Utilising Systems Thinking for Sustainable Consumption: How Participatory Systems Mapping Achieves Four Types of Insight

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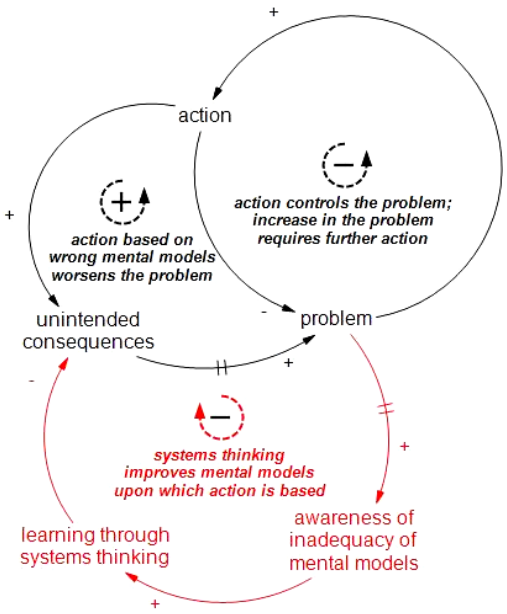
Abstract

The paper aims to present how the usage of systems thinking, in particular as participatory construction of causal loop diagrams (CLDs), can contribute to a systemic understanding of sustainable consumption. In the framework of an FP7 project titled RESPONDER we are testing the usage of CLDs for knowledge brokerage. Building on participatory modelling approaches and applications we developed a method of 'participatory systems mapping' (PSM) in which CLDs serve as boundary objects and enable co-creation of knowledge. The paper describes the PSM method, our experience with it, as well as five different 'lenses' for production of specific types of insights. These insights together support a systemic, complex and multi-perspectival understanding of the problem issues and thereby can effectively foster learning and help formulation of effective policies for sustainability.

Graphical abstract



Keywords

sustainable consumption, economic growth, systems thinking, knowledge brokerage, participatory systems mapping

1 Introduction

When the Brundtland report popularised the concept of 'sustainable development' in 1987, it also emphasised the need for developing more sustainable consumption patterns: "Sustainable development requires that those who are more affluent adopt lifestyles within the planet's ecological means" (WCED, 1987: 9). The commitment to sustainable consumption has been confirmed at the 1992 Earth Summit in Rio, and in a number of programmes initiated by international organisations and governments at all levels. Nevertheless, government action on sustainable consumption focuses on the individual consumer (perhaps using misleading models of consumer behaviour) and on improving environmental efficiency of consumption rather than addressing scale issues or the social context and systemic dimensions. Over the last decade several strands of research on sustainable consumption (particularly sociological and anthropological research) have provided evidence which suggests that this dominant policy approach might be the reason for the relatively modest success of sustainable consumption initiatives.

As a contribution to the discussion we are testing the usage of systems thinking methods for the purpose of knowledge brokerage between science and policy aimed to help 'manage the contradictions of sustainable consumption and economic growth'. The project *Linking Research and Policy Making for Managing the Contradictions of Sustainable Consumption and Economic Growth* (acronym RESPONDER) is one of the knowledge brokerage (KB) projects funded by the European Commission through the Seventh Framework Program for Research and Technological Development (FP7) to increase use of available evidence and scientific expertise in sustainable development and environmental policy making. RESPONDER attempts to bridge not only the science–policy gap but also the 'pro-growth'–'beyond growth' discourse gap by recognising and linking four communities: 'pro-growth' scientists, 'pro-growth' policy makers, 'beyond-growth' scientists and 'beyond-growth' policy makers. This paper aims to present the method of participatory systems mapping, developed in the project, and to demonstrate its use can result in particular insights into problems related to sustainable consumption.

The next section introduces the discursive context of the RESPONDER project and presents our definition of sustainable consumption. The third section describes our systems thinking approach: the method of participatory systems mapping (PSM), developed for the purposes of the project, is explained and situated in the organisation of project's tasks and events. The fourth section provides a theoretical framework of our CLD usage and on five different ways of engaging with CLDs in detail demonstrates the different types of insight produced. The fifth section is devoted to conclusions.

2 The competing discourses of sustainable consumption

Over the 1990s and 2000s a number of programmes on sustainable consumption has been initiated by international organisations such as UN or OECD as well as by a number of national governments and the European Union (Fuchs and Lorek, 2005; Berg, 2011; Fuchs, forthcoming). Most of these programmes share the same basic understandings and, contrary to the call of the Brundtland Report, are quite far from any serious challenge to the lifestyles of the affluent. First of all, sustainable consumption is not seen to be in contradiction with continued economic growth in the rich countries, and there is no mention of reserving consumption growth for poor people. As UNEP states in 2000: "sustainable consumption is not about consuming less, it is about consuming differently, consuming efficiently, and having an improved quality of life" (UNEP and CDG, 2000). The policy documents on sustainable consumption stay within the framework of the ecological modernisation discourse that emphasises win-win strategies: consumption can become more sustainable, new business opportunities emerge, and quality of life improve, all at the same time. This should be achieved by increasing the resource efficiency of consumption, encouraged mainly by market-based policy measures. Labelling of green products combined with information campaigns should help consumers to make informed choices and thus make it profitable for business to provide green products. Simultaneously, environmental taxation of resources, in particular energy and water, and of emissions of polluting substances could promote resource efficiency and reduce pollution. The actual toolbox included other instruments like direct regulation (bans on problematic substances, tightening of building regulations) and subsidies to consumers, e.g. for insulation, but direct regulation was not promoted as a part of the

win-win repertoire (Christensen et al., 2007). Politically, it was an attractive strategy to translate the alleged consumer sovereignty in free markets to consumer responsibility: if consumption does not become more sustainable, consumers can be blamed. The focus on improving the efficiency of consumption has been termed 'weak sustainable consumption' (used by Fuchs and Lorek, 2005, as a differentiation from 'strong sustainable consumption' which focuses on the pursuit of fundamental shifts in consumption patterns and reduced levels of consumption in the rich countries).

Considering the results of the first twenty years of consumer-oriented environmental policies, results have surely been achieved. Nevertheless, there are grounds for criticism. For instance, the combination of compulsory energy labelling, energy taxes and information campaigns has increased the efficiency of electrical appliances significantly, and various measures have reduced heat consumption per square meter. At the same time, however, critics point to an increase in the number of appliances and the area of heated space that counteract the achieved energy savings. In other cases, like transport and travelling, it has not been politically acceptable to follow the 'recipe': since mobility is considered decisive for economic growth and personal freedom, economic instruments have not been applied effectively, and energy consumption has increased considerably. Many areas of consumption are not addressed by environmental policies, and consumer-oriented environmental policies have not in any way questioned the continued rise in material living standards, the ongoing renewal of consumer goods, or the costly individualisation of consumption.

A new and related field of research developed over the last 20 years and interacted with policy making (for anthologies see e.g. Princen et al., 2002; Jackson, 2006; Reisch and Røpke, 2004). It has collected knowledge on environmental impacts of consumption, with the consumption clusters of food, mobility and housing identified as having particularly large impacts (Hertwich, 2006). A lot of research applied an individualistic perspective and concentrated on the understanding of consumer behaviour, trying to explain the attitude–behaviour gap and investigating the results of various interventions like taxes, eco-labels and information campaigns. Some research saw a solution in the identification of different consumer groups and lifestyles and addressing them in different ways. Nevertheless, under 'green consumption' it is perfectly possible for consumers to demonstrate their 'greenness' by carrying out a large number of token green practices and simultaneously increase their

environmental impacts considerably. Large segments of consumers have developed a sort of 'compartmentalisation' where only some categories of consumption are considered in environmental terms, while much ordinary consumption and increases of normal standards go unnoticed.

Concurrently with the individualistic-oriented consumer research, more sociological and anthropological perspectives were developed (Gronow and Warde, 2001; Southerton et al., 2004). Here the embeddedness of consumption activities within wider social, economic and technological frameworks was emphasised, and the interplay between systems of provision and consumption practices was explored. So far this strand of research has not been influential in policymaking, but this may be about to change. Maybe the limited results of the win-win strategies in terms of the overall environmental impacts of consumption have contributed to a search for broader approaches. The individualistic-oriented research increasingly tries to take 'context' into account (Thøgersen and Grønhøj, 2010), and sociologists try to develop more policy-oriented advice that goes beyond the traditional ABC (attitude–behaviour–choice) approach (Shove, 2010). Simultaneously, bottom-up experiments with more sustainable consumption and production patterns emerge and call for studies on the possibilities for scaling up (Seyfang, 2009).

Concepts which roughly correspond to the directions of these strands have been developed also in other sustainability literatures. It is possible to organise the literatures into a discourse focusing on the individual and 'weak' sustainability (with concepts of ecological modernisation, green consumption (Princen et al., 2002), responsible consumerism or virtuous circle (Hobson, 2002: 132), a discourse focusing on the individual and 'strong' sustainability (e.g. voluntary simplicity), and a discourse focusing on the social/systemic dimensions and 'strong' sustainability (de-commodification or bioregionalism (Sale, 1985)). The RESPONDER project can be seen as tied to the last discourse. First of all, the challenge of sustainable consumption is considered in a global perspective where the focus on improved efficiency in consumption is replaced by 'strong sustainable consumption'. Sustainable consumption is thus characterised along three objectives: a reduction of the overall consumption of resources to steer the socioeconomic system away from natural limits; the ethical challenge of redistribution of resource appropriation from rich to poor within and between nations; and the striving to achieve well-being, quality of life or a 'good life' (Buen Vivir) (see Scholl, 2011). Second,

consumers are not only considered in the role of buyers on a market, but also as practitioners that carry out meaningful practices and, at the same time, fulfil roles in broader socio-technical systems. Nevertheless, we do not push for a specific understanding, but rather expect that the mapping exercises expose a plurality of systemic aspects to facilitate policy-relevant learning.

3 Systems thinking and the method of participatory systems mapping (PSM)

Systems thinking is a discipline developed from feedback concepts of cybernetics and servomechanism engineering theory (Senge, 1990). It provides a framework for holistic thinking while addressing complex societal issues. The core of systems thinking is seeing 'wholes' instead of 'parts', making sense of interrelationships between system components to understand what drives dynamic behaviour. Richmond (1993) advanced a set of critical thinking skills which cater for more holistic policy-making processes, including: i) dynamic thinking (the ability to deduce dynamic behaviour patterns rather than focusing on events), ii) closed-loop thinking (the ability to think in feedback terms leading to recognition of process interdependencies and endogenous causes of systemic change), and iii) operational thinking (the ability to understand the physical processes and 'how things really work'). Research related to natural resource management, ecological economics and sustainable development was attracted to systems thinking since the end of 1960s, and particularly since the publication of *The Limits to Growth* (Meadows et al., 1972). In the area of sustainable consumption, the importance of systems thinking has been increasingly recognised over the recent years (see, e.g., Klingert, 1998; Geels et al., 2008; Timmer et al., 2009a, 2009b; Mont and Power, 2010; Soderquist, 2010; Prinet, 2011). Nevertheless, as of now, a more thorough application of systems thinking is quite rare (see, e.g., Nemecskeri et al., 2008; Jackson, 2009; Green et al., 2010).

Approaches involving clients in systems thinking, applied since the 1970s, have over recent years evolved into, among others, group model building (Vennix, 1996) and mediated modelling (van den Belt, 2004). While providing structured platforms for participation and active engagement of inter-organisational stakeholder groups in policy and decision-making processes, these methods foster co-production of knowledge and group learning as outcomes of the modelling process (Videira et al.,

2009). They constitute settings which enable deliberation among participants and stimulate the development of critical thinking skills, such as the recognition of interconnections and feedback processes. In recent years, these methods have been increasingly used in the context of public policy making on natural resources (e.g. Hare et al., 2003; FLUF, 2010; van den Belt et al., 2010).

Causal loop diagrams (CLDs), shaped in particular by systems dynamics and cybernetics, are probably the most-utilised systems-thinking visualisation tool. Two widely recognised uses of CLDs are the transformation of verbal descriptions into feedback structure during early stages of model conceptualisation (Goodman, 1974), and the presentation of a 'distilled' understanding at the end of the whole modelling process (Morecroft, 1982). Since an underlying principle of systems thinking is that the behaviour of a system is the result of the structure of its elements, CLDs provide an endogenous explanation for observed behaviour. In RESPONDER we intend to test the use of CLDs for KB; we use CLDs as boundary objects (Cash et al., 2003) to (i) transform perceptions and mental models of individuals and groups into a causal and feedback structure, (ii) expand the boundary of thinking by enabling exploration and exchange of knowledge and paradigmatic and value positions accepted in various communities in the process, (iii) identify knowledge gaps through comparison with evidence-based and systematised knowledge, and (iv) formulate hypotheses about causes and effect and insights regarding system's behaviour and identify potential leverage points.

In the RESPONDER project we organise a number of thematic events in which the participants representing all four target communities engage with CLDs. At the time of this writing we were able to reflect on experience from workshops devoted to sustainable food consumption, sustainable mobility and sustainable housing. For the workshops we developed a method of 'participatory systems mapping' (PSM) building on participatory modelling approaches and applications (see Richardson and Andersen, 1995, Vennix et al., 1992; van den Belt, 2004; Videira et al., 2009). Since then we have tested the method on about 30 occasions in group sizes of 8 to 18 participants (excluding the facilitator). Application of PSM can best be described as the preparation and execution of a facilitated group process of development of causal loop diagrams to provide insights into a particular problematic issue and enable knowledge exchange.

The method requires an experienced facilitator, ideally possessing expertise both in systems thinking and in the issue being mapped. In terms of material it requires a large sheet of paper, larger sticky index cards for variables (they might need to be moved around), flipchart markers, pencils and erasers (for recording and changing causal relationships), sticker dots (for voting on knowledge gaps or leverage points) and a flipchart for documentation. Group size is discussed below.

Systems mapping needs to be focused on a particular problem issue, otherwise the lack of even implicit system boundaries can paralyse the process. Although an issue reflecting the group's interests can be defined as late as the start of the session, we have chosen to formulate a set of problem issues for each consumption area prior to the workshops. This was done to help moderators prepare as well as to ensure that the problem issues link sustainable consumption with macroeconomic (growth-related) concerns, could lead to unexpected insights and are viable for mapping (e.g. have an appropriate level of abstraction and complexity). As a part of issue identification two starting variables were formulated, the primary cause variable and the primary effect variable. They provided an implicit system boundary as well as a general causal direction. Before the session they were written on two index cards of a different colour. (In the future we will experiment with starting with a simple feedback loop.) In addition we formulated a guiding question and wrote a short paragraph describing the issue. The guiding question helped to manage the system boundary during the process; it made it possible to ask whether a newly introduced element in the map helps answer the question.

The mapping itself was exploratory and, at least in the first round of events, diagnostic (aiming to describe the problems in their current situations and institutional contexts). The facilitator strived to create an open and creative atmosphere, focusing not only on the result (the quality of the produced CLD), but also on group interaction and knowledge exchange.

After familiarising the participants with the problem issue and CLD syntax (described below) several steps were followed over two 90' sessions. There were no strict boundaries between the steps, both in terms of timing or sequence; the facilitators adapted to the flows and needs of the group when (repeatedly) switching between the steps.

1. mapping effects of the primary cause (endogenising the primary cause was sometimes helpful to explain the issue);

2. mapping causes of the primary effect and linking the primary cause to the primary effect (exploring further effects of the primary effect was sometimes helpful);
3. forming of feedback loops from effects back to causes;
4. acquiring feedback from outside audience (participants of other groups), which also forced the group to formulate statements expressed by the map when presenting;
5. analysis of the map using a range of possible 'lenses' (see below);
6. voting on knowledge gaps, i.e. choosing variables, causal linkages or loops where the participants saw the demand for more evidence or for further exploration by future mapping exercises.

The resulting CLDs were 'raw': they contained inconsistencies, errors, duplicities and under-developed system structures. Following the workshops we therefore 'cleaned up', processed and digitalised the CLDs, while respecting the interests and concerns of the participants developing the map. The processed CLDs will be placed in the RESPONDER online knowledge brokerage platform, enabling further interactive engagement.

4 Achieving different types of insight with CLDs: a discussion

Causal loop diagrams are expressed in a formal language originating in systems dynamics (Forrester, 1968) and cybernetics (Wiener, 1948; Ashby, 1956; Bateson, 1972). They depict causal relations between selected variables, focusing on positive and negative feedback loops and development trends. We understand systems as purposive, transcending the subject/object boundary by connecting relevant elements of individuals, social systems and the natural environment through pathways and feedback loops (see also the 'theory of the mind' by Bateson, 1972). Systems thinking thus typically does not concern itself with the question of agency; agents are typically 'hidden' in the assumptions. Furthermore, institutions (rules, norms etc.) are also rarely explicitly present; they, however, enable the depicted causal connections, are 'behind' them. Therefore structure can be understood as 'objectively given' by material and institutional conditions. Nevertheless, in relation to the context of participation and knowledge brokerage, we respect Churchman's (1970) understanding of boundaries

as ‘social or personal constructs that define the limits of the knowledge that is to be taken as pertinent in an analysis’, acknowledging that ‘[w]here exactly boundaries are constructed, and what the values are that guide the construction, will determine how issues are seen and what actions will be taken’ (Midgley, 2000: 35–36). The participatory design is supposed to address the valid concern of Dryzek (2005) of a technocratic elite of systems thinkers dictating societal solutions based on impenetrable computer models. PSM serves to provide an explicit picture of how participants see the system in positivist terms, and empower them to think of and deliberate on viable solutions. Furthermore, it should enable a discussion of boundaries (i.e. where lies the power to draw boundaries), as well as the assumptions and institutions behind the structure. In terms of stability of system structure we understand the CLDs as ‘snapshots’ of systems at certain points in time. Systems continually evolve and change their structures, and sometimes they collapse and are reorganised radically (see, e.g., the adaptive cycle; Holling, 2001). More abstract system representations tend to be more useful for depicting longer time frames than detailed CLDs representing concrete situations.

The most important elements of CLDs are variables, which are relevant for explaining the behaviour of the system, and their interdependencies represented by arrows. Relationships are causal and exist between two variables. They are either positive (drawn as arrows tagged with a plus sign) or negative (dashed arrows with a minus sign).[1] To depict longer time delays between changes in the cause variable and in the effect variable (which typically have significant implications on the dynamic behaviour of the system), the arrow is marked with a double slash sign. Central to CLDs are feedback loops (circular causalities) which are either reinforcing (i.e. positive, leading to exponential growth or exponential decay) or balancing (negative, leading towards an equilibrium or goal value). Feedback loops are depicted as independent and smaller circular arrows placed within a chain of variables and labelled with a plus or minus sign. Small clusters of reinforcing and balancing feedback loops in certain arrangements are often referred to as the ‘engines of the system’.

[1] A positive causal relationship between cause X and effect Y means that an increase in X will lead to an increase in Y above what it would otherwise have been (assuming all other variables remain constant) and, conversely, a decrease in X will lead to a decrease in Y below what it would otherwise have been. A negative causal relationship is inverse, i.e. an increase in X will lead to a decrease in Y below what it would otherwise have been and a decrease in X will lead to an increase in Y above what it would otherwise have been. (For the discussion on the ‘proper reading’ of causal relationships see, e.g., Richardson, 1997; Sterman, 2000.)

We were also able to make some observations regarding the PSM process. These will be presented in the next sub-sections. The following sub-sections demonstrate some of the 'lenses' for thinking about CLDs and highlight what types of insight and learning effects they support.

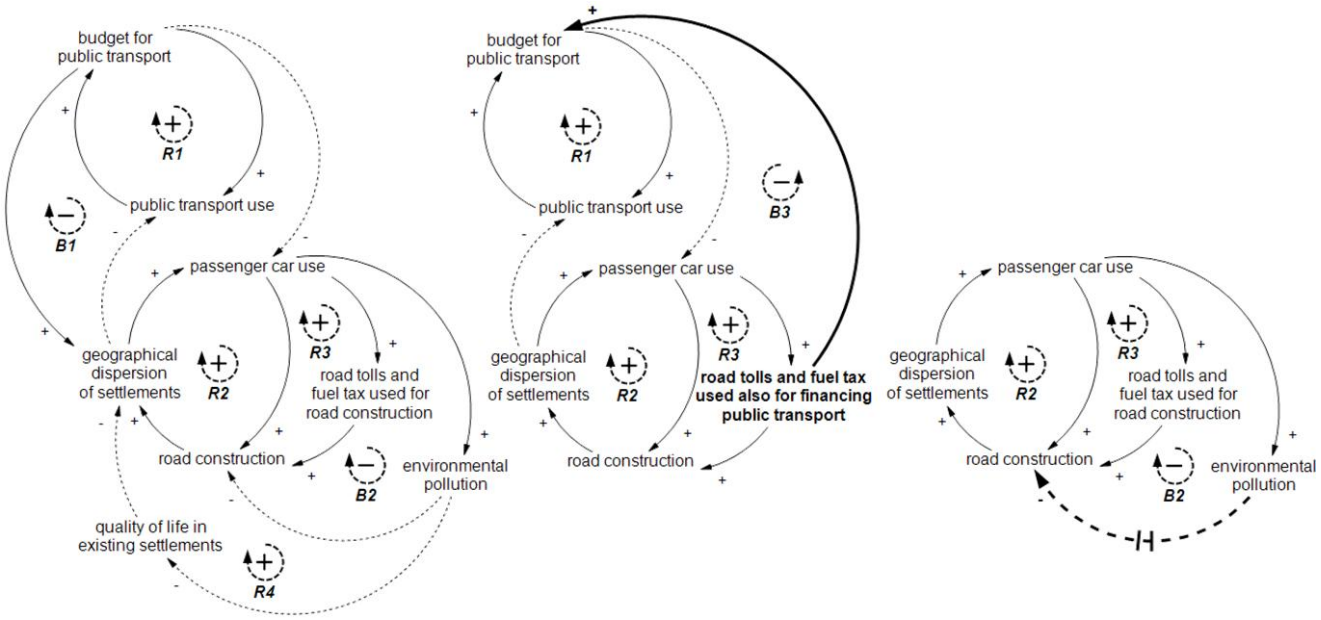
4.1 Reflecting on process-related experience with PSM

In the following we would like to present our observations and experience related to a PSM session's length, group size and composition, and facilitation style. A viable duration of a PSM session seems to be between 90 and 120 minutes. With less time the chance of producing a useful result as well as 'spotlight time' per participant decreases and the risk of dissatisfaction grows. We have experimented with longer sessions on a few occasions and we observed that due to concentration demand they lead to fatigue. Since following the six steps above usually requires more than one session, it is ideal when the sessions are separated by a longer break.

It would seem that larger group sizes enable a higher plurality of perspectives and potentially provide more opportunity for knowledge exchange and learning. Nevertheless, they also limit the available time per participant and make consensus (to a large extent necessary) harder to achieve. An ideal balance seems to lie at about 10–12 participants. The group can also be bigger if it is more homogeneous in respect to the communities and discourses its participants represent. Our experience seems to indicate that higher homogeneity of the group correlates with a higher pace of the map's development as a lower number of controversial issues are tackled in the process so such a map may be richer in detail but poorer in terms of the diversity of underlying paradigms or disciplines contained.

A tight facilitation style seems to be the most productive, in particular towards the beginning of the exercise. This means that the input by the participants is channelled into the map through the facilitator and the facilitator focuses the attention of all participants on the issue currently discussed.

4.2 Closed-loop thinking: an example from mobility



a *b* *c*

Figure 1. Public transport use vs. passenger car use map with two variants

Closed-loop thinking is a 'lens' which enables to think about interrelationships between feedback loops. Thereby it helps to understand and infer behaviour of systems over time. Figure 1 shows a simplified excerpt from a system map from the mobility consumption area (map *a*) and its two variants (*b* and *c*), mapping the issue "How does road construction influence transport volume and modal split?". The excerpt highlights dynamic tensions between public transport use and passenger car use.

We will first describe the map *a* in more detail. The reinforcing loop R1 indicates that an increase in public transport use will (through an increase in net ticket revenue) be reflected in budgets for public transport being higher than they would otherwise have been. Proper spending of these budgets should result in the public transport becoming more available and attractive which further increases public transport use and decreases passenger car use. This loop, when unchecked, would cause that public transport use and budgets for public transport grow exponentially. Nevertheless, geographical dispersion of settlements (the balancing loop B1) is pulling against this reinforcing tendency. Increasing availability of public transport would result in the settlements being more dispersed than they would otherwise have been and this would push public transport use down (with simultaneous

growth of car use). For the sake of brevity a number of other limiting factors is not included in the map (e.g. factors inhibiting switching from car use to public transport, population size or urbanisation structure) and many of the causal relationships are simplified (e.g. between budget and public transport use).

Another cluster of loops shows the feedback processes underpinning private passenger car use. The reinforcing loop R2 represents the political pressure to construct new roads or widen existing roads as a traditional (and short-sighted) way of fixing the problem. With increasing car use, the importance of automotive industry for domestic economy and the political weight of car users would be higher than otherwise, which would result in more road construction. This would, in turn, result in an increase of geographical dispersion of settlements and in a further increase in car use, thereby over time exponentially increasing the scale of the problem. The loop R3 adds a second powerful reinforcing effect, the economic dimension of financing road construction through road tolls and fuel taxes. The loop R4 shows how the negative impacts of increasing car use further contribute to the growth of car use: higher car use causes the quality of life in existing settlements be lower than it would otherwise have been, resulting in people moving out into 'quieter' or 'calmer' areas, and thereby contributing to a further growth of the geographical dispersion of settlements which, unfortunately, additionally contributes to an increase in car use. This set of three reinforcing loops, potentially further strengthened by the influence of availability of public transport on dispersion of settlements, is counterbalanced by only two forces: the attractiveness and availability of public transport as a factor causing switching from car to public transport use, and by the balancing loop B2. This loop represents public pressure in response to environmental pollution caused by car use and the resulting changes in political priorities and regulation, which would result in road construction being less intensive than it would otherwise have been.

Without simulation the behaviour of the system (i.e. the change in modal split over time) can be only roughly inferred. The map, however, invites discussion on the relative strength of feedback loops, time delays and possible solutions. It could be theorised that the loops R2, R3 and R4 are much more powerful than the balancing loop B2, and that the resulting moment of the 'engine' related to passenger car use is stronger than that of the cluster related to public transport (which has one

moderately strong reinforcing loop and one moderately strong balancing loop). As a probable result, the geographical dispersion of settlements, which seems to be the most crucial variable in the map, would, unless meeting limits not depicted in the map, continually grow and cause a migration of public transport users to car use at an accelerating rate.

The second variant (map *b* in Figure 1) shows a potentially powerful leverage point. (The changes to map *a* are depicted in bold. The rest of *a* remains the same, even though it is not reproduced in its entirety in map *b*.) If a share of collected road tolls and fuel taxes would be channelled to public transport instead of road construction, relative strengths of the passenger car use 'engine' and the public transport 'engine' would change. In more detail, the economic reinforcing loop R3 would become 'weaker' and the loop R1 related to attractiveness and availability of public transport 'stronger'. This effect would be the more pronounced, the higher the share channelled to public transport would be. (Should 100% be channelled away from the car use cluster, the link between road tolls and road construction, and thereby the loop R3, would disappear.) Nevertheless, this solution has its limits as well. The new loop B3 suggests that should public transport attract significantly more users, car use would also be significantly lower than otherwise. It is possible that other factors (peer pressure and position of a private car as a status symbol, growth in household incomes, availability of consumer credit or leasing etc.) would still cause growth of passenger car use in absolute numbers; but should this trend reverse, unless the fees per unit of passenger car use grow the income from road tolls and fuel taxes would decrease as well. In these conditions, the more successful public transport use vis-à-vis car use would become, the less effective this policy measure would also become. In addition, a stronger loop R1 would also more strongly contribute to the growth of geographical dispersion of settlements. A more robust solution could therefore be weakening the link between budgets for public transport and geographical dispersion of settlements, or between dispersion of settlements and passenger car use.

The third variant (map *c*) is a modification of map *a* only in the respect of placing a time delay on the arrow between environmental pollution and road construction. If public mobilisation and political change represented by this arrow become noticeably slower than the causal relationships in loops R2, R3 and R4, the current strength with which the balancing loop B2 counteracts road construction is at

any time equivalent to the state of environmental pollution only some time ago. This would effectively weaken B2's balancing function of keeping car use at acceptable levels. Also, perhaps surprisingly, a policy solution towards decreasing the environmental impacts of car use (by, e.g., increasing fuel efficiency of cars or noise caused) would make the link between car use and environment pollution weaker and as a result inhibit the balancing function of the loop B2 as well. Such a measure would also weaken the reinforcing loop R4 (i.e. less people would move into new settlements), but the economic and political reinforcing loops of R2 and R3 would have less counterforce.

The goal of this relatively detailed analysis was to demonstrate the issue-specific insight that can be acquired through CLDs. The 'lens' of closed-loop thinking facilitates understanding of structural causes for observed behaviours in a specific problem, helps to uncover unintended consequences of actions and limitations to policy measures, and makes boundaries of thinking explicit.

4.3 Factors of influence and their interactions: an example from housing

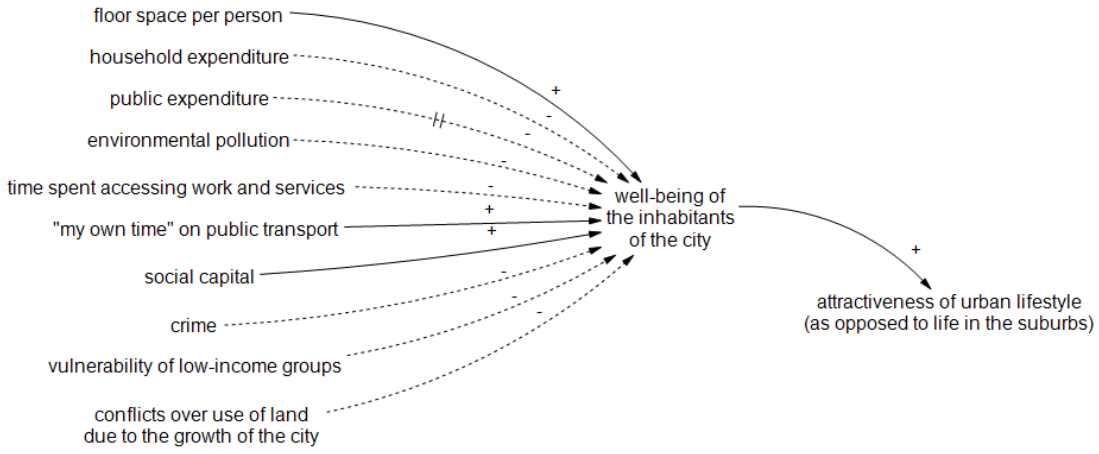


Figure 2. Factors influencing well-being of the inhabitants of the city

In this example we will show an approach that, complementary to closed-loop thinking, also fosters a detailed understanding of a particular problem. Figure 2 represents an excerpt from a map developed at a session focusing on sustainable housing; the issue mapped was "What effect does mono-functional urban planning have on the well-being of citizens?". It depicts 10 factors influencing well-being of the

inhabitants of the city, identified during the mapping process by the participants; all factors were endogenous to the system. We suggest that it is possible to acquire a more detailed insight by focusing on the factors of influence of a particularly important variable, in this case well-being of the inhabitants of the city. An increase in floor space per person, of 'my own time' on public transport (meaning the 'private' time spent reading, relaxing or conversing while comfortably travelling), or of social capital would cause an increase in the average inhabitant's well-being to a level higher than it would otherwise have been. An increase in costs (reflected in higher household or public expenditure), environmental pollution, time spent accessing work and services, crime, vulnerability of low-income groups, or conflicts over use of land would result in well-being being lower than it would otherwise have been (for public expenditure, this effect would occur with a time delay and to a large extent indirectly through deterioration of infrastructure, increase of taxes and fees, lower quality of public services etc.). This also demonstrates that a systemic approach makes it easy to cross the boundaries of policy areas or scientific disciplines: in the map above variables related to housing, transport, crime or social capital inter-relate.

Furthermore, a CLD facilitates a discussion about interrelationships between influencing factors: Are factors complementary (i.e. a multiplicative relationship) or substitutive (an additive relationship)? Are the functions between individual factors and well-being linear? What are the trade-offs between factors? Are some factors conditional or inhibitive to other factors' effects? Is the effect of a factor dependent on an additional variable? Furthermore, what scientific evidence exists for particular causal relationships? As an example related to Figure 2, what is the relationship between the influence of each of household expenditure, environmental pollution, time spent accessing work and services, social capital and crime on well-being? Or perhaps, in more detail, how is the enjoyment of 'my own time' dependent on the quality of public transport and time spent travelling? The map in Figure 2 facilitates bringing in existing debates around well-being into the process of map construction or later usage, fostering learning of participants.

It is easy to switch between this and the previous 'lenses' during map construction and analysis. Closed-loop thinking could, in this case, seek for linking changes in well-being (which has been the primary effect in this issue) back into the system through responses of various actors (including policy

response). Changes in well-being of city's inhabitants could, as an example, affect attractiveness of urban lifestyle as compared to life in the suburbs and thereby open up feedbacks to variables such as value of both urban and suburban properties, public expenditure, social stratification or mobility, directly or indirectly influencing well-being.

4.4 Generalising lessons learned: an example from food

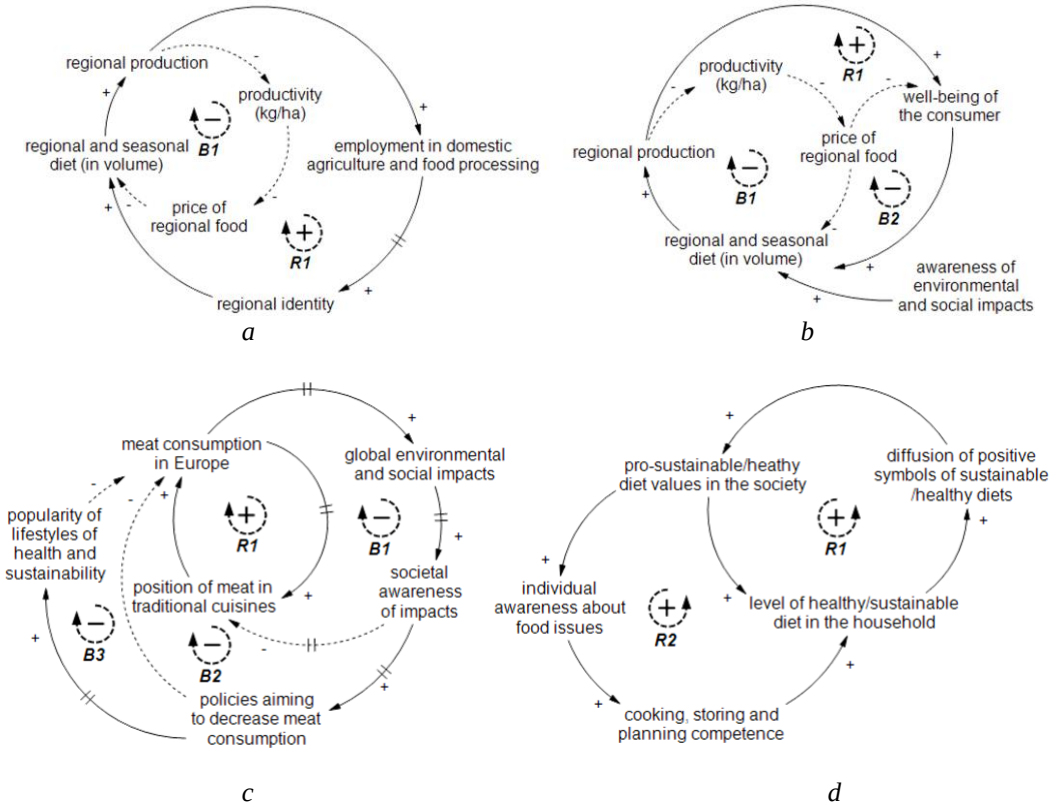


Figure 3. The role of the social dimension in sustainable food consumption, four examples

Comparing some of the key or 'distilled' feedback loops across different but related maps can generate useful insights. For example, we found striking that social factors play a much higher role for sustainability-related practices in the area of food consumption than in other consumption areas.

Figure 3 shows partial 'distilled' maps from four mapping sessions (i.e. results of Stage 3). Maps *a* and *b* were developed around the issue 'How does increasing consumption of regional produce affect the employment in domestic agriculture?'. In map *a*, lower productivity and higher price of regional food resulting from an increase of regional production serve as limiting factors to increases of regional

and seasonal diet. The balancing loop B1 would cause the volume of regional and seasonal diet to even out towards a certain level. (Again, the maps show a simplification of possible relationships. For example, they do not show that initially an increase in regional production may cause an increase in productivity; also, this group has not identified awareness of environmental benefits of regional production as important.) Against this loop pulls the reinforcing loop R1, representing a delayed positive effect of an increase of employment in domestic agriculture and food processing on regional identity, which should in turn cause the volume of regional and seasonal diet to be higher than it would be otherwise. It would seem that the balancing loop B1 is relatively stronger than the loop R1 relying on regional identity, which might be insufficient (note also the time delay) to overcome the material and economic limiting conditions of production. Ensuring lower productivity losses or higher employment effects of regional and seasonal production or removing the time delay between employment and regional identity would change the relative strengths of the loops.

Map *b* is an attempt to explain the same issue by a different group, focusing instead on the variable of the well-being of the consumer (i.e. the frame is rather 'individualistic'). Well-being is negatively influenced by higher price of regional food (loop B1) and positively influenced by various direct benefits of regional production (loop R1) such as sense of fairness, producer–consumer proximity or diversity of local/regional production. One of the key assumptions in this map is that an increase in well-being from these benefits would (perhaps in combination with individual's awareness of positive environmental and social impacts not related to objective well-being) result in higher demand for regional and sustainable food and thereby in an increase of the volume of regional and seasonal diet. This assumption enables to close the loops R1 and B2. Achieving higher well-being gains from regional production or ensuring a lower price would change relative influences of B1+B2 and R1 and would translate into volume higher than it would be otherwise. In this map, awareness of environmental and social benefits of regional production does not directly contribute to well-being, but contributes to a higher volume of regional and seasonal food. Compared to the importance of relative strengths of B1+B2 and R1 it does not seem to be critical. As can be seen from the comparison of *a* and *b*, different framings of the same issue could result in identification of different intervention options. Addressing the lower productivity problem or subsidising the price of regional food would

work for both as these address the same loop. Nevertheless, in *a* policies could include increasing the number of jobs per unit of production as well as achieving a stronger association between employment in domestic agriculture and regional identity, whereas in *b* they could include providing consumers with information about positive environmental and social impacts and improvement of direct benefits for consumers (which might involve strengthening the social dimension of food consumption).

Maps *c* ('What factors influence the global environmental effects of a shift to a Mediterranean diet (less meat) in Europe?') and *d* ('Could healthier and more sustainable diets lead to increased food waste in European households?') conceptualise the social dimension of food consumption in more detail. Map *c* shows that relying on a cultural change in meat-eating practices alone can be risky because of the numerous time delays. Participants have placed a time delay on the translation of negative global environmental and social impacts into collective awareness, on the effect of changes in awareness on cultural traditions or (through collective pressure) on policies, and on the effect of changes of policy on lifestyles (which, in addition, might meet with policy resistance; this is not captured in the map). Despite the difficulty of inferring behaviour due to time delays, we could observe that the balancing effect of all three loops would counteract an initial increase in meat consumption too late (after three time delays, which is a time during which meat consumption can further grow), and significant environmental or social damage could occur in between. Removing the time delay between meat consumption and occurrence of negative impacts might not be possible, but addressing the time delay between the impacts' occurrence and their awareness is an important leverage point for policy (to a smaller extent this is valid for the other time delays in the map). What's more, the map invites discussion on how culture and practices change (loop R1), since mobilising the depicted reinforcing effect for a decrease of meat consumption could be crucial.

Map *d* places decisions of the individual into a social context. Loop R1, the source of reinforcing dynamics, understands societal values as a mechanism for the spreading of specific social practices. In turn, social practices have a communicative effect and thereby achieve value change; a reflexive coupling between values and practices is thus established. Loop R2 shows how actions and decisions of the individuals reinforce this dynamics: societal values affect individual awareness, awareness translates into development of competence, and competence translates into practice (a sequence which

roughly corresponds to the traditional ABC). Thus, the ABC approach is placed into the context of a more powerful social dynamics.

4.5 Mental models and paradigms: different ways to decrease TMC

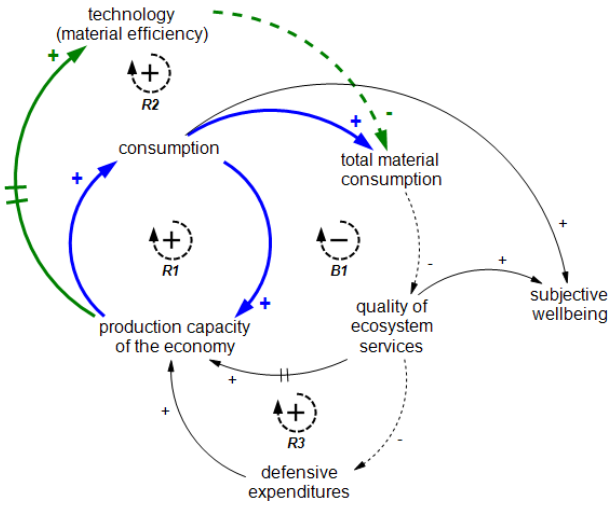


Figure 4. Decreasing total material consumption, two strategies

One of the ways to better understand a system is also through understanding the various mental models, perspectives and discourses which different individuals and social groups have in respect to the system. A CLD could link or confront these differences by visualising: i) different goals in the system, associated with different paradigms (e.g. increasing consumption *vs.* increasing consumption while decreasing total material consumption *vs.* increasing well-being); ii) visualising how an issue is defined and which causal links and feedback loops are perceived as dominant different paradigms; iii) visualising different strategies.

Since RESPONDER attempts to link different communities with different paradigms and discourses, the mapping sessions have served also as a means to explore these differences during the construction and interpretation of the maps. Nevertheless, we have not uncovered the full potential of this 'lens' yet – primarily because, until now, representation of communities other than 'beyond-growth' scientists in the events was low.

The map in Figure 4 shows an abstract representation of economy–environment relations with the focus on consumption, prepared during background work on the project. (Note that for the purpose of simplicity the variable production is omitted, even though it could behave differently than production capacity.) The colours represent two different strategies, preferred by different communities, towards lowering total material consumption (TMC) and preserving the quality of ecosystem services. The green colour represents a strategy to increase material efficiency of consumption while leaving the overall engine of economic growth (loop R1) intact to realise gains from consumption growth on subjective well-being. This is the 'weak sustainability' position. The structure of the map would suggest that increasing the quality of ecosystem services weakens one limit to the growth of production capacity of the economy (i.e. the delayed influence of the erosion of the ecological basis of the economy, loop B1) and weakens one contributing factor as well (lower defensive expenditures, i.e. loop R3, will contribute to the growth of production capacity to a smaller extent than they would otherwise). Nevertheless, growth caused by loop R1 would continuously increase the pressure on constant improvement of material efficiency, should TMC be kept in check over a longer term.

The blue colour shows a strategy of addressing TMC through lowering consumption. This can be associated with the 'strong sustainability' position. In addition to pushing down TMC, this strategy directly tackles economic growth by (perhaps with a time delay) decreasing production capacity of the economy (loop R1). The behaviour of reinforcing loops tends to either exponential growth or exponential decay (as can be witnessed in the times of economic crisis). Decreasing consumption could generate a spiralling effect of economic de-growth which, however, would be slowed down by the positive effects of healthy ecosystems on the economic base. (A more qualitative change in the structure of the system would also be probable in such a case.)

A potential challenge which needs to be explored is that due to different framing individual system pictures might not be easily integrated into a common whole (when, e.g., one would have a more structure-oriented framing and another more agency-oriented framing).

4.6 *Connections between problem issues: conflicts over use of land and popularity of LOHAS*

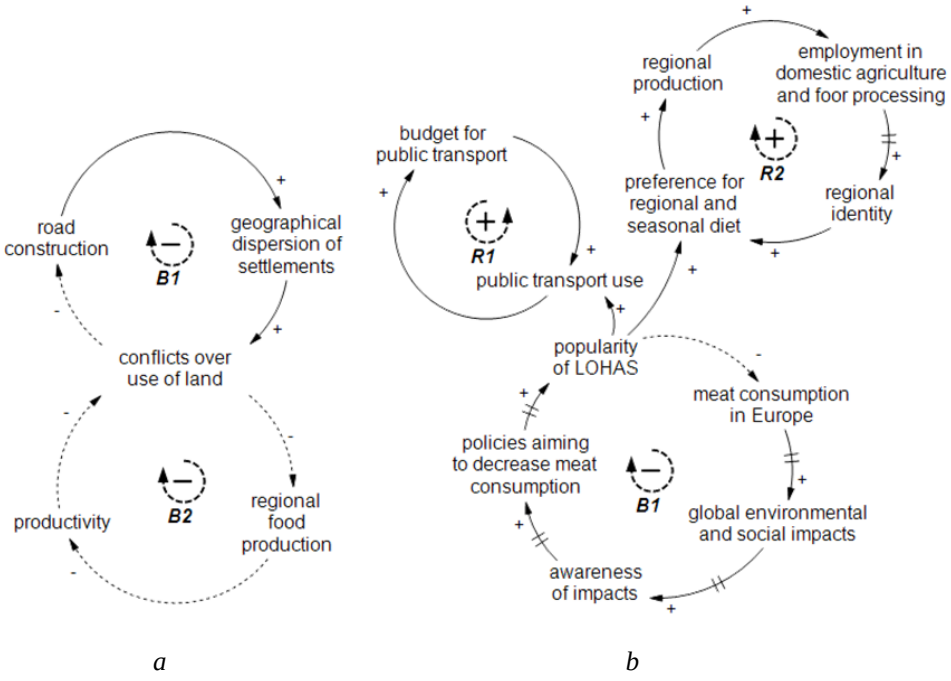


Figure 5. Two possible types of connection between problem issues

Our last 'lens' is looking at connections between problem issues. It has been suggested that 'distilled' depictions of the system structure underpinning particular issues can be linked in the manner of 'cascaded archetypes' (Wolstenholme, 2004: 350), illustrating how unintended consequences of one issue can become drivers in the next. Such a linking has remained a rarely-addressed 'major research challenge for system dynamics' (ibid.). We will briefly examine two possibilities for connections between problem issues.

In Figure 5, map *a* shows how individual problems can act as mutual limits, balancing each other out and mutually preventing growth in scale. Structures of two heavily simplified problem issues (road construction and low productivity of regional food production) are connected through conflicts over use of land. Pressure on land use and resulting conflicts result from increases in geographical dispersion of settlements through road construction and take up of land through a shift towards regional food production (assuming that a shift to regional production would overall result in lower productivity). The stronger the policy goals, the more pressure would there be on conflicts over land

use. Should, for example, the problem of low productivity of regional food production be solved, it would stop contributing to an increase in conflicts over use of land. As a result, there would be less counterforce to road construction and the scale of the problem of road construction and geographical dispersion of settlements could grow until it meets another 'layer of limits' (Meadows, 2008). When problems limit each other, solving one problem could remove a limit to the growth of another problem.

Map *b* connects problem issues into a cascade where change in one problem issue causes changes in other issues. Policies aiming to decrease meat consumption would, provided they overcome policy resistance, over time contribute to the popularity of lifestyles of health and sustainability (LOHAS), which encompass more dimensions than just meat consumption. Increasing popularity of LOHAS could therefore plausibly result in an increase of preference for regional and seasonal diet above what it would otherwise have been, thereby providing more counterforce to the loop R2 against the balancing loop related to falling productivity (loop B1 in map *a*, Figure 3). Similarly, increasing popularity of LOHAS could result in an increase of public transport use to a level higher than it would otherwise have been, thereby potentially contributing to an improvement in the problem of car use/road construction/geographical dispersion of settlements. Analogously, a decrease in the popularity of LOHAS could affect these linked problems negatively. This example shows that addressing one problem may help solve other problems through systemic spillover effects, rather than the traditional behavioural spillover effect (Thøgersen and Ölander 2003).

5 Conclusions

In this paper we followed two objectives: i) to explain our usage of the method of participatory systems mapping (PSM) in the context of knowledge brokerage; and ii) to demonstrate the various types of insight facilitated by causal loop diagrams (CLDs) that support a systemic, complex and multi-perspectival understanding of issues related to sustainable consumption. Such an understanding can be reached by simultaneously using several 'lenses' to look at a single CLD. We described 5 different 'lenses' and demonstrated the insights they produce; an overview is provided in Table 1. We

have highlighted the discussion-supporting function of CLDs, which is particularly relevant for knowledge brokerage processes involving representatives of various communities. Furthermore, we tried to demonstrate that diagnostically used CLDs possess significant policy-relevant potential by enabling identification of leverage points which serve to conceptualise policy interventions and by supporting thinking about effectiveness, policy resistance and potential side effects of policy interventions. Structuring the problem issues using the language of CLDs also allows identification of missing evidence and knowledge needs of the policy makers (research-related potential).

Table 1. An overview of different lenses and the insights they produce

'Lens'	Produced insights
Closed-loop thinking	structural causes for observed behaviours, unintended consequences, limitations to policy measures, leverage points, explicit boundaries of thinking (detailed, issue-specific insight)
Factors of influence	implied relationships between factor of influence, necessary conditions for exertion of influence, identification of evidence gaps (detailed, issue-specific insight)
Comparison of 'distilled' CLDs	different framings of the same issue, opening up policy options, characteristics of problematic categorical variables (generalisable, transferable insight)
Mental models and paradigms	different perspectives, comparison of mental models, comparison of strategies, placing paradigms into a larger picture (actor- and discourse-oriented insight)
Connections between issues	interlocking of problem issues, side effects of policy solutions, system boundaries, higher level of system organisation (policy resistance, resilience, path-dependencies) ('inter-issue' insight)

In line with Sterman (2000) we suggest that 'improving' the mental models upon which policy solutions are based can to a large extent prevent unforeseen and delayed side effects which are the main threat to sustainability (see Figure 6).

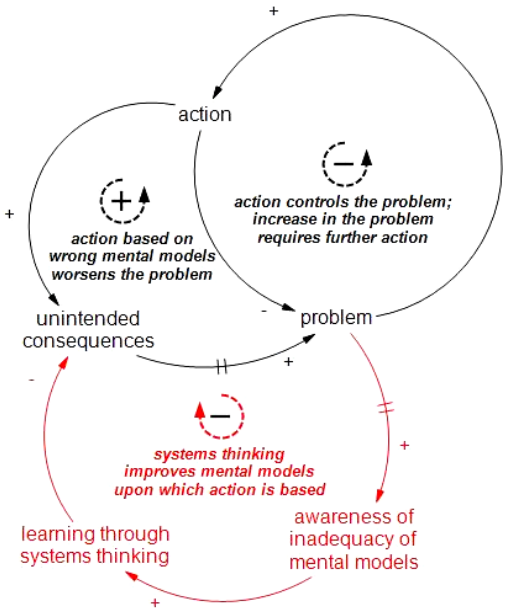


Figure 6. Systems thinking as a way to improve mental models

Our project is to be seen in the context of a stream of studies, initiatives and exercises which might collectively contribute to change of policy to more systemic understanding of sustainable consumption.

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