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The impact and spin-off of participatory backcasting: From vision to niche

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ABSTRACT

This paper reports on a study that has systematically investigated the follow-up and spin-off of participatory backcasting experiments in the Netherlands five to ten years after completion. A methodological framework for participatory backcasting is presented, after which a conceptual framework is developed to describe and evaluate the impact of backcasting experiments. Three cases are analysed: (1) Novel Protein Foods and meat alternatives; (2) Sustainable Household Nutrition; and (3) Multiple Sustainable Land-use in rural areas. The cases show that participatory backcasting can lead to substantial follow-up and spin-off, but that is not always the case. Substantial follow-up and spin-off after five to ten years is predominantly found at the level of niches, and can be seen as potential seeds for future system innovations. The emergence of follow-up and spin-off comes along with the diffusion of the visions generated in the backcasting experiment. The visions provide orientation (where to go) and guidance (what to do). Visions also show both stability and flexibility. Factors that influence the extent of impact and spin-off of backcasting are identified, with a focus on stakeholders, learning and visions. Finally, relevance for system innovation theory, governance and policy as well as research recommendations are briefly discussed.

1. Introduction

In the last decade, the focus of researchers, policy-makers and many other actors involved in environmental and sustainability issues has shifted strongly towards system innovations and socio-technical transitions [1–6]. System innovations and socio-technical transitions are needed in order to achieve large environmental improvements and to deal with sustainability problems at a societal level, including mitigating and adapting to climate change. Addressing complex sustainability problems by system innovations and transitions requires participatory integrated approaches like transition management [2,4,6] and participatory backcasting [3,7,8]. Such approaches not only have a long-term future and system orientation, but also share a broad view of sustainability and take into account the dynamics of complex socio-technical change processes. The involvement of stakeholders is crucial: on the one hand their interests are affected, while on the other hand they possess essential knowledge and resources. Their involvement is also needed for endorsement and legitimacy.

Participatory backcasting has grown into an adequate approach to explore system innovations and transitions towards sustainability. It includes defining first steps and roadmaps or pathways towards an envisaged system innovation [3,7–9]. Backcasting literally means looking back from the future; it is a normative approach to foresight using desirable or alternative futures. It is very different from regular forecasting, which looks to the future from the present and is not normative, or only to a very limited extent[1].

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[1] However, backcasting can be related to what has been called normative forecasting [71,72] and normative forecasting is one of the roots of backcasting. How backcasting relates to forecasting has also been discussed by Robinson [73] and by Höjer and Mattsson [74].

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According to Dreborg [10], backcasting is particularly useful in case of highly complex problems; when there is a need for major changes, when dominant trends and externalities are part of the problem and when the scope and time-horizon involved are broad enough to leave room for the development and implementation of very different alternatives. In the last decade, backcasting has received increasing attention and is applied more and more. For instance, Giddens [11]: p 98–100] has put forward backcasting as a tool for moving toward alternative futures when dealing with climate change, and as a sustainable alternative to traditional planning.

Since a few decades, sustainable futures have been explored in participatory backcasting experiments, especially in the Netherlands, Canada and Sweden, and recently in other countries as well. Numerous stakeholders have been involved and the first follow-up steps and implementation strategies have been planned in line with envisaged sustainable futures. But what are similarities and differences between backcasting experiments? And what is the impact of participatory backcasting experiments five or ten years later? Moreover, do the impact and spin-off actually contribute to system innovations towards sustainability in the longer term? Unfortunately, studies evaluating backcasting experiments after several years and systematically comparing them have not or hardly been conducted so far. But if backcasting experiments could eventually lead to system innovations, or at least offer a significant contribution, we need to know more about the effects after five to ten years, as well as about the underlying mechanisms and dynamics.

Despite the lack of comparative studies on backcasting, it has been shown that there are considerable differences with regard to the way backcasting experiments have been conducted. In addition, the degree to which particular backcasting experiments have led to follow-up and spin-off after a few years considerably varies too [3,7]. There are some evaluations of backcasting experiments available, but they are limited in the sense that they focus either (i) on the way the backcasting approach has been applied and the content results that have been achieved [8,9], or (ii) on the stakeholder learning process and the social dynamics among stakeholders during the backcasting experiment [12,13]. As a consequence, no conceptual and analytical frameworks for analysing the follow-up and spin-off of participatory backcasting after several years have been developed so far.

The issues discussed earlier give rise to several questions that are addressed in this paper. Firstly, what are the discernable effects of backcasting experiments after five to ten years and how can they be analysed? Secondly, what are differences and similarities across backcasting experiments, and can these be related to factors enabling or constraining the impact and spin-off of backcasting experiments after such a period? Thirdly, can the impact and spin-off of backcasting experiments be seen as a stepping stone towards system innovations, or could it make a significant contribution to them? To answer these questions, this paper reports on a study that has systematically investigated backcasting experiments in the Netherlands, as well as their follow-up, impact and spin-off seven to ten years after completion.

The paper is organised as follows. In Section 2, we briefly summarise major developments in backcasting, in particular in the Netherlands, and we present an overarching methodological framework for participatory backcasting that cover most of the diversity in participatory backcasting. In Section 3, we develop a conceptual framework that includes both the backcasting experiment and its impact after five to ten years. In Sections 4 and 5, we describe and analyse three case studies from the Netherlands; (1) Novel Protein Foods and meat alternatives (NPF), (2) Sustainable Households and Nutrition (SHN), and (3) Multiple Sustainable Land-use in rural areas (MSL). In Section 4, we evaluate and compare the backcasting experiments, whereas in Section 5 we analyse their impact and spin-off before discussing factors that may have enabled or constrained the extent of spin-off and follow-up. In Section 6 we present our conclusions. Finally, in Section 7 we relate the results to (system) innovation theory and we also discuss relevance for governance, transition monitoring and some research recommendations.

2. Participatory backcasting: from diversity to an overall framework

Backcasting was first applied in the 1970s in energy studies [14,15]. The focus was on developing and comparing the feasibility of alternative energy futures. Later, backcasting was also applied to sustainability problems [10,16] and for moving organisations towards sustainability [17]. Since the early 1990s it has developed into a participatory approach, especially in the Netherlands [7,8,18,19], Canada [20,21] and Sweden [10,17,22,23]. A more detailed overview of the developments in backcasting is given elsewhere [3,7].

Focusing on the Netherlands, participatory backcasting was, for instance, applied at the Sustainable Technology Development Programme [8,18]; as part of the EU-funded 'Strategies towards the Sustainable Household (SusHouse)' project [24–26]; and within several stakeholder dialogues, like the COOL (Climate Options On the Long-term) dialogue [13], the hydrogen dialogue [27] and the biomass dialogue [28]. In addition, participatory backcasting has been applied to sustainable industrial paint chains [29], livestock breeding [30], horticultural research [31], academic education [32] and as part of various international projects on local and regional land-use futures [33–35].

A literature overview has shown that there is a considerable variety in backcasting methodologies [3,7,32]. For instance, there are differences in whether and how stakeholder participation has been organised, in the number of steps in which the methodology has been split, the methods that are used, the kinds of topics being addressed, the nature and scale of the systems addressed (e.g. local, regional, national, consumption systems, or societal domains), the number of visions developed and how the visions have been developed, and if the focus is on learning and raising awareness among stakeholders, or on realising follow-up and implementation. In addition, the term backcasting can refer to a conceptual approach or to a more operational methodology, though it is also possible that it only refers to the step in which the backwards-looking analysis is conducted. Furthermore, other approaches like transition management, roadmapping and several others also use normative future visions and pathways how to get there, sometimes without explicitly referring to the term backcasting, which makes the variety even larger.

To deal with this variety, four different backcasting methodologies and their frameworks have been analysed and compared [3]: (i) the methodology developed by Robinson [16]; (ii) the Natural Step methodology, as reported by Holmberg and Robèrt [17,23]; (iii) the methodology applied at the Dutch STD programme [8,9,19], and; (iv) the methodology applied in the international Sustainable Households project [9,24,26]. Using these four approaches as a starting point, a more comprehensive methodological framework for participatory backcasting was developed. It is briefly discussed subsequently, while a more comprehensive comparison of the four approaches is given elsewhere [3].

The developed methodological framework is depicted in Fig. 1. It consists of five steps and four groups of tools and methods: (1) participatory tools and methods; (2) design tools and methods; (3) analytical tools and methods, and; (4) management, coordination and communication tools. The backcasting approach reflected by the framework is not only interdisciplinary (by combining and integrating tools, methods and results from different disciplines), but also transdisciplinary in nature, in the sense that it involves stakeholders, stakeholder knowledge and stakeholder values. Despite the fact that the steps are presented in a linear fashion in Fig. 1, iteration and moving forward and backward between steps are inherently part of the process.

The framework also distinguishes three types of demands: normative demands, process demands and knowledge demands. Normative demands reflect the goal-related requirements for the future vision, as well as how sustainability is defined in the case under study and turned into principles or criteria that future visions should meet. Secondly, process demands are requirements regarding stakeholder involvement and their level of influence in the way issues, problems and potential solutions are framed and resolved in the backcasting study. Finally, knowledge demands are needed to set requirements to the scientific and non-scientific knowledge strived for and how these are valued one to another. The demands need to be specified in the beginning of a backcasting study. This can be done by the organisers, but it may also be the outcome of early stakeholder involvement. It is also possible that demands are partly set by the organisers and are partly based on stakeholder discussions.

In addition, different goals can be distinguished in backcasting studies, which cannot only refer to process-related variables, but also to content-related variables, or to a range of other variables like knowledge or methodology development. In general, multiple goals are set in participatory backcasting, though they are not necessarily all equally important. Usually stakeholders from different societal domains like business, research, government and society are involved; the latter includes both the wider public and public interest groups. The presented framework should be seen as a first draft of an overall methodological framework for participatory backcasting that covers a large majority of backcasting methodologies available in the literature and it can be used to categorise them in a systematic way. In addition, the presented methodological framework is also useful to researchers and professionals who want to apply participatory backcasting. They can use the framework when elaborating an operational backcasting methodology for a specific study.

3. Conceptual framework and research methodology

3.1. Participatory backcasting and its impact: definitions and focus

Studying the effects of participatory backcasting experiments requires a more comprehensive framework than the methodological framework presented in the previous section. But first we would like to go briefly into our perspective on participatory backcasting [3,7]. We define a backcasting experiment as a project or study in which backcasting is applied explicitly and in which a broad range of stakeholders is involved. In the backcasting experiment stakeholders meet and are involved in

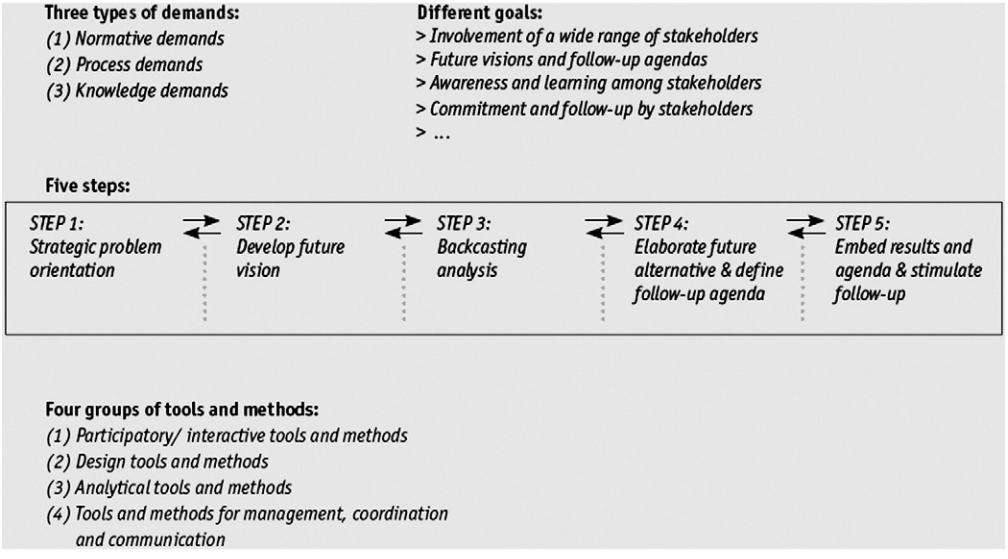

Fig. 1. The methodological framework for participatory backcasting [3: p. 232].

developing, assessing, discussing and adjusting future visions. The backcasting experiment functions as a protected experimental space in which ideas can be articulated and discussed, while ignoring the interests and rules of the outside world. This stimulates first and higher order learning among the stakeholders involved [3,24,36–38]. Learning may not only result in increased awareness of and support for these sustainable futures, but also lead to formulating follow-up agendas or transition paths. It may also lead to increased understanding how these futures link to strategic opportunities for stakeholders, as well as to alternatives for current practices and activities that may contribute to bringing about the future vision. Stakeholders seizing opportunities in the future vision can then initiate activities or start collaboration to initiate joint actions and activities, which can be research, business-related activities, policy development, user pilots, or others. This process also leads to diffusion of the visions, and the visions can become guiding images to the actors involved [3,39,40].

Finally, the backcasting experiment and its follow-up and spin-off activities can be seen as both part of and surrounded by a socio-technical system. Depending on the sustainability problem being targeted, it can be a production and consumption system, a geographical region, an industry, an entire country, or a societal domain like mobility or food.

3.2. Conceptualising participatory backcasting experiments

After an extensive literature review, we concluded that there is no single theory or model that incorporates all the relevant aspects of backcasting experiments and their follow-up and spin-off [3]. Therefore, a new conceptual framework has been developed, which builds on several theories and models from innovation studies, policy sciences and technology assessment. It is shown in Fig. 2. It depicts several building blocks that originate from a heterogeneous set of models and theories and it has been used to conceptualise (i) the phase of the backcasting experiment and (ii) the phase of spin-off and follow-up [3]. Each building block contains several variables that are used to analyse the cases.

The backcasting experiment phase consists of four building blocks: (1) stakeholder participation, (2) future visions, (3) learning, and (4) settings and methodological aspects. Starting point is that broad stakeholder participation in articulating, elaborating and evaluating future visions induces higher order learning among the stakeholders involved.

To start with, broad stakeholder participation is key to participatory backcasting, and it may increase support and involvement in follow-up and spin-off [3,8,13]. This builds on stakeholder and citizen participation in policy making, public decision making, sustainable development and citizen participation in science (for an overview, see [13]). Participation makes stakeholder expertise available and it can help increase legitimacy and accountability. It may also contribute to structuring complex unstructured problems like sustainability problems, and broaden issues with a range of aspects and perspectives. However, stakeholder participation can be organised in different ways and they can have different degrees of influence [3,13]. In addition, involving stakeholders that are relevant to the issue and are motivated and willing to develop and discuss alternative future visions is essential. Who to involve also depends on how the problem and the socio-technical system under study have been defined. This is reflected in the building block *participation* by the following variables: the extent of stakeholder influence and the intensity and type of stakeholder involvement. The intensity of involvement reflects how strong stakeholders were involved in the backcasting experiment, whereas different types of involvement are for instance (co-)funding and attendance of workshop and other meetings in the backcasting experiment.

Secondly, generation and assessment of future visions by the stakeholders in the backcasting experiment is also central to participatory backcasting. Future visions can be seen as shared multi-actor constructions that have the potential to guide actor behaviour. Emerging future visions may thus provide guidance and orientation to participating stakeholders, especially in situations where existing rule sets and institutions are not effective or valid [3,24,30,40,41]. It has also been shown that visions are at play when an entire socio-technical system is in a process of transformation [42]. The building block *future visions* includes the variables 'orientation' (where to go) and 'guidance' (what to do), which are adjusted from the *Leitbild* concept [39,40]. Emerging visions also face competition from other emerging visions and their supporters [42,43], as well as from the regular dominant vision supported by vested interests and actors.

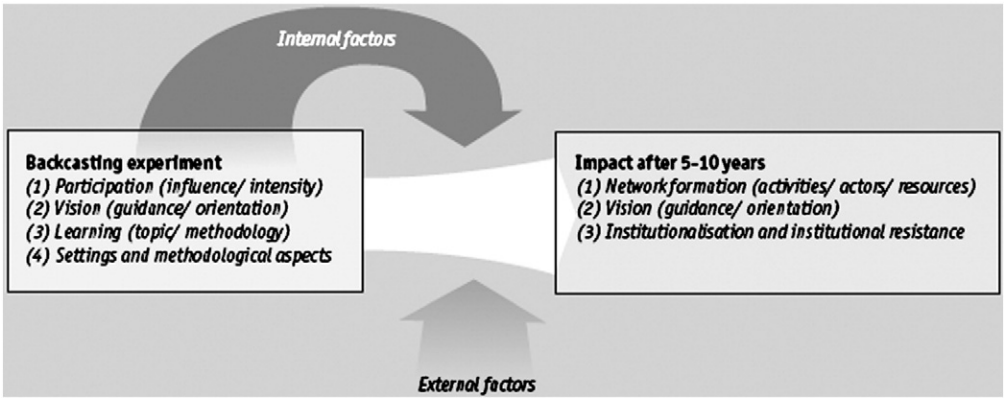

Fig. 2. A conceptual framework for backcasting experiments and their impact [3: p.67].

Higher order learning is seen as another condition for increased awareness and changing behaviour by stakeholders [3,12,13,30,36,38], though higher order learning is named and defined slightly different in different fields (for an overview, see Brown et al. [38]). The building block *learning* conceptualises higher order learning by actors, in line with Brown et al. [38] who, using a range of sources, defined learning as (i) shifts in problem definitions, perceived solutions and principal approaches to dealing with the problems at the level of individual actors and (ii) joint and congruent learning at the level of groups of stakeholders. Learning may also include increased understanding of the values and views of other stakeholders. Whereas joint learning refers to consensus and joint opinions, congruent learning reflects win-win situations without a full consensus[2].

In addition, both the way the backcasting experiment is applied and its organisational settings are likely to affect the nature and degree of follow-up. The building block on *settings and methodological* consists therefore of a variable reflecting particular settings (characteristics) of the backcasting experiment, as well as a variable on how the participatory backcasting approach has been applied in comparison to the developed methodological framework presented in Section 2.

3.3. Conceptualising the impact of backcasting experiments

The follow-up and spin-off phase consists of three building blocks: (1) network formation, (2) future visions, and (3) institutionalisation. Starting point is that successful network formation coming along with follow-up and spin-off may lead to diffusion of and guidance by visions and instances of institutionalisation, whereby existing institutions may change.

Various network theories have been proposed to understand and study the relationships among actors and how these influence actor behaviour as well as how actors may influence relationships and the network in fields like innovation, policy studies and business studies [44–46] The building block *network formation* is based on the industrial network theory proposed by Håkansson [45,47]. This model emphasises 'activities', 'actors' and 'resources', which are variables in this building block. The building block *future visions* contains the variables 'guidance' and 'orientation' similar to the same building block in the phase of the backcasting experiment. Finally, the building block *institutionalisation and institutional resistance* builds on institutional theory [48,49] and consists of the variable 'institutionalisation', reflecting changes in institutions, practices and rules, and the variable 'institutional resistance' by vested interests and existing institutions and the actors backing them.

The conceptual framework also proposes *internal factors* and *external factors* that both can exert influence on the emergence of follow-up and spin-off. Internal factors are characteristics of the backcasting experiment. External factors are exerted by the socio-technical system and its context, which surround the backcasting experiment and its follow-up and spin-off. The socio-technical system 'enters' the backcasting experiment through the participation of stakeholders, while at the same time the backcasting experiment is to some extent an organised, albeit rather protected space for experimentation within the socio-technical system. The context of the socio-technical system consists of other sectors and socio-technical systems in the Netherlands, as well as abroad. Internal factors and external factors can have a positive (enabling) or a negative (constraining) influence on follow-up and spin-off. Four societal domains are distinguished in which follow-up and spin-off may occur: (1) research, (2) business, (3) government, and (4) society, which includes both public interest groups and the wider public.

Interestingly, the whole of all follow-up and spin-off resembles what is called a *niche* in Strategic Niche Management [50,51] and in Transition Management [2,4,6,52,53]. This refers to a mechanism that could be summarised as from vision to niche. Vision development takes place in the backcasting experiment and it grows into a niche during follow-up and spin-off. This is depicted by the broad arrow in Fig. 2, which connects the backcasting experiment and the follow-up and spin-off after five to ten years. The arrow comprises the process whereby stakeholders that are attracted to the future vision and the agenda generated in the backcasting experiment mobilise resources and turn this into actions and activities that ultimately result in 'spin-off and follow-up' that may evolve into a niche.

3.4. Case selection and research methodology

An empirical *ex post* case study was conducted to study the impact of participatory backcasting experiments in the Netherlands and to identify factors that enable or constrain their impact and spin-off. Given the purpose of the paper and underlying study, case selection was crucial. The following set of criteria was defined and used for case selection. First, the backcasting experiment had to be fully completed and had to include clear articulation and use of backcasting, as well as broad stakeholder participation from different societal domains. In addition, the backcasting experiment had to be completed at least five years in order to allow for follow-up and spin-off to emerge. The final criterion was that there had to be sufficient variation in the degree of follow-up and spin-off across the selected cases in order to determine factors that could have constrained or enabled the extent of follow-up and spin-off.

Around twenty-five backcasting experiments could be identified in the Netherlands in which participatory backcasting had been applied to complex sustainability problems. These backcasting experiments could be clustered into four groups [3]. Two groups of backcasting experiments met all criteria. The first group consisted of nearly fifteen backcasting experiments conducted at the STD programme [8,9,19], which showed a varying extent of follow-up and spin-off. The second set comprised of backcasting experiments in the Sustainable Households (SusHouse) project and several related studies [9,24–26]. Here, the impact in terms of follow-up and spin-off of specific backcasting experiments (e.g. on food, clothing care, shelter and industrial paints) was limited.

[2] A discussion on consensus versus congruence in learning by stakeholders has been provided by Grin and Van de Graaf [75].

Two cases were selected from the STD programme having significant follow-up and spin-off: (i) the case of Novel Protein Foods and meat alternatives (NPF), and (ii) the case of Multiple Sustainable Land-use in rural areas (MSL). From the SusHouse project the case of Sustainable Household Nutrition (SHN) in the Netherlands was selected, which showed limited follow-up and spin-off. While all cases related to parts of the food production and consumption system in the Netherlands, they focused on different parts of the food system with (partially) different characteristics. The NPF case focused on a production and consumption system of protein foods, which includes meat alternatives, meat and meat products, and in which food companies were the central players. The SHN case investigated food consumption and production from the viewpoint of households and consumers. Finally, the MSL case focused on a regional land-use system in which the agricultural function would be integrated with other functions and in which farmers, as well as other land-use and spatial planning actors were important.

Each case consisted of a completed backcasting experiment and the follow-up and spin-off after five to ten years. The three cases were investigated by looking at (i) the use of (internal) documents and reports including Internet sources, and (ii) by conducting eight to ten semi-structured in-depth interviews for each case (mostly face-to-face, sometimes by telephone) with persons from research, business, government and societal groups that had been strongly involved in either the backcasting experiment, or in follow-up and spin-off activities, or in both. The people interviewed were asked about content, methodological, stakeholder and learning results of the backcasting experiment, as well as what they considered its follow-up, spin-off and broader effects.

Finally, it needs to be mentioned that three cases allow for in-depth yet exploratory analysis of the cases. Furthermore, follow-up, spin-off and other effects are in general not causally related to the backcasting experiment in a simple way, but could be the result of a range of other factors too. Such aspects were also discussed during the interviews.

4. Three backcasting experiments

4.1. Novel Protein Foods and meat alternatives (NPF)

The Novel Protein Foods (NPF) backcasting experiment took place at the STD programme from 1994 to 1996 and focused on sustainable meat alternatives that were called Novel Protein Foods [3,12]. A future vision was generated in which a substantial share of meat and meat products would be replaced by protein foods from non-animal sources with a very low environmental impact. The backcasting experiment was financed by the Dutch government and co-funded by three major Dutch food firms. It had a budget of around € 2 Million and was led by a retired research director from a major food multinational.

Broad stakeholder involvement took place in various ways in different stages of the NPF backcasting experiment. Idea articulation and early vision development was done by a small group of key stakeholders from business and research, facilitated by two key persons from the STD programme and the Netherlands Council for Agricultural Research. As fierce resistance from the Dutch livestock and meat sector was expected, only a small group of carefully selected stakeholders was initially consulted. However, stakeholder involvement was step by step enlarged and broadened. This included the application of a constructive technology assessment method called 'Future Visions for Consumers' [54], in which nearly twenty stakeholders from industry, science, government and public interest groups met in three workshops of a day and a half. A similar range of stakeholders was involved in the advisory committee, though mostly through different persons. This stage also comprised substantial research into more advanced meat alternatives conducted by seven research groups from different universities and research institutes in the Netherlands. The research was multidisciplinary and included research into consumer-related and social aspects, food technology research, environmental analysis, economic input-output analysis and production costs calculations (for some results see [8]).

Whereas the original vision in the early stage was very concise and strongly influenced by the small group of involved key stakeholders, a more detailed future vision was elaborated in the research stage or in the backcasting experiment when also more stakeholders were involved. The core of the further elaborated vision was that Novel Protein Foods made from vegetables, moulds and micro-organisms will substitute 40% of the meat consumption in 2035. This vision was very novel to mainstream food industry and the mainstream food research system in the Netherlands, though some elements had already been articulated by more marginal groups like the vegetarian movement and SMEs producing meat alternatives. However, the latter stakeholders were not involved when the vision was developed. In fact, these stakeholders were initially kept out of the core of the backcasting experiment because they were outsiders to the mainstream food research system. The vision was also novel to a large majority of the environmental movement, where the vision of organic livestock breeding and organic meat had been dominant for a long time.

From a backcasting perspective the vision implied that new food technology was required to enable the production of protein foods superior in taste and structure compared to existing meat substitutes. It implied cultural changes related to the role and status of both meat and Novel Protein Foods too. It also implied structural changes in the Netherlands. The meat sector would become substantially smaller and a new protein food industry would emerge and grow to a considerable size. These changes and implications were quantified for the vision of 40% consumption of NPFs by 2035 and elaborated in a transition path to 2035.

When the backcasting experiment was completed late 1996, it was concluded that these new protein foods could be produced 10 to 30 times more environmentally efficient as compared to the production of pork meat in the Netherlands in 1995; that they could be attractive to both consumers and producers, while the socio-economic effects would be relatively limited compared to the impact on the livestock and meat sector of ongoing developments at the level of the EU. In addition, it was concluded that new knowledge, research and development would be required. Results included an analysis of seven potential NPFs, the pathway to and vision for 2035, and an action agenda for follow-up and implementation. The action agenda addressed relevant stakeholders and comprised research programmes, product development, education, communication, raising of public awareness, policy recommendations, as well as a roadmap towards the future vision.

4.2. Sustainable Household Nutrition (SHN)

The backcasting experiment on Sustainable Household Nutrition (SHN) was part of the EU funded "Strategies for the Sustainable Household" project and focused on the food system from a household and consumer perspective. Though the nutrition part of the project took place in three countries, this case study focuses on the SHN backcasting experiment in the Netherlands. It ran from1998 to 2000, had a budget of around € 200,000, and involved a broad range of stakeholders from research, business, government and societal groups in two one-day workshops. After a round of stakeholder interviews and involvement, a stakeholder workshop was organised in which ideas were generated and clustered into three draft future visions. These were further elaborated by an appointed project researcher who also conducted the initial backcasting analysis. Despite limited interaction with stakeholders after the first workshop, further stakeholder involvement took place through a second workshop one year later and by three focus groups involving different groups of citizens.

Three future visions were developed and assessed in this backcasting experiment. In the first vision, which was entitled 'Intelligent Cooking & Storing', environmental improvement was based on high-tech and ICT-based solutions facilitating a lifestyle that highly resembles existing urban life styles in developed countries. The second vision was called 'Super-Rant' (based on combining the words supermarket and restaurant). In this vision eating out and food shopping were integrated at neighbourhood level and it was also based on eco-efficient technologies. The third vision was called 'Local and Green' and it was based on the idea of people growing vegetables themselves and on consumption from local and regional food chains as much as possible.

Three assessments of the future visions were conducted by the project team: an environmental assessment using a system analysis approach with indicators; an economic assessment using a questionnaire to assess each vision on socio-economic variables, and; a consumer acceptance analysis involving three different focus groups to evaluate the acceptability of the visions to consumers and citizens. The assessments showed that the Intelligent Cooking and Storing vision and the Local and Green vision would reduce the environmental burden considerably. Surprisingly, with regard to the Super-Rant vision it turned out that, on the basis of the energy requirements of restaurants in the late 1990s, the environmental impact could considerably increase. It was not possible to select the single most sustainable future vision, but arguably they depicted more sustainable alternatives to existing ways of living.

The visions and assessment results were inputs for a second stakeholder workshop in which the backcasting analysis was also extended. The workshop showed that the Intelligent Cooking and Storing vision was seen as the dominant direction, while the Super-Rant and Local and Green visions were appreciated because of their community and public values that will be important in a sustainable future too. Participants also developed implementation proposals and policy recommendations for each of the three future visions.

Final results of the backcasting experiment included the three visions, their assessments and agendas for further development and implementation.

4.3. Multiple Sustainable Land-use (MSL)

In 1994 a backcasting experiment on Multiple Sustainable Land-use (MSL) was started at the STD programme, which dealt with the integration of different land-use functions in rural areas. It focused on combining agriculture with a range of other functions related to landscape, nature, recreation, water production and water management. After articulation of the MSL concept in a stakeholder workshop and studying it at a general level, it was elaborated for the Winterswijk region, which is in the east of the Netherlands at the border with Germany.

Developing and implementing MSL in rural areas is a highly complex issue. It assumes new ways of farming and combining crop growing and livestock breeding with other rural land-use functions and activities, not only at the level of fields, but also at the level of farms and regions. Large-scale introduction of MSL also requires new organisations, new structures and new institutions. MSL is related to Multi-Functional Agriculture, which is less radical and emphasises farmers and combining the agricultural functions with others. The latter vision was widely supported by part of the agricultural research system in the Netherlands. However, a more radical vision on MSL could be developed in the MSL backcasting experiment by actively involving land-use researchers and stakeholders from outside the agricultural research system.

Stakeholder involvement gradually increased during the backcasting experiment and was organised by the project team in charge of the backcasting experiment. Stakeholder involvement included co-funding, stakeholder workshops, stakeholder interviews and establishing a stakeholder steering group for the backcasting experiment led by the regional authorities. The steering group involved regional and national stakeholders including major farmer organisations, agriculture-related firms, a utility, experts and also nature and environmental organisations. The multidisciplinary research was conducted by eight agricultural and landscape research groups that not only provided expertise and research capacity, but also had stakes in the MSL topic and its future research demands. Nearly € 2 million in funding was provided by the government and various other stakeholders.

It was found that applying the MSL concept in the Winterswijk region, in combination with the use of new farming technologies and closing material flows at the regional level, was feasible and could reduce the environmental burden up to a factor 10 [55,56]. As a next step a long-term regional vision on MSL in the Winterswijk region could be developed in which demands and goals articulated by regional stakeholders were included. This was feasible because a large part of the region physically enabled combining between five and ten land-use functions [35,57]. The stakeholders consulted in this phase had thus considerable influence on the development of the regional vision and were subsequently invited for the steering group.

Backcasting analysis in several stages of the backcasting experiment showed that the technologies, organisational structures and institutional arrangements needed to realise MSL were lacking. The analysis also resulted in the identification of critical

technologies, technological bottlenecks and required cultural and structural changes. Next, the regional vision was elaborated into two more detailed options for the region in 2020, each with a different integration of the proposed land-use functions [57]. The two options were called scenarios to distinguish them from the more general regional vision and were, though in different configurations, both based on regional self-sufficiency in terms of energy supply, fewer cows per hectare, a substantially increased catchment of water and more nature of a higher quality. Both options also assumed the development and use of new technologies to upgrade biomass and the re-use of manure within the region. Scenario analysis confirmed considerable environmental improvement. In addition, both options were also attractive in terms of economic value and employment compared to a business-as-usual scenario based on trend extrapolations.

Finally, nine follow-up projects were defined for demonstrating multiple land-use and solving the identified technological bottlenecks, while also a policy agenda and a supporting research programme was developed. The project proposals and the follow-up agenda were supported and approved by the established stakeholder steering group after which raising funding became a major issue for more than a year.

4.4. Case comparison

All three backcasting experiments involved a wide range of stakeholders, developed one or several desirable future visions, and proposed follow-up activities and agendas. Follow-up agendas included R&D activities, strategy development, policy recommendations and short-term proposals. In this sense all three cases are good examples of participatory backcasting.

With regard to the other variables the results of the three backcasting experiments were less similar. Most differences were found between the MSL and NPF backcasting experiments on the one hand and the SHN backcasting experiment on the other hand. For instance, the MSL and NPF cases showed a high intensity of involvement of some stakeholders, for instance by doing the research in the backcasting experiment or by providing co-funding. In these cases small groups of key stakeholders had considerable influence on vision development, especially when they were considered important for implementation, follow-up or co-funding. By contrast, in the SHN case, there was a lower intensity of stakeholder involvement, as stakeholder participation largely consisted of workshop participation. No further resources (e.g. funding, capacity) were mobilised. However, despite low intensity of involvement the stakeholders in the SHN case attending the workshops had all similar high degrees of influence on the content when the visions were generated, which was different from the other two cases.

Another difference was with regard to the number of generated visions. Whereas the NPF and MSL backcasting experiments evolved around single visions, three visions were generated in the SHN case. The future visions provided guidance and orientation to the stakeholders involved during the backcasting experiment in all three cases. However, due to a higher intensity of involvement, the degree of guidance and orientation was higher in the MSL and NPF cases than in the SHN case.

Higher order learning among was induced among participating stakeholders in all three cases with regard to the topics under investigation. However, in the SHN backcasting experiment learning was more due to comparing the visions and occurred at the individual level. By contrast, in the MSL and NPF cases learning also took place at group level and focused more on the opportunities and constraints in the future vision.

With regard to how backcasting had been applied, all three cases showed a good match with the methodological framework presented in Section 2. The steps, the different kinds of goals and all four different groups of methods could be identified, though iteration between steps took place in all three backcasting experiments. With regard to particular settings, again differences were found between the SHN case and the MSL and NPF cases. The latter backcasting experiments had significantly higher budgets, had project managers that acted as vision champions within relevant networks and had institutional protection from several key stakeholders, such as the ministries funding the backcasting experiments. Finally, there was a strong focus on achieving follow-up and spin-off. By contrast, the SHN backcasting experiment had a lower budget and though the relevance of follow-up and implementation was recognised, its focus was more on methodology development.

5. The impact and spin-off after five to ten years

5.1. Novel Protein Foods and meat alternatives

In the NPF case, various clusters of follow-up and spin-off activities and related networks of actors could be identified ten years after the end of the backcasting experiment. These networks could be linked to the vision and had been capable of mobilising sufficient resources for the activities. To start with, a large multidisciplinary research programme entitled Profetas [58] was initiated, involving research groups from different disciplines as well as several large food companies. Funding was provided by two research councils, five companies and the Ministry of Agriculture. A second cluster of activities involved new R&D collaborations on meat alternatives, NPFs and related supply chain management between firms and research institutes. The cluster also included the introduction of a new meat alternative made from dairy proteins by a major dairy firm in the Netherlands. A third cluster consisted of new activities by SMEs operating in the area of vegetarian protein foods and meat alternatives. These firms not only extended their regular activities and market share, but also started new activities. The new activities were significantly stimulated by the NPF backcasting experiment and its spin-off, but were also partly regular business activities in a gradually growing market. A fourth cluster of activities was found in the government domain, where, as a spin-off of the NPF backcasting experiment, meat alternatives and vegetarian protein foods became a topic of policy-making on sustainable consumption at the Ministry of the Environment. A new policy strategy addressed both regular food actors and public interest groups like consumer

organisations and environmental organisations with the aim to stimulate market share and consumption of meat alternatives. A fifth cluster emerged in the public domain. Due to involvement in other NPF-related activities and encouraged by the Ministry of the Environment, environmental organisations became more positive about meat alternatives. They started or extended their activities on this topic, whereas vegetarian organisations used the NPF activities to strengthen their own agenda and activities and started to collaborate with environmental organisations.

In all clusters of activities the core of the NPF vision was clearly present and links to the backcasting experiment could not only be found through the diffusion of ideas and elements present in the vision, but also through involvement of the same stakeholders and persons in both the backcasting experiment and follow-up activities. This was also the case in the SME cluster, though to a lower extent. Diffusion of the vision occurred and during this diffusion process the vision provided a high degree of guidance and orientation to the actors and networks involved. At the same time, the vision was adjusted due to the entry and exit of actors, but its core of 'advanced meat alternatives reducing the consumption of meat' sustained. Adjustments were also partly due to the alignment of the vision to the nature and priorities within a particular domain. For instance, at the Ministry of the Environment policies were developed to increase the consumption of meat alternatives on the short term.

The emergence of new activities came along with instances of institutionalisation. For instance, the topic of meat alternatives and NPFs became not only more widely accepted and dealt with at new places where this had not happened before, such as among food researchers in the Dutch food innovation system, at Dutch food firms and at the Ministry of the Environment. As a result NPF knowledge, concepts and activities became more widely accepted and affected practices and institutions. Institutional resistance from vested interests in the livestock and meat industry was limited. Major responses included (i) ignoring this novel development at a niche level, and (ii) reformulating meat alternatives as a very small niche serving a specific yet small group of consumers, whereas meat and meat products would continue to serve mainstream markets.

5.2. Sustainable Household Nutrition

With regard to the SHN case various follow-up attempts were undertaken by actors who had been involved in the backcasting experiment, and new collaborations were started around ideas and follow-up proposals. This led to proposals on matching household kitchen use and food supplies better, on a transition to a sustainable food service and eating-out sector and one on sustainable food appliances for meat alternatives. However, submitted proposals were not approved for funding. At the Ministry of the Environment the backcasting experiment served as a source of inspiration to policy development on sustainable food consumption, though its results were not explicitly used for policy-making. In 2001 the Ministry of the Environment shifted its focus from consumption to climate change and socio-technical transitions, and reduced its activities on sustainable consumption. Food-related activities were also transferred to the Ministry of Agriculture, where the focus was shifted to food chains instead of food consumption.

The results show that the backcasting experiment led to awareness among relevant actors and initiatives for follow-up activities, but that proposals did not get funded. So, the networks around the initiatives did not develop sufficiently to be able to mobilise resources to go on for a longer period. As a consequence, the visions generated in the backcasting experiment were not continued or kept alive by supporting networks and eventually faded away. Not surprisingly, no instances of institutionalisation occurred.

Finally, the Dutch SHN backcasting experiment was part of the larger EU-funded 'Sustainable Households' project. By contrast, the project as a whole and the participatory backcasting methodology that was developed and applied to households had a clear scientific and academic impact.

5.3. Multiple Sustainable Land-use

In the MSL case four clusters of follow-up and spin-off activities and related networks that had been able to mobilise resources could be identified. To start with, a large follow-up demonstration and research programme was carried out between 1999 and 2003 [59], involving research, policy, business and public interest actors. The programme focused on initiating and demonstrating Multiple Sustainable Land-use in the Winterswijk region. A related policy and implementation programme was also initiated, and, additionally, various spin-off activities of these programmes were started too. Another cluster of activities included replication of participatory MSL vision development in other regions where Multiple Sustainable Land-use was seen as a major development option (for some examples, see De Graaf et al. [35]). A third cluster of activities consisted of MSL-related studies commissioned by the Netherlands Council for Agricultural Research (NCAR) and its successor the Innovation Network for Green Space and Agro-cluster (INGRA). This cluster also included extension of MSL-related policymaking at the Ministry of Agriculture.

The more detailed vision of MSL for the Winterswijk region was a major factor in the regional follow-up and spin-off activities. MSL vision development in other regions resulted in different visions, though based on core principles of the generic MSL vision. The third cluster of activities resulted in new knowledge for the MSL concept and relevant parts, and was in this way aligned to the core of the MSL vision. The vision thus clearly provided guidance and orientation during its diffusion.

Like in the NPF case, the emergence of spin-off and follow-up activities came along with diffusion of the core vision, as well as with first instances of institutionalisation at involved research organisations, agricultural, spatial planning policy units, at farmer unions and front-running farmers. However, there was also institutional resistance and opposition from more traditional and conservative parts of these actors.

5.4. Case comparison

With regard to the extent of follow-up and spin-off after five to ten years, Table 1 summarises the main results for the three cases. Briefly, the SHN case showed limited follow-up and spin-off. By contrast, the MSL and NPF cases showed considerable impact and spin-off across the four societal domains distinguished, as well as initial instances of institutionalisation.

In both the MSL and NPF cases, most follow-up and spin-off was in the research domain, whereas in the NPF case significant follow-up emerged in the business domain too. Both cases also showed instances of initial institutionalisation in the sense that knowledge, concepts and activities became more widely accepted. In addition, visions provided guidance and orientation in the two cases. Interestingly, it was especially the cores of the two visions that diffused within and across societal domains. The diffusion of the visions took place through the actors and networks involved in the activities, whereas adjustments to the visions occurred not only in the different domains, but also in the various clusters of activities. These adjustments were in part due to the exits and entries of actors and in part due the alignment of the vision to the nature and priorities within a particular societal domain. In addition, clusters of follow-up and spin-off activities related in general to a shared adjustment to the future vision, though without affecting the core of the vision. The visions thus showed both stability and flexibility.

Furthermore, in the MSL and NPF cases all clusters of activities included actors from the backcasting experiment, as well as newly mobilised actors. Nearly all clusters of activities involved actors from more than one societal domain. In addition, the total number of involved actors had increased considerably in both cases. The mobilised budgets for spin-off and follow-up activities had multiplied too, though the main share of financial resources in all domains involved government funding. In the NPF case, however, a second major source of mobilised resources involved investments from companies comprising R&D, product development and market introduction.

5.5. Factors enabling and constraining impact and spin-off

Next, our aim was to identify factors of backcasting experiments that could enable or constrain follow-up and spin-off activities. By comparing the NPF and MSL cases on the one hand, and the SHN case on the other, we have been able to identify differences between the two types of cases that are potentially enabling or constraining factors. Before doing this, we would like to emphasise that all three backcasting experiments including the SHN backcasting experiments were selected as good examples of participatory backcasting and that this was confirmed by the analysis in Section 4. However, we expect that differences between the cases with and without significant impact can shed more light on the factors that could constrain and enable spin-off, follow-up and other effects and that deepening our understanding of these factors is relevant to improve achieving spin-off and follow-up in participatory backcasting. It needs to be mentioned that comparing the cases in this way, it may neglect constraining factors in the MSL and NPF cases. However, details of the case studies [3] show that constraining factors were also present in the NPF and MSL cases. For instance, there were temporarily problems with mobilising resources and involving actors at several occasions, but as these problems were overcome these issues did not emerge from this analysis that focused on the main differences between the cases with and without impact.

The differences between the three cases are listed in Table 2. Although some of the differences and the underlying factors may be related and interdependent, this was not investigated. Instead, we used the differences to identify internal factors that could have constrained or enabled the spin-off and follow-activities of the backcasting experiments under examination. The factors that follow from comparing the cases are listed in Table 3 and are briefly discussed subsequently.

For instance, a high degree of stakeholder involvement is an important internal enabling factor, because it enhances learning and awareness. In addition, other types of participation then attending meetings, such as co-funding or providing substantial additional capacity by stakeholders indicate commitment by these stakeholders. Another enabling factor is a single vision backcasting experiment, because a single vision seems to stimulate the domestication of and the attachment to the vision by the stakeholders involved, as well as the development of a sense of ownership. Furthermore, high degrees of guidance and orientation from the vision are a strong indication of its attractiveness and its potential to mobilise resources. Institutional protection from higher management levels of participating stakeholders helps against competing visions and vested interests that might eventually become affected. Vision champions are as important to visions as product champions are for product innovations. A strong focus on achieving follow-up and spin-off activities means that it gets priority and that actions are defined to achieve related goals. Learning at group level among stakeholders reflects higher order learning and is in line with actor and stakeholder learning theories. Finally, a high degree of influence from key stakeholders appears to be an important enabling factor too. This suggests that making alliances with powerful actors that have more access to resources may be helpful, but the risk might be that it

Table 1
Comparing major impact results of the three cases.

	NPF case	SHN case	MSL case
1. Networks: activities, actors, resources	Clusters of networks in all four domains	Very limited, attempts, but not successful in mobilising resources	Clusters of networks in all four domains, especially in the Winterswijk region
2. Vision: guidance and orientation	Core of vision guides, but decentralised adjustments	Visions faded away	Vision lives on in the region, new MSL visions in other regions
3. Institutionalisation	Starting, instances	No	Starting, instances

Table 2
Differences between cases with and without significant impact.

MSL case & NPF case	SHN case
High degrees of stakeholder involvement among some groups of stakeholders	A low degree of stakeholder involvement
Various types of stakeholder participation including co-funding and substantial capacity	Only one type of stakeholder participation, workshop attendance
Limited (selected) groups of stakeholders have a high level of influence	All participating stakeholders have a high level of influence
Single vision	Multiple visions
High degrees of guidance and orientation provided by the vision	Moderate degree of guidance and low degree of orientation provided by the visions
Considerable budgets (around € 2 million)	Moderate budget (around € 200,000)
Institutional protection	No institutional protection
Several vision champions	No vision champion
Strong focus on follow-up and implementation	Focus on academic methodology development; little focus on follow-up and implementation
More instances of higher order learning regarding the topic under investigation at the level of specific stakeholders	Moderate instances of higher order learning regarding the topic of investigation at the level of specific stakeholders
Joint and congruent learning among groups of stakeholders	No joint or congruent learning among groups of stakeholders

brings in incumbent actors and interests. However, marginalised perspectives and actors might have more to offer in terms of ideas and relevance [60], but not necessarily in terms of influence.

Several internal constraining factors could be derived from the cases. A low degree of stakeholder involvement is a constraining factor. It suggests that less learning occurred. It also suggests that in case of multiple visions stakeholder develop less or no attachment and a limited sense of ownerships to the vision. A lower degree of guidance and orientation might be the result of other factors like limited involvement, less attachment to the vision and lack of joint and congruent learning at the group level. A strong focus on academic achievements and methodology development implies a more limited focus on spin-off and follow-up in the project design. The question what would be the deciding factor for the lack of impact of the SHN backcasting experiment is difficult to answer. The current analysis does not allow for identifying the main factor. Moreover, it is more likely that several factors together lead to the limited impact.

If no main factor(s) for enabling and constraining follow-up and spin-off can be derived from the cases then the enabling factors can be seen as conditions to be met, whereas the constraining factors should be avoided when striving for spin-off and follow-up. With regard to the lower number of constraining factors, it appeared that this was in the SHN case due to the lack of enabling factors, instead of the presence of constraining factors. Furthermore, the substantial number of enabling factors also raises the questions (i) whether some enabling factors are more important than others, and (ii) how the various factors relate to each other. For instance, different factors may enhance each other's enabling effect, may be conditional, or may have to come together. It might even be possible that all the enabling factors are required, but this is an issue for further research, as the empirical results did not allow to rank the various factors or to see whether and how they are connected.

Finally, external factors were relevant in the MSL and NPF cases and they seem to have a considerable influence on the extent of follow-up, spin-off and other effects in the cases examined. For instance, in both the MSL and NPF cases, the outbreak of several livestock and chicken diseases was a positive external factor. In the NPF case, the supermarket war in the Netherlands led to lower meat prices and reduced opportunities for meat alternatives temporarily. In the MSL case changing rural and agricultural policies at the EU had a positive influence on the opportunities for MSL. Although external factors did not appear to be important in the SHN case, this could be explained by the fact that in this case the impact was very limited and therefore not affected by external trends and factors.

More potentially relevant external factors could be identified, and are discussed elsewhere [3]. Generally, external factors appeared to be highly context-dependent, case-specific and in some cases also highly contingent. This makes it considerably more difficult to identify more generic enabling and constraining external factors that may have a wider relevance for other cases. Nevertheless, based on the cases we examined, some 'generalised' external factors can be proposed. Examples of enabling external factors were motivated stakeholders that became accidentally involved and the coincidental presence of government funding or policy programmes or other initiatives that could be 'mobilised' and could provide resources. Examples of constraining external

Table 3
Internal factors influencing the extent of spin-off and follow-up.

Enabling internal factors	Constraining internal factors
High degree of stakeholder involvement	Low degree of stakeholder involvement
Diversity in types of stakeholder involvement	–
Single vision backcasting experiment	Multiple visions backcasting experiment
High degree of guidance and orientation of the future vision	Low degree of guidance and orientation by the future vision
Institutional protection	–
Presence of vision champions	–
Strong focus on follow-up and implementation	Strong focus on academic achievements
Joint and congruent learning	No learning and learning only at the individual level

factors were the exit of stakeholders due to external developments, competition from other emerging visions, and constraining influences from developments at supranational organisations like EU and WTO.

6. Conclusions

This study has shown that backcasting experiments involving various stakeholders from different societal domains can result in the development, exploration and analysis of desirable visions of the future that provide orientation (where to go) and guidance (what to do) to involved stakeholders. Backcasting experiments can also lead to instances and processes of higher order learning among participating stakeholders and to the formulation of follow-up agendas. This confirms that participatory backcasting is an adequate approach to envisaging and exploring system innovations and transitions towards sustainability, and can be seen as a promising sustainable alternative to traditional planning.

However, participatory backcasting experiments do not automatically lead to follow-up, spin-off and implementation in line with the vision and the follow-up agenda. This depends on various internal and external factors that can be both enabling and constraining in nature. Follow-up and spin-off that occurs can be seen as activities that are constituted by networks of actors that have been successful in mobilising sufficient resources. Furthermore, the findings suggest that higher order learning at group level among stakeholders in the backcasting experiment is strongly related to the emergence of spin-off and follow-up activities.

Important internal enabling factors are a high degree of stakeholder involvement, other types of participation like co-funding or providing additional capacity, a single vision backcasting experiment, high degrees of guidance and orientation by the vision, institutional protection by high-level participating stakeholders, the emergence of vision champions, a strong focus on follow-up and spin-off activities, learning at group level among stakeholders and a high level of influence from key stakeholders. Internal constraining factors include a low degree of stakeholder involvement, a multiple visions backcasting experiment, a lower degree of guidance and orientation by the future visions, a strong focus on academic achievements and on methodology development and no learning at the group level. External factors that evolve in the surrounding socio-technical system or its context can be either constraining or enabling, but they are case-specific.

It must be realised that the set of internal factors is based on a limited number of cases. Therefore, this list should be seen as exploratory and indicative. Further research is needed to look in a more detailed way into this list as well as in the specific contexts of backcasting experiments. For instance, multiple visions may constrain the degree of guidance and orientation resulting in less substantial follow-up and spin-off activities. However, if the purpose of a particular backcasting experiment is to evaluate several contested alternative futures [60] or to articulate also a broader range perspectives [28,61], then the socially endorsed decision not to pursue a certain vision can be a significant outcome having a major impact. It might then be interesting to conduct a backcasting analysis how to avoid such a vision to become reality and define activities for that too. This can for instance be done to avoid climate change. Backcasting allows for this [16], though it is in general not explicitly applied in this way.

Future visions are also highly relevant to follow-up and spin-off activities, as they provide orientation (where to go) and guidance (what to do). Future visions are stable because their core is clearly present in new clusters of activities, also when they diffuse into other societal domains. Visions are flexible because they co-evolve with the supporting networks in the sense that networks and actors are influenced and inspired by the visions, while networks and actors involved in follow-up and spin-off influence and adjust the vision too.

In addition, when substantial follow-up and spin-off occur after five to ten years, this is still at the level of niche activities, or consists of several niches in the four distinguished societal domains of research, business, government and society. Follow-up and spin-off activities are accompanied by initial instances of broader effects like institutionalisation. The niches have thus 'grown out' of the backcasting experiments in a process 'from vision to niche' and the niches have potential to become stepping stones for system innovations towards sustainability. The backcasting experiments themselves can be seen as the initial niche for experimentation and vision development from which the spin-off and follow-up activities have grown.

In this paper, we also constructed a conceptual framework that is based on various theories and building blocks. This framework enabled us (i) to relate backcasting experiments to their impact and spin-off, (ii) to identify factors that influence the extent of spin-off and follow-up, and (iii) analyse and relate the dynamics in both the backcasting experiment and its 'impact and spin-off phase'.

Finally, we also discussed a methodological framework for participatory backcasting and we have shown that key characteristics, like stakeholder heterogeneity, interdisciplinarity, and the presence of both different groups of methods and different types of goals were present in all three cases.

7. Broader relevance: innovation theory, policy and governance

The clusters of activities identified in this research can be seen as a set of related niches that can be found in all four societal domains distinguished. This result can be used to refine the existing niche concept in innovation studies as proposed by scholars working on Strategic Niche Management and social niche experiments [50,62–64]. This research shows that the niche concept is not limited to a market niche or a technological niche, but can consist of various types of niches in different societal domains. The 'from vision to niche' mechanism may also provide an interesting addition to the Multi-Level Perspective [52,53], and the growing body of literature on niche management [50,65]. Despite the fact that the results of this study do not point to changes and effects at the level of socio-technical systems, they can be related to the Multi-Level Perspective, as visions developed and explored in backcasting experiments can grow into a set of niches in which visions, supporting networks and activities can be found. This

research thus sheds some light on the phase before the niche and may in this way also contribute to the Multi-Level Perspective and to the concept of Strategic Niche Management.

In addition, this research has also pointed to the relevance of visions in system innovations and niche formation, whereas until now this has only got limited attention in innovation theory. In this study visions appeared to be important because they can provide guidance and orientation, while emerging follow-up and spin-off coincides with the diffusion of a vision. In addition, our results indicate that visions and networks of actors evolve in a co-evolutionary way and mutually influence each other. This may also provide an explanation for the stability and flexibility of visions as found in our results, as well as a possible mechanism for decentralised guidance and orientation to different clusters of activities in different domains. These issues need further investigation, but are interesting additions to the conceptualisation of visions, as put forward by Dierkes et al. [40] and therefore interesting for the further development of (system) innovation theory. Furthermore, there are similarities and differences with the evaluative frameworks applied in Strategic Niche Management [50,51] and the Functions of Innovation Systems approach [66–68]. This calls for further study too.

The results also showed that government funding and resources are crucial to bringing about follow-up and spin-off activities. However, the government focus in the cases was in particular on research and knowledge development. Based on this, we would recommend extending government support beyond funding knowledge development and to facilitate system innovations towards sustainability in a broader sense. This could include the stimulation of follow-up and spin-off of backcasting experiments by additional regulatory or market development instruments and other policies to stimulate further development towards a system innovation.

Although the results of this study clearly indicate that the government is a key actor in facilitating the spin-off activities of backcasting experiments, we emphasise that actors and stakeholders from all four societal domains are important and that they should all provide a necessary contribution that cannot be provided by stakeholders from the other groups.

Clearly, more time is needed before it can be determined whether a participatory backcasting experiment will have led to or contributed to a system innovation towards sustainability. Moreover, in most cases, additional activities and policies may be needed to really bring about systems innovations. The question is who should take the lead, knowing that the government, rather than being the controlling actor, is now merely one of the actors in public decision-making. This raises the issue of governance for system innovations towards sustainability. Voß et al. [69] have argued in favour of reflexive governance, in line with the concept of reflexive modernisation [41,70]. This research indicates that visions may contribute to such reflexive governance, as they can provide guidance and orientation if they emerge from a reflexive process in a participatory backcasting experiment in which the visions of desirable alternative futures have been articulated and explored.

The developed conceptual framework is also relevant for the evaluation and monitoring of spin-off and follow-up activities regarding other types of interventions and intervention instruments that involve stakeholder involvement. This includes what is currently known as transition policies and transition monitoring in the Netherlands. The framework developed in this paper may also be relevant when it comes to evaluating research and innovation policies in other areas and determining the impact of public technology assessment activities.

Finally, various research recommendations can be made: (i) extending the number of evaluations of backcasting experiments and their impact, including a comparison of different approaches and across countries; (ii) further methodology development and application of specific methods within a backcasting framework and an evaluation of whether and how this enables or constrains the impact and spin-off activities of backcasting experiments; (iii) further theorising and conceptualising regarding the mechanisms and other theoretical variables connected to the dynamics involved in backcasting experiments and their follow-up activities and how they relate to system innovation theories and governance concepts. Clearly, stakeholder involvement, learning, vision development and network formation are important, but more theoretical and conceptual work is needed, especially with regard to the processes and mechanisms that generate and shape follow-up and spin-off of backcasting experiments.

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References

[1] B. Elzen, F.W. Geels, K. Green, System innovation and the transition to sustainability, Edward Elgar, Cheltenham UK/Northampton MA, 2004.
[2] J. Rotmans, R. Kemp, M. van Asselt, More evolution than revolution: transition management in public policy, Foresight 3 (2001) 15–31.
[3] J. Quist, Backcasting for a sustainable future: the impact after ten years, Eburon, Delft NL, 2007.
[4] D. Loorbach, Transition Management: a New Mode of Governance for Sustainable Development, International Books, Utrecht NL, 2007.
[5] System Innovation for Sustainability 1: Perspectives on Radical Changes to Sustainable Consumption and Production, in: A. Tukker, M. Charter, C. Vezzoli, E. Stø, M. Munch Andersen (Eds.), Greenleaf Publishers, Sheffield UK, 2008.
[6] J. Grin, J. Rotmans, J. Schot, Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change, Routhledge, New York NY/Oxon UK, 2010.
[7] J. Quist, P. Vergragt, Past and future of backcasting: the shift to stakeholder participation and a proposal for a methodological framework, Futures 38 (2006) 1027–1045.
[8] P. Weaver, L. Jansen, G. van Grootveld, E. van Spiegel, P. Vergragt, Sustainable Technology Development, Greenleaf, Shefield UK, 2000.
[9] P. Vergragt, Back-casting for environmental sustainability: from STD and SusHouse towards implementation, in: M. Weber, J. Hemmelskamp (Eds.), Towards Environmental Innovation Systems, Springer, Heidelberg, 2005.
[10] K.H. Dreborg, Essence of backcasting, Futures 28 (1996) 813–828.

[11] A. Giddens, The Politics of Climate Change, Polity Press, Cambridge UK, 2009.
[12] A. Loeber, Practical Wisdom in the Risk Society: Methods and Practice of Interpretive Analysis on Questions of Sustainable Development, University of Amsterdam, Amsterdam, 2004.
[13] M. van de Kerkhof, Debating Climate Change: a Study of Stakeholder Participation in an Integrated Assessment of Long-Term Climate Policy in the Netherlands, Lemma Publishers, Utrecht NL, 2004.
[14] A.B. Lovins, Soft Energy Paths: Toward a Durable Peace, Friends of the Earth Int/Ballinger Publishing Company, Cambridge MA, 1977.
[15] J.B. Robinson, Energy backcasting: a proposed method of policy analysis, Energy Policy 10 (1982) 337–344.
[16] J.B. Robinson, Futures under glass: a recipe for people who hate to predict, Futures 22 (1990) 820–842.
[17] J. Holmberg, Backcasting: a natural step in operationalising sustainable development, Greener Manage. Int. 23 (1998) 30–51.
[18] P.J. Vergragt, L. Jansen, Sustainable technological development: the making of a Dutch long- term oriented technology programme, Proj. Appraisal 8 (1993) 134–140.
[19] L. Jansen, The challenge of sustainable development, J. Cleaner Prod. 11 (2003) 231–245.
[20] J. Robinson, Future subjunctive: backcasting as social learning, Futures 35 (2003) 839–856.
[21] J. Robinson, J. Tansey, Co-production, emergent properties and strong interactive social research: the Georgia Basin futures project, Sci. Public Policy 33 (2006) 151–160.
[22] A. Carlsson-Kanyama, K.H. Dreborg, H.C. Moll, D. Padovan, Participative backcasting: a tool for involving stakeholders in local sustainability planning, Futures 40 (2008) 34–46.
[23] J. Holmberg, K.H. Robèrt, Backcasting: a framework for strategic planning, Int. J. Sustain. Dev. World Ecol. 7 (2000) 291–308.
[24] J. Quist, M. Knot, W. Young, K. Green, P. Vergragt, Strategies towards sustainable households using stakeholder workshops and scenarios, Int. J. Sustainable Dev. 4 (2001) 75–89.
[25] W. Young, J. Quist, K. Toth, K. Anderson, K. Green, Exploring sustainable futures through 'Design Orienting Scenarios': the case of shopping, cooking and eating, J. Sustain. Prod. Des. 1 (2001) 117–129.
[26] K. Green, P. Vergragt, Towards sustainable households: a methodology for developing sustainable technological and social innovations, Futures 34 (2002) 381–400.
[27] M. Hisschemoller, R. Bode, M. van de Kerkhof, What governs the transition to a sustainable hydrogen economy? Articulating the relationship between technologies and political institutions, Energy Policy 34 (2006) 1227–1235.
[28] E. Cuppen, Putting perspectives into participation: constructive conflict methodology for problem structuring in stakeholder dialogues, , 2010.
[29] P.J. Partidario, J. Vergragt, Planning of strategic innovation aimed at environmental sustainability: actor-networks, scenario acceptance and backcasting analysis within a polymeric coating chain, Futures 34 (2002) 841–861.
[30] J. Grin, F. Felix, B. Bos, S. Spoelstra, Practices for reflexive design: lessons from a Dutch programme on sustainable agriculture, Int. J. Foresight Innov. Policy 1 (2004) 126–149.
[31] M. Blom-Zandstra, H. van Keulen, Innovative concepts towards sustainability in organic horticulture: testing a participatory technology design, Int. J. Agric. Sustain. 6 (2008) 195–207.
[32] J. Quist, C. Rammelt, M. Overschie, G. de Werk, Backcasting for sustainability in engineering education: the case of Delft University of Technology, J. Cleaner Prod. 14 (2006) 868–876.
[33] K. Kok, M. Patel, D.S. Rothman, G. Quaranta, Multi-scale narratives from an IA perspective: Part II. Participatory local scenario development, Futures 38 (2006) 285–311.
[34] K. Kok, D.S. Rothman, M. Patel, Multi-scale narratives from an IA perspective: Part I. European and Mediterranean scenario development, Futures 38 (2006) 261–284.
[35] H.J. de Graaf, M.A.W. Noordervliet, C.J.M. Musters, G.R. de Snoo, Roadmap for interactive exploration of sustainable development opportunities: the use of simple instruments in the complex setting of bottom-up processes in rural areas, Land Use Policy 26 (2009) 295–307.
[36] M. van de Kerkhof, A. Wieczorek, Learning and stakeholder participation in transition processes towards sustainability: methodological considerations, Technol. Forecasting Soc. Change 72 (2005) 733–747.
[37] M. van de Kerkhof, M. Hisschemöller, M. Spanjersberg, Shaping diversity in participatory foresight studies: experiences with interactive backcasting in a stakeholder assessment on long-term climate policy in the Netherlands, Greener Manage. Int. (2002) 85–99.
[38] H.S. Brown, P. Vergragt, K. Green, L. Berchicci, Learning for sustainability transition through bounded socio-technical experiments in personal mobility, Technol. Anal. Strateg. Manage. 15 (2003) 291–315.
[39] J. Grin, A. Grunwald (Eds.), Vision Assessment, Shaping Technology in the 21st Century: Towards a Repertoire for Technology Assessment, Springer Verlag, Berlin, 2000.
[40] M. Dierkes, U. Hoffmann, L. Marz, Visions of Technology: Social and Institutional Factors Shaping the Development of New Technologies, Campus Verlag/St. Martin's Press, Frankfurt/New York, 1996.
[41] J. Grin, Reflexive modernization as a governance issue or: designing and shaping re-structuration, in: J.P. Voß, D. Bauknecht, R. Kemp (Eds.), Reflexive Governance for Sustainable Development, Edward Elgar, Cheltenham UK, 2006, pp. 57–81.
[42] A. Smith, A. Stirling, F. Berkhout, The governance of sustainable socio-technical transitions, Res. Policy 34 (2005) 1491–1510.
[43] F. Berkhout, Normative expectations in systems innovation, Technol. Anal. Strateg. Manage. 18 (2006) 299–311.
[44] M. Callon, P. Laredo, V. Rabeharisoa, T. Gonard, T. Leray, The management and evaluation of technological programs and the dynamics of techno-economic networks: the case of the AFME, Res. Policy 21 (1992) 215–236.
[45] H. Håkansson (Ed.), Industrial Technological Development: a Network Approach, Routhledge, London UK, 1987.
[46] W.J.M. Kickert, E.H. Klijn, J.F.M. Koppenjan (Eds.), Managing Complex Networks, Sage Publications, Thousand Oaks CA, 1997.
[47] H. Håkansson, Corporate Technological Behaviour: Cooperation and Networks, Routledge, London UK, 1989.
[48] C. Oliver, Strategic responses to institutional processes, Acad. Manage. Rev. 16 (1991) 145–179.
[49] W.R. Scott, Institutions and Organizations, Sage Publications, Thousand Oaks CA, 2001.
[50] R. Raven, Strategic Niche Management for Biomass, Eindhoven University of Technology Press, Eindhoven NL, 2005.
[51] A. Smith, Green niches in sustainable development: the case of organic food in the United Kingdom, Environ. Plann. C Gov. Policy 24 (2006) 439–458.
[52] F. Geels, Technological Transitions and System Innovations: a Co-evolutionary and Socio-technical analysis, Edward Elgar, Cheltenham UK/Northampton MA, 2005.
[53] F.W. Geels, Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study, Res. Policy 31 (2002) 1257–1274.
[54] G. Fonk, Een constructieve rol van de consument in technologieontwikkeling (A Constructive Contribution of Consumers in Technology Development), Twente University, Enschede, 1994.
[55] O. de Kuijer, H. Aarts, J. Beeren, H. de Graaf, D. Jansen, R. Kwak, S. van der Pas, J. Tiggeloven, Resultaten project Duurzaam Landgebruik (Results MSL project), STD programme, Delft, 1997.
[56] O. de Kuijer, H. Linsen, J. Quist, New perspectives: sustainable technological development in agriculture, in: T. Schneider (Ed.), Air Pollution in the 21st Century: Priority Issues and Policy, Elsevier, Dordrecht NL, 1997, pp. 733–753.
[57] H.J. de Graaf, C.J.M. Musters, W.J. Ter Keurs, Regional Opportunities for Sustainable Development: Theory, methods and Applications, Kluwer Academic Publishers, Dordrecht NL, 1999.
[58] H. Aiking, J. de Boer, J. Vereijken, Sustainable Protein Production and Consumption: Pigs or Peas? Springer, Dordrecht NL, 2003.
[59] J. Akkkerman, A. van Cooten, L. Noordwijn, D. Sleurink, Bouwstenen voor creatief ruimtegebruik: vier jaar praktijkervaring met meervoudig duurzaam landgebruik in Winterswijk (Building Bricks for Creative Use of Space), Steering Goup MSL Winterswijk programme Winterswijk NL, , 2003.
[60] A. Stirling, "Opening up" and "closing down": Power, participation, and pluralism in the social appraisal of technology, Sci. Technol. Hum. Values 33 (2008) 262–294.

[61] M. Eames, W. McDowall, M. Hodson, S. Marvin, Negotiating contested visions and place-specific expectations of the hydrogen economy, Technol. Anal. Strateg. Manage. 18 (2006) 361–374.
[62] R. Kemp, J. Schot, R. Hoogma, Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management, Technol. Anal. Strateg. Manage. 10 (1998) 175–195.
[63] R. Hoogma, R. Kemp, J. Schot, B. Truffer, Experimenting for Sustainable Transport: the Approach of Strategic Niche Management, Spon Press, London/New York, 2002.
[64] H. Verheul, P.J. Vergragt, Social experiments in the development of environmental technology: a bottom-up perspective, Technol. Anal. Strateg. Manage. 7 (1995) 315–326.
[65] J. Schot, F.W. Geels, Niches in evolutionary theories of technical change: a critical survey of the literature, J. Evol. Econ. 17 (2007) 605–622.
[66] M.P. Hekkert, R.A.A. Suurs, S.O. Negro, S. Kuhlmann, R.E.H.M. Smits, Functions of innovation systems: a new approach for analysing technological change, Technol. Forecasting Soc. Change 74 (2007) 413–432.
[67] S.O. Negro, M.P. Hekkert, R.E. Smits, Explaining the failure of the Dutch innovation system for biomass digestion-A functional analysis, Energy Policy 35 (2007) 925–938.
[68] L.M. Kamp, Socio-technical analysis of the introduction of wind power in the Netherlands and Denmark, Int. J. Environ. Technol. Manage. 9 (2008) 276–293.
[69] J.P. Voß, D. Bauknecht, R. Kemp (Eds.), Reflexive Governance for Sustainable Development, Edward Elgar, Cheltenham UK/Northampton MA, 2006.
[70] U. Beck, Reflexive governance: politics in the global risk society, in: J.P. Voß, D. Bauknecht, R. Kemp (Eds.), Reflexive Governance for Sustainable Development, Edward Elgar, Cheltenham UK, 2006, pp. 31–56.
[71] E. Jantsch, Technological Forecasting in Perspective, OECD, Paris, 1967.
[72] H.A. Linstone, When is a need a need — problem of normative forecasting in a changing environment, Technol. Forecasting Soc. Change 1 (1969) 55–71.
[73] J.B. Robinson, Unlearning and backcasting: rethinking some of the questions we ask about the future, Technol. Forecasting Soc. Change 33 (1988) 325–338.
[74] M. Höjer, L.-G. Mattsson, Determinism and backcasting in future studies, Futures 32 (2000) 613–634.
[75] J. Grin, H. van de Graaf, Technology assessment as learning, Sci. Technol. Hum. Values 21 (1996) 72–99.

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