) and corporate social responsibility 'CSR',[8] which is defined as "the responsibility of enterprises for their impacts on society" (European Commission 2011, p. 6), although CSR is often defined by multidimensionality not just concerning the social aspect. This broad corporate social responsibility is comprised of integrating environmental, ethical, social, and human rights, and concerns of the consumer into the corporate strategy, "with the aim of ... maximising the creation of shared value for their owners/shareholders and for their other stakeholders and society at large" and "identifying, preventing and mitigating their possible adverse impacts." Another term for corporate sustainability is "Corporate Responsibility", which is defined similarly through a business management with sustainability as the major focus to achieve long-term success.

United Nations (2010, p. 15) developed a more detailed guideline for companies, to achieve a higher level of sustainability. These 'ten principles of the global compact' include besides principles about human rights, labour standards, and anti-corruption, three environmental principles (7 to 9) that "[b]usinesses should support a precautionary approach to environmental challenges", "undertake initiatives to promote greater environmental responsibility" and "encourage the development and

[7] Translated and paraphrased from German.

[8] Please note that CSR and corporate sustainability are still not clearly distinguished (Baumgartner 2014, p. 259) and this is why both terms are used to prevent confusion.

diffusion of environmentally friendly technologies." To find out how to implement sustainability at corporate level, please see Sects. 6.1 and 6.1.3.

However, (corporate) sustainable development requires assessment, which is difficult. More than 41 sustainability indices offer various approaches, from integrated and holistic to specific and narrow, including, for example, life-cycle assessments (LCAs) (Singh et al. 2012) with respective standards such as the ISO 14040:2006 (ISO 2006a) and 14044:2006 (ISO 2006b). The mentioned LCA is a holistic and systematic analysis of a product from the cradle to the grave including the initial raw material extraction up to the disposal at the end-of-life (Owens 1997, p. 37), or a "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life-cycle" (Shrader-Frechette 2012). Several LCA methods, which have been developed and improved in the last years, are applicable for achieving a rigour and holistic life-cycle assessment also to "avoid problem-shifting from one part of the life-cycle to another, from one geographical area to another" (Finnveden et al. 2009, p. 17).

Now focusing on the social aspect of corporate sustainability, CSR can be outlined in various ways and very simply, such as done by Carroll and Buchholtz (2001, p. 36) who state four components of social responsibility, which suggest that a company which incorporates CSR should be profitable, conforming to the law, act ethically and be a good member of society. As the concept of CSR is, as the definition suggests, deeply linked to societal aspects, the next section will draw on this and other remaining aspects of sustainability, but not just focused on the corporate level.

2.4.4 Societal, Ethical, Psychological, Political, and Technological Aspects

Sustainability in general also incorporates social aspects including ethics and psychology, which are of equal importance to the ecological and economic aspects. Starting with society and following the notion of Dillard et al. (2008, p. 4), it is to be highlighted that sustainability in social terms is divided into sustainable processes and social facilities, which foster the former.

Within the social aspects of sustainability, also ethics emerge as a field of interest, as they are the foundation of responsible acting. According to Kant (1993), ethics are defined as the following imperative: "Act only according to that maxim whereby you can at the same time will that it should become a universal law without contradiction." Formulated very simplistically, this imperative suggests that what evokes social benefit is positive, and what evokes social disadvantage is negative. Additionally, Kant (1993, p. 5) argues that society has the duty to incorporates efforts to improve freedom, peace, justice, and human rights, and to preserve the natural environment.

As a result, these notions establish and drive the implementation of a new paradigm or consensus called the 'global ethic' (Küng 1993, p. 6). Further, it is time to pursue

responsible economic practices concerning the present world, the natural world and the future world (Küng 2010, p. 126). Consequently, the global ethic can be utilised to channel these required practices. Now, in order to understand how we can pursue such responsible economic practices, we have to briefly assess the political and psychological aspects as well. Within this book, the social (and also the economic) aspect of sustainability is only indirectly of relevance due to the link to the ecological sustainability, for example, when increasing the circular economy in terms of plastics which can cause a reduced need for waste exports to countries that have less strict regulations concerning landfilling, including manual treatment of (toxic) waste.

However, sustainability is also concerned with psychology, simply for the reason that humans are involved. The decision-making process performed in companies, the government and in the mind of each individual human being is especially relevant for automotive plastics recycling, for example due to a possible change of material sources. According to University of Massachusetts Dartmouth (2017), the steps of decision making are:

1. "Identify the decision"
2. "Gather information"
3. "Identify alternatives"
4. "Weigh the evidence."
5. "Choose among alternatives"
6. "Take action"
7. "Review your decision."

However, this decision making process can be influenced heavily by cognitive and personal biases (Manktelow 2012), which can lead to serious failures regarding decisions within a complex system that requires a rigorous and holistic analysis of the system elements and their relationships. One relevant aspect in this case is the possibility of egoistic action by the individual in the system which can lead to seriously negative outcome, and this usual actor is called "limited homo oeconomicus" (Kulke 2013, p. 55).

Besides society and the economy represented by businesses, politics and political decision-makers represent an additional key player in the changing and environmentally critical system of automotive plastics, because "... science and technology developments are challenging existing public policies and legislation due to the impact that they may have in terms of environmental sustainability ..." (Klüver et al. 2015). In fact, politicians can influence this system through impeding, promoting, and stalling action by means of legislative measures, incentives, lobbying, and simple action, inaction, or even counter measures. Through these options of influence, politics represent another actuator for improving sustainability within companies. More importantly, the mentioned key players (politics, companies and society) do act accordingly to certain decision making processes and are influenced by biases.

In the field of plastics recycling in the automotive sector, the technical aspect is of particular interest. This is because the available and future technologies determine the paths we can choose from when pursuing sustainable development. When thinking about technology to improve the level of sustainability, it is necessary to evaluate

technology. However, current practice is to focus on the economic and technical characteristics. If new technology is intended to be designed humane and environmentally sound, ecological, social and political dimensions ought to be included in the system of aims within the development of this new technology (see Ropohl 2009). This notion is called 'eco-technological systems knowledge' or 'eco-socio-technological systems knowledge[9] (Ropohl 2009, p. 277). This concept builds on the assumption that nature, human beings, and society create the conditions to which technology is subject. Vice versa, consequences induced by technology influence nature, human beings and society (see Ropohl 2009).

Now, to develop future conscious strategies in line with nature and society, an examination of technology and its possible issues is required. Prominent examinations are the holistic 'technology assessment' or 'TA' (United States Congress 1995) to analyse the impact of technology on society (Coates 1976), or the focussed 'environmental-impact analyses' 'EIA' (Shrader-Frechette 2012). A popular TA method is for example the 'risk-cost-benefit analysis' 'RCBA'. Concerning these types of assessments, the biggest challenge is forecasting and anticipating "higher-order" consequences of high complexity (Shrader-Frechette 2012).

2.5 Conclusion: Sustainability as Schrödinger's Cat

Is sustainability dead or alive? I am not so sure. But reflecting on the gathered information in the preceding sections concerning plastics recycling in the automotive sector with the focus on ecological sustainability, one is led to these main findings:

- Humankind is the determining factor on the globe in the era of the Anthropocene (Crutzen 2002; Steffen 2007).
- Certain boundaries of the earth have been transgressed or are being transgressed (Rockström et al. 2009).
- Solutions and strategies exist in theory, such as

– Resource and impact decoupling (Fischer-Kowalski and Swilling 2011, p. 4).
– Eco-efficiency and eco-effectivity (Braungart et al. 2007).
– Concepts for holistic and transdisciplinary strategies for sustainable development including the FSSD (Janschitz and Zimmermann 2010; Robèrt et al. 2002, p. 137).
– Corporate sustainability and CSR (Baumgartner 2014; Baumgartner and Ebner 2010; European Commission 2011).
– Ecotechnical systems knowledge and technology assessment (Ropohl 2009; Shrader-Frechette 2012; Singh et al. 2012).

[9]Translated and paraphrased original German passage: "ökotechnologisches Systemwissen" and "öko-sozio-technologische Systemwissen" (Ropohl 2009, pp. 214, 215).

As a intermediate result, the scientific sustainability approach revealed that in order to develop sustainability with strategies as mentioned above, first the key elements including the key players, resources and goods, as well as their relationships within the automotive plastics production and recycling system have to be understood (Fischer-Kowalski and Weisz 1999; Knox et al. 2008; OECD 2003; Ossimitz 2002; Weichhart 2008). Furthermore, it is necessary to gather knowledge and data on the above-mentioned system aspects suitable for the normative, the strategic, and the operational management level in companies (see Baumgartner 2014). Consequently and foremost, information about the economic branches and goods in the focus of this book is required, which is done in the following Sect. 3 and the subsequent empirical analysis.

When going back to the beginning of this book and reflecting on the research questions (see Sect. 1), the theoretical outline in the preceding sections provided reasons and criteria for the selection and formulation of research questions following the overarching question: What can we do to advance the ecological sustainability of plastics in the European automotive sector? But first, when thinking beyond the main findings above and especially the section about sustainability, it was discovered that companies do think differently. Sustainability is 'good' and a requirement, but in fact, the only thing companies really understand are key performance indicators (KPIs). Therefore, a new definition was required. And this is why it was decided to adapt the notions of sustainability science for companies by creating a new approach.

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