sustainability

MDPI

Article

A Methodological Framework to Initiate and Design Transition Governance Processes

Johannes Halbe [1,2,*] and Claudia Pahl-Wostl [1]

[1] Institute of Environmental Systems Research, University of Osnabrück, Barbarastr. 12, 49076 Osnabrück, Germany; cpahlwos@uni-osnabrueck.de
[2] Department of Bioresource Engineering, McGill University, Macdonald Stewart Building, 21111 Lakeshore Road, Ste-Anne-de-Bellevue, QC H9X 3V9, Canada
* Correspondence: jhalbe@uos.de; Tel.: +49-541-969-2297

Received: 30 September 2018; Accepted: 20 January 2019; Published: 6 February 2019

Abstract: Sustainability transitions require societal change at multiple levels ranging from individual behavioral change to community projects, businesses that offer sustainable products as well as policy-makers that set suitable incentive structures. Concepts, methods and tools are currently lacking that help to initiate and design transition governance processes based upon an encompassing understanding of such diverse interactions of actors and intervention points. This article presents a methodological framework for the initiation and design of transition governance processes. Based upon a conceptualization of sustainability transitions as multilevel learning processes, the methodological framework includes participatory modeling, a systematic literature review and governance system analysis to identify social units (learning subjects and contexts), challenges (learning objects) and intervention points (learning factors) relevant for initiating case-specific transition governance processes. A case study on sustainable food systems in Ontario, Canada is provided to exemplify the application of the methodological framework. The results demonstrate the merit of combining stakeholder-based and expert-based methods, as several learning factors identified in the participatory process could not be found in the general literature, and vice versa. The methodological framework allowed for an integrated analysis of the diversity of existing initiatives in the case study region and specific intervention points to support place-based sustainability innovations. Initiators of transition governance processes can use the results by designing targeted interventions to facilitate and coordinate existing initiatives or by setting new impulses through purposeful action.

Keywords: transition governance; transition management; adaptive management; learning; leadership; sustainable food systems

1. Introduction

Broad societal transformation processes towards sustainable development require actions at different societal levels comprising individual, group, organizational and policy levels [1]. Instead of centralized leadership using a command-and-control approach, steering societal transformations involves distributed and collaborative leadership [2–4] taken over by various social units, such as consumers, schools, business organizations, NGOs and policy-makers. The fading distinction between subject and object of steering [5] has spurred the development of transition governance concepts. The term "transition governance" denotes the proactive steering of societal transformations towards sustainability, which is challenged by high complexity, ambiguity and distributed control [6]. Addressing the aforementioned challenges requires a reflexive approach, which can be realized through various strategies [6]: (1) Transdisciplinary knowledge production, (2) experiments and adaptivity of

strategies and institutions, (3) anticipation of long-term systemic effects of measures, (4) iterative and participatory goal formulation and (5) interactive strategy development.

While various reflexive governance approaches exist that address a subset of the aforementioned governance strategies, adaptive management and transition management are more comprehensive [6]. Adaptive management particularly deals with managing change in social-ecological systems towards sustainability by supporting continuous learning from experimental actions [7–9]. Transition management focuses on transforming social-technical systems towards sustainable development [10,11]. Transition management considers the importance of network governance, long-term collective goals, innovation and learning in sustainability transitions [12]. Foxon et al. [13,14] examine the differences and commonalities between adaptive and transition management and identify various complementary aspects. In the following, we use the term "transition governance", which builds upon reflexive governance [6], transition management and adaptive management [8] and is understood to embrace the full complexity of multi-actor processes in societal transformations towards sustainable development (see Halbe [15] for more details).

A particular challenge of transition governance is related to the case-specific initiation and design of the transition processes. Participatory processes following an adaptive management or transition management approach are usually initiated by a small group of people held together by a joint future vision [16]. The initiating team can have a profound impact on the design of the process, including the selection of stakeholders, problem frame and potential solutions [16,17]. Starting a transition governance process can easily follow a command-and-control approach if the initiating team is not aware of its selective bias with regards to the framing of problems and solutions [18]. Initiating place-based transition governance processes from an integrated viewpoint requires knowledge of the plurality of frontrunners, innovations and intervention points. Based upon this knowledge, the initiating team is able to purposefully link and support existing initiatives and thereby play into local dynamics [19].

While the adaptive (co-)management approach bases upon a conceptually sound understanding of collaborative processes, including vertical and horizontal integration and polycentric governance (e.g., Pahl-Wostl [2]), the transition management approach is more operationally developed by offering practical guidance for initiating transformative processes. At the outset of a transition management process, a transition team is formed that consists of members of the initiating agency, such as a municipality, which can be supported by external experts, transition management scholars and process facilitators [19]. Loorbach [12] propose that the transition team conducts an integrated systems and actor analysis in an "expert preparation phase" with the intention of providing a factual basis of the transition topic and selection of 10–15 stakeholders. Several steps are recommended for systems and actors analysis while the choice of specific methods and depth of analysis is determined by the transition team [19]. These methods can help the transition team to broaden the perspective and reduce the bias in selecting problems and change agents, but critical aspects can still be omitted, such as multilevel and multi-scale issues. Thus, systematic methodologies are needed to guide transition governance processes in their predevelopment stage [20], in which it is unclear who are relevant actors and which innovations are expedient and will prevail (cf. Rijke et al. [21]).

Wolfram [20] addresses this research challenge by developing an integrated conceptual framework, which allows for an analysis and targeted development of the transformative capacity at a predevelopment stage of urban sustainability transitions. The conceptual framework was created in a deductive research process, including a systematic literature review and theoretical coding. It consists of ten interdependent components and 60 development factors of transformative capacity [22]. Three components deal with agency and interaction forms (i.e., inclusive and multiform urban governance; transformative leadership; empowered and autonomous communities of practice), four with development processes (i.e., system(s) awareness and memory; urban sustainability foresight; diverse community-based experimentation with disruptive solutions; innovation embedding and coupling; reflexivity and social learning) and two with relational dimensions that have an influence on

all other components (i.e., working across human agency levels; working across political-administrative levels and geographical scales) [20].

Supplemental to the aforementioned analytical approaches (e.g., as part of the expert preparation phase [19]) and deductive approaches (e.g., conceptual framework of transformative capacity [20]), this article presents a participatory approach for initiating and designing transition governance processes. The proposed methodological framework helps to specify the various opportunities to contribute to sustainable development at multiple societal levels through purposeful action. The methodological framework focuses on the identification of frontrunners and intervention points to foster sustainability innovations. These innovations are understood as innovative social, technical or nature-based solutions for the provision of societal functions (e.g., for water, energy and food supply). Sustainability innovations are often residing at a niche level today but might be a promising element of a sustainable supply system in the future [23]. The term "innovation" draws on Rogers's ([24], p. 11) definition as an "idea, practice, or object that is perceived as new by an individual or other unit of adoption". Thus, a sustainability innovation is not necessarily novel but can also include traditional practices that are rediscovered to contribute to the solution of sustainability issues. The methodological framework bases upon a conceptualization of societal transformations as learning processes that take place at different societal levels, each forming a distinct learning context. Supportive factors of learning are understood as practical leverage points for supporting forerunners and for implementing sustainability innovations, which can take the form of knowledge (e.g., skills), institutions (e.g., a piece of legislation) or operational aspects (e.g., infrastructure).

The article is structured as follows. First, the proposed methodological framework is presented comprising a description of the conceptual background and a stepwise method for the case-specific initiation and design of transition governance processes. An example application is provided using a case study on sustainable food systems in Ontario, Canada. The article ends with a discussion and conclusion.

2. A Methodological Framework for the Initiation and Design of Transition Governance Processes

The methodological framework presented below bases upon a conceptualization of sustainability transitions as learning processes. The conceptual multilevel learning framework presented by Halbe [15] comprises the various dimensions and aspects of learning processes in sustainability transitions. The conceptual framework differentiates between learning intensities and learning objects (What needs to change?), learning processes and learning factors (How can learning be actively supported?) as well as subjects and contexts (Who needs to become active?). Thereby, the conceptual framework supports an integrated analysis of transition governance processes, which is required for an effective process initiation and design. The learning intensity addresses the depth of learning ranging from routine learning to reframing and transformative change. Learning intensities are related to specific learning objects (printed in italics). For instance, an iterative improvement of *conventional strategies* pertains to routine learning, while changing *fundamental values* and *beliefs* are related to a transformative change. Concepts linked to the process of learning specify mechanisms by which subjects learn and how learning objects are altered. Thus, learning processes can involve direct experiences of a particular issue or object (e.g., experience of an environmental problem or experimentation with innovative solutions) and social interactions (e.g., social learning in a collaborative process). Subjects can learn as an individual as well as a part of a group, a business or public organization. Social units thereby form particular contexts for learning, such as individual, group, organizational and policy learning contexts. Learning contexts are defined by an agency perspective, i.e., whether an individual, a group, an organization or policy actors are becoming active to address a sustainability issue [15].

As another preparatory step to the development of the methodological framework, a systematic literature review has been conducted to identify supportive and impeding factors of learning in the

fields of socio-ecological and social-technical systems research [25]. The systematic review resulted in a list of supportive and impeding factors of learning that were sorted according to individual, group, organizational and policy learning contexts (see the factor list in Tables S1.1–1.4). Their susceptibility to change in a specific learning context was assessed ranging from endogenous (i.e., factors can be addressed by a subject independently within a learning context) to exogenous (i.e., factors cannot be directly addressed but depend upon exogenous forces/support). Endogenous factors are considered as intervention points in transition governance processes as they allow a proactive facilitation of learning. Exogenous factors, however, point to exogenous events (e.g., an environmental issues or an economic crisis) or interdependencies between learning contexts. As a specific example of the latter, a community garden project (related to a group learning context) can be supported by policy actors who provide public land (related to a policy learning context). The identification of learning factors and their susceptibility to change allows for the design of transition governance processes that consider opportunities for self-reliant action as well as interdependencies between stakeholders at multiple societal levels.

In the following, a methodological framework for the initiation and design of transition governance processes is presented that base upon the aforementioned conceptualization of transition governance as multilevel learning processes. The methodological framework combines different streams of previous research [15,23,25,26] and consists of four steps (see Figure 1): (1) A problem and actor analysis to identify case-specific experts, frontrunners and sustainability innovations; (2) a participatory modeling approach to identify case-specific barriers and drivers of innovation [23]; (3) an integrated analysis of learning objects, subjects, contexts and factors to determine intervention points; (4) an integrated transition governance system analysis providing an integrated perspective on interactions contexts and agencies in order to guide process initiation and design [15,26]. In the following sections, each step of the methodological framework is presented in detail.

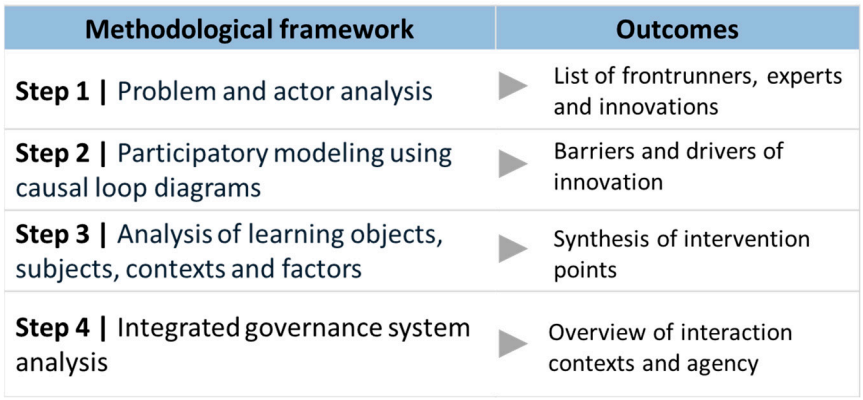

Figure 1. The methodological framework for the initiation and design of transition governance processes.

2.1. Step 1: Problem and Actor Analysis

The first step includes the gathering of data and information about the transition topic at hand. Societal transitions are complex phenomena due to the multi-domain and multilevel interactions as well as path-dependent and self-reinforcing processes [27]. Thus, analytical frameworks are needed to guide the analysis of transition processes. The Multi-Level Perspective (MLP) [28,29] is an analytical framework that can guide data collection and the gathering of relevant information (e.g., Auvinen et al. [30]). Various transition scholars have applied the MLP to analyze elements of past transition processes including niches (e.g., sustainability innovations), regime elements and landscape signals (e.g., References [31,32]). After the analysis of landscape, regime and niche elements, a preliminary list of relevant stakeholders is needed to prepare the participatory modeling process. Two types of stakeholders can be distinguished, which are experts (who can provide an overview

on perceived problems and solution perspectives) and frontrunners/innovators (who can offer more in-depth information of innovations and their barriers and drivers) [15]. In the end the problem and stakeholder analysis should be considered as a preliminary analysis, which needs to be adapted throughout the process based upon new experiences and input from stakeholders [33].

2.2. Step 2: Participatory Modeling Using Causal Loop Diagrams

In the second step, stakeholders (i.e., experts and frontrunners) who have been identified in the first research step are asked for an interview. The participatory development of conceptual models supports a structured and in-depth analysis of stakeholder perceptions on complex sustainability issues (e.g., References [34,35]). The method of building causal loop diagrams (CLDs) with innovators and experts follows a number of consecutive steps (see Figure 2) [15,23].

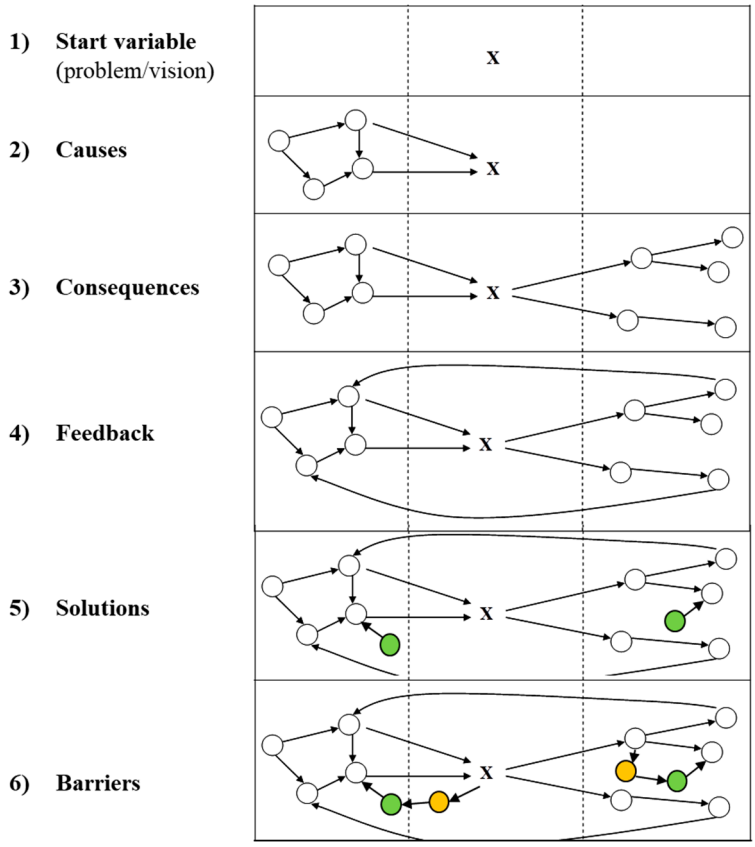

Figure 2. The steps of the participatory modeling process (steps 1 to 4 based upon Vennix [35]).

Expert interviews start with the definition of the problems with regards to the transition topic (e.g., a sustainable food or energy system), which is used as a start variable. Second, causes of the problems are identified. Third, the consequences of the problem(s) are studied, and, fourth, the interviewee is encouraged to find feedback loops [15,23,36]. Fifth, potential solution strategies and innovations are included to address the problems. Finally, the barriers of potential solutions and innovations are added [15,23]. In summary, the presented approach supports the systematic construction of a CLD that includes a representation of the participant's mental model of the status quo as well as preferred strategies and challenges related to the transition topic being explored. In addition, the naming of potential innovations can guide the selection of frontrunners for subsequent interviews.

Frontrunner interviews start with the definition of their vision of a sustainable food, energy or water system (depending on the topic of the study), which usually includes specific sustainability innovations (such as organic farming or renewable energy production). Second, innovators examine aspects that influence their particular innovations or general vision. These can be constraining

or supportive factors (e.g., aspects that motivated them to implement the innovation). Third, the consequences of the innovation are added (e.g., desirable effects on the environment), and, fourth, potential feedback processes are included. Finally, the interviewee is asked to think about further drivers and barriers to the implementation of the innovation [15,23]. Further participation methods, such as stakeholder interviews and surveys, can complement the participatory modelling approach to interrogate stakeholders' visions as well as perceived intervention points.

2.3. Step 3: Analysis of Learning Objects, Subjects, Contexts and Factors

In the third step, interview results (i.e., CLDs) are analyzed to identify learning objects, learning contexts and supportive/impeding factors. First, sustainability issues (i.e., problem variables) are identified in each diagram, which represent the learning objects (i.e., aspects that need to be addressed to support sustainability innovations). Second, the learning context is determined by examining the social units related to learning objects (i.e., individuals, groups, organizations or policy actors). For instance, lack of consumer knowledge is related to an individual learning context, as the learning object (i.e., consumer knowledge) pertains to the individual. Third, supportive factors of learning are identified, which are specific intervention points to address learning objects or overcoming barriers. These learning factors have been added to the CLDs by asking interviewees for solution strategies to address the identified problems. Fourth, impeding factors are identified, which are the barriers of proposed solution strategies.

The participatory research process reveals case-specific problems and solution perspectives that base upon local knowledge. However, interviewees might disregard important aspects due to a selective perception and limited knowledge. Thus, expert-led approaches are still necessary to provide scientific rigor and add experiences from other processes (cf. Reed et al. [37]). The case-specific learning factors are, therefore, compared to learning factors from the systematic literature review mentioned above (see list of learning factors in Table S1 and Halbe [25]). Experts and forerunners should be involved in the comparison of learning factors from the participatory process and the general literature review in order to identify factors relevant to the specific case-study that have been omitted in the participatory analysis. As a result, a consolidated list of impeding and supporting learning factors is prepared by the initiating team. Finally, endogenous learning factors are identified and linked to their specific learning contexts. Endogenous learning factors are in the following termed 'intervention points', as they can be actively addressed in the transition governance process.

2.4. Step 4: Integrated Transition Governance System Analysis

Lower tier analytical frameworks are needed (in comparison to the MLP) that help to depict key elements of transition governance processes, including specific multilevel actions and actor roles [15,23,38]. A useful tool is the Management and Transition Framework (MTF), which is a conceptual and methodological framework that allows for the analysis of properties and dynamics of complex systems [38]. The conceptual pillars of the MTF are adaptive management, social learning, regime transitions and the Institutional Analysis and Development Framework (see Ostrom [39]). The MTF consists of a static and process-related representation of governance systems. The static representation provides an ontology of the governance system by defining important elements, including the societal system, ecological system, and technical infrastructure. The process-related representation allows for the analysis of governance processes as a sequence of interaction processes (called "action situations") that are linked by institutions, knowledge and operational outcomes (i.e., the outcome from one action situation can be an input to other action situations). Up to now, the MTF has been mainly applied to understand governance processes through ex post analysis (e.g., References [40–43]). However, the same framework can also be applied in an ex ante planning exercise that defines the action situations, participating actors and aspired outcomes. The application of the framework for such a prospective design of transition paths has already been explored in prior research [17,26].

In the proposed methodological framework, the MTF is used for the representation of multilevel learning processes as interlinked action situations. These action situations address detected issues (i.e., learning objects) and are embedded in a particular learning context. Learning factors are represented as linkages between action situations and are marked as institutions, knowledge and operational outcomes. Thus, transition governance processes are visualized as interlinked learning processes within and across learning contexts. For instance, a learning process within a group context (e.g., a community project) can result in an operational outcome (e.g., a community garden), which can function as a supportive factor of learning in an individual learning context (e.g., an individual who gains knowledge about food processes by participating in the community garden).

The governance system analysis is conducted at two different abstraction levels (see Figure 3): (1) an overall inter-context analysis addresses the interactions between learning contexts and (2) a detailed intra-context analysis focused on interaction processes within learning contexts. In the overall inter-context analysis, a small number of high-level action situations are defined that subsume similar context-internal learning objects. For instance, a high-level action situation might be the development of consumer awareness for sustainable consumption, which subsume a number of learning objects, such as consumer values, knowledge or behavior. In Figure 3A, a high-level action situation is defined for each of the individual, group, organizational and policy learning contexts. In the detailed intra-context analysis, a context-internal analysis is conducted for each high-level action situations, comprising the design of more detailed action situations (i.e., interaction processes) (see Figure 3B). Following the above example, the intra-context analysis of the individual learning context would include detailed and interlinked action situations that address consumer values, knowledge and behavior.

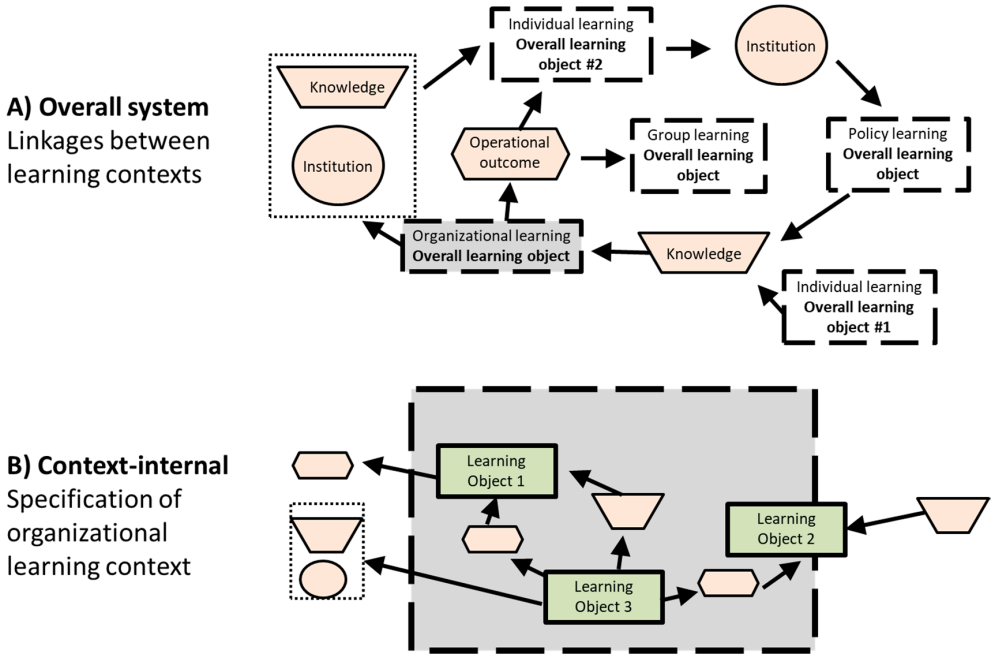

Figure 3. A graphical representation of the method for analyzing governance systems from an overall system perspective (**A**) and a context-internal perspective (**B**).

The integrated governance system analysis provides an overview of interaction contexts and agency in sustainability transitions. The intra-context analysis examines intervention points that can be implemented within social units and thus requires leadership at the individual level (e.g., self-leadership, see References [44,45]), group level (e.g., emergent leadership in group processes, see References [46,47]), organizational level (e.g., leadership in organizations, e.g., References [48,49]) and policy level (e.g., distributed leadership in policy formulation, e.g., Reference [50]). The inter-context analysis examines intervention points that require cooperation between social units, such as an

organization that actively relates and reshapes its context [51,52], consisting of other organizations, civil society and policy-makers, amongst others. As other examples serve group initiatives, which actively network with group-external actors to receive support (e.g., References [53,54]). Another type of leadership is required to coordinate these interactions between social units and actively support forerunners at various societal levels, which is the ultimate goal of transition governance processes. Initiators of transition governance processes can, therefore, use the results of the transition governance system analysis in designing an effective process. The integrated governance system analysis provides an overview of forerunners, sustainability innovations and intervention points, which allows for the tailoring of process designs to local dynamics and initiatives.

In the following section, we present an example application of the methodological framework in a case-study on sustainable food systems in Southwestern Ontario.

3. Example Application to a Case Study on Local Food Systems in Ontario

The proposed methodological framework was applied in a case study on sustainable food systems in Southwestern Ontario, Canada, comprising Bruce, Grey, Huron, Wellington and Middlesex counties, along with the area around the city of Guelph. A transition governance approach is particularly suitable for sustainable food systems, as multiple actors have to show leadership and cooperation along the value chain.

3.1. Problem and Stakeholder Analysis

Canada is in the top ten of food exporting countries (rank 7 with a US $22.4 billion total agriculture exports in 2016 [55]) and thus a key player in the global food system. Agriculture in Ontario is an important sector which is reflected in the province's lead in the number of farms in Canada [56]. Visions of a sustainable food system were collected through a literature review, as well as a survey and the organization of a visioning exercise at an organic food conference in Guelph. Participants at the conference were asked to explain their personal vision of a sustainable food system. In addition, 27 stakeholder interviews were organized. The interviews and surveys (55 surveys were completed) revealed the existence of multiple alternative visions regarding a sustainable food system: some participants envisioned a large-scale organic food production system while others stressed the importance of a localized food system including small-scale organic agriculture and urban farming (see Halbe et al. [57]). Thus, farming for self-supply, e.g., in the form of community gardens [58], could become a significant approach to develop farming skills as well as consciousness of food production. The visions were grouped in three alternative system designs for food production, namely "globalized commodity-based organic food system", "local diversified organic food system" and "urban organic gardening" [57]. In the following, the results regarding a "local diversified organic food system" are presented.

The agriculture regime in Ontario is mainly related to the large-scale, conventional type of farming. Small farms (less than 10 acres/~4 hectares) account for only 5% of the total number of farms in Ontario. Certified and non-certified organic farming remains at a niche level, representing roughly 1% and 5% of farms, respectively [59]. Data on the relevance of farming for self-supply (e.g., community gardening) is currently unavailable, as official statistics focus on commercial forms of agriculture. There are several current challenges (e.g., a changing climate), as well as likely challenges in the future (e.g., depleting resources for fossil fuel and phosphate) that could pose significant landscape challenges to the food system.

The initial stakeholder analysis was based on a desk study and a survey at the organic food conference in Guelph. Survey results pointed to several frontrunners in the field of sustainable food systems, including community gardening initiatives, actors that foster the development of more regional food systems (e.g., owners of local food stores and small scale, diversified farmers) or governmental initiatives that support newcomers to farming (e.g., FarmStart, Guelph, Ontario, Canada). Our desk research complemented the list of stakeholders by adding interest groups at the

provincial and national level (e.g., National Farmers Union, Canadian Organic Growers and Canadian Organic Food Association) and governmental agencies (e.g., Ministry of Agriculture, Food and Rural Affairs and Agriculture and Agri-Food Canada).

3.2. Participatory Modelling on Sustainable Food Systems

In September 2012, a participatory modelling process was initiated by the first author of this article, that included individual interviews with farmers, distributors and other stakeholders. Over the course of 1.5 years (until March 2014), 27 stakeholder interviews have been conducted. These interviews aimed at the analysis of alternative approaches for a sustainable food system (i.e., sustainability innovations) and their intervention points. CLDs have been built in 21 interviews, while six interviews proceeded in a more informal way without the construction of a CLD. Each CLD was analyzed with respect to learning objects and to supportive factors of learning. Figure 4 shows an example of a CLD that was constructed by an innovator in the Ontario case.

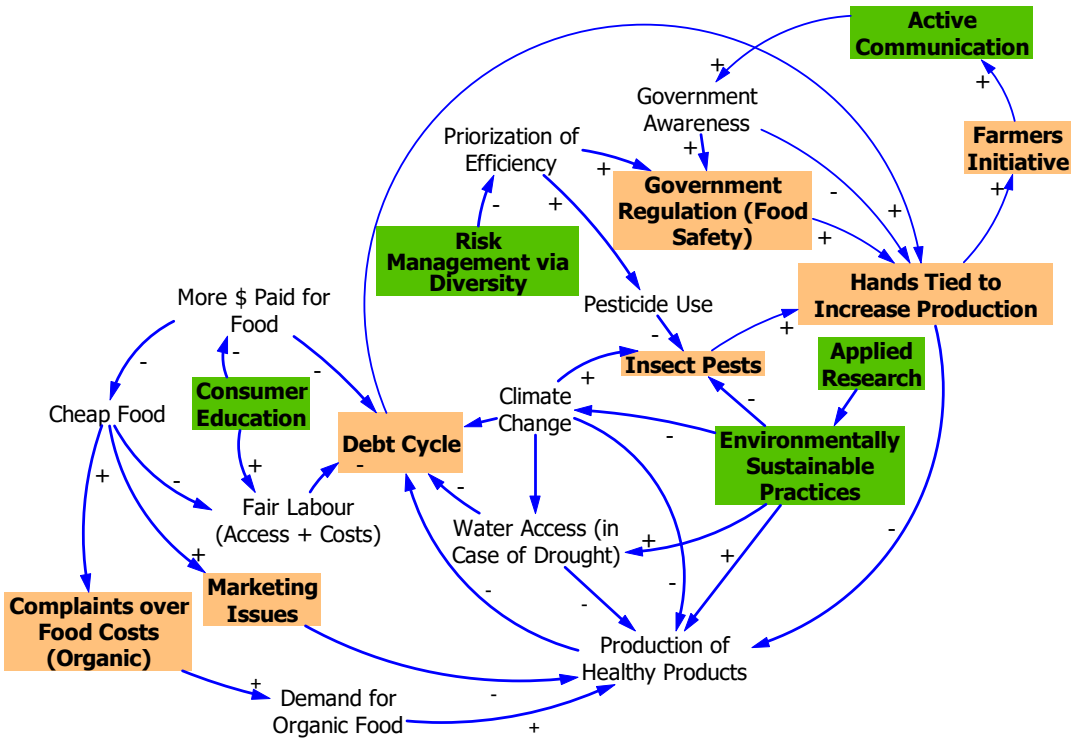

Figure 4. A causal loop diagram prepared in an individual interview with a small-scale, diversified organic farmer. The problem variables (i.e., learning objects) and potential barriers to innovation are marked in orange; the drivers of innovations (i.e., supportive factors of learning) are marked in green.

Figure 4 shows the system perspective of the interviewee, including perceived problems, barriers to innovation (orange) and drivers of innovation (green) regarding small-scale, diversified organic farming. The interviewee distributed his produces in a self-reliant way, i.e., customers were either able to pick up their ordered products on the farm site or to buy it at local farmers markets. The farmer identified several issues with regards to his farming approach, which need to be addressed in the future. First, the demand for organic produce is relatively low, as many potential customers are used to cheap food (i.e., they *complain over higher costs of organic products*). In addition, there are *marketing issues* as the farmer has to justify a higher price by convincing customers about the superior quality of his products and the sustainability of the production process (i.e., the consumer has to trust the farmer due to the absence of official certificates). *Insect pests* and tight *governmental regulations* are further factors that *tie the hands of farmers to increase production*. Due to a limited production, the danger increases of getting caught in a *debt cycle*. Several solutions were identified to address these issues. First, the farmer

proposed the *education of consumers* (in particular in their early ages) to increase the consciousness of customers about the quality of food and the production process. In addition, *applied research* needs to be accomplished to find innovative *environmentally sustainable practices* to deal with insect pests and droughts. The concept of "*risk management via diversity*" needs to be propagated to suppress the economies of the scale paradigm that runs the current regime. This can be achieved through *active communication* with the government to induce supportive regulations for the small-scale, diversified organic food sector. The lack of *farmer initiatives* is, however, found to be a potential impeding factor of active communication.

The CLD in Figure 4 shows the interconnections between prevalent sustainability issues (learning objects), solutions (supportive learning factors) and barriers (impeding learning factors). Learning objects in the CLD of Figure 4 mainly relate to a higher learning intensity, such as paradigms (economies of scale), values (customers' prioritization of cheap food) and lack of knowledge and experience of high-quality food (customers' consciousness about food quality). However, learning objects related to routine learning and reframing are also included in the CLD, such as the improvement of agricultural practices. From a leadership perspective, some intervention points can be addressed by the farmer herself/himself and thus requires self-leadership. However, other intervention points, as perceived by the interviewee, require action from other social units, such as education and research institutions (i.e., schools, or universities) or the farmer community and farmer associations (e.g., communication with the government).

3.3. Analysis of Learning Objects, Subjects, Contexts and Factors

As explained in Section 2.3, causal loop diagrams are first analyzed in order to identify case-specific learning objects, subjects, contexts and factors before learning factors from the interviews are compared to literature-based learning factors.

3.3.1. Analysis of CLDs to Identify Learning Objects, Subjects, Contexts and Factors

All learning objects, supportive factors and actor roles that have been derived from the analysis of CLDs and surveys in the Ontario case study are listed in Table 1. A crisis of conventional food systems is considered to be a supportive learning factor with regards to most learning objects, as a crisis lets people rethink the current regime and actively look for alternatives. However, other learning factors can be related to specific learning objects, as presented below.

Table 1. Stakeholder-based learning objects, supportive factors and roles for a transition towards a sustainable food system in Southwestern Ontario: Stakeholder-based learning factors are compared to literature-based learning factors (see factor identifiers in Tables S1.1–1.4). Learning factors that are not included in the list of literature-based factors are marked in green.

Learning Contexts	Learning Objects	Learning Intensity *I: Routine Learning* *II: Reframing* *III: Paradigm Change* *(Specification of Underlying Learning Object)*	Supportive/Impeding Learning Factors (Solutions/Barriers to Solutions)	Comparison to Learning Factors from Systematic Review, cf. Halbe et al. [25]	Links to Other Learning Contexts	Roles in the Implementation of Learning Factors	Endogenous (N); Exogenous (X); Ambiguous (N/X)
All			Crisis of conventional agriculture	I-1; G-1; O-1; P-1			
			Rising food demand of the world population (Imp)				
Individual Context	Consumer preferences and values (e.g., food has to be cheap and look perfect) *(Learning object no. 1)*	III (Consumer preferences and values)	Rise public attention about organic products through media (e.g., TV, papers, social media)	I-6; I-8.1	I, G, O	Farmer community; NGOs; journalists	N/X
			Lead by example (e.g., healthy diet; buy local/organic products, become active)	I-6	I	Citizens	N
			Regain connectedness to nature and place	I-2	I, G	Citizens, community groups; farmer community	N/X
			Clear labeling of food products		G, O, P	Policy-makers; farmers community	X
	Knowledge of food and agriculture *(Learning object no. 2)*	II *(Food-related knowledge to allow reframing)*	Education of consumers, esp. children and youth (e.g., about farming approaches; health impacts of diet; use of fresh produce; preservation of food)	I-10.2	I, G, O, P	Schools; parents; NGOs; farming community; Agricultural enterprise; citizens	N/X
			Spread the word about alternatives and healthy nutrition	I-10.2	I, G	Citizens; citizen groups	N
			Community gardens and urban farms as educational facilities (e.g., farming skills)	I-6	I, G, O	community groups; farmers; farmer community	X
			Translation of research findings about sustainable agriculture to the wider public	I-10.2	I, G, O, P	Researchers; public organizations; policy-maker (funding requirement)	X
	Resistance of people to take action (e.g., getting informed; develop new habits) *(Learning object no. 3)*	III (Change people's mindset with regards to taking action)	Clear goals and vision of a desirable future	I-4	I, G, O, P	Citizens; Researchers; NGOs; Public organizations; policy-makers	N/X
			Leadership of public organizations, e.g., demanding local food for cafeterias	I-6; I-9.3	O, P	Public organizations; policy-makers	X

Table 1. *Cont.*

Learning Contexts	Learning Objects	Learning Intensity *I: Routine Learning II: Reframing III: Paradigm Change (Specification of Underlying Learning Object)*	Supportive/Impeding Learning Factors (Solutions/Barriers to Solutions)	Comparison to Learning Factors from Systematic Review, cf. Halbe et al. [25]	Links to Other Learning Contexts	Roles in the Implementation of Learning Factors	Endogenous (N); Exogenous (X); Ambiguous (N/X)
Group context	Cooperation within the farmers community *(Learning object no. 4)*	III *(Change of mindset)*	Joint action that yields visible results that are helpful in the farmer's practice (e.g., famer research center; alliance to educate the public)	G-3.1; G3.4	G, O	Farmer community	N
			Programs that connect young farmers to share knowledge	G-10.1	G, O, P	Farmer community; NGOs; Public organizations	N/X
			Develop a positive reputation of local farmers (e.g., stewards of the land)	G-7.8	G, O, P	farmers; farmer community; media	N/X
	Lack of seed saving infrastructure *(Learning object no. 5)*	III *(Paradigm change from buying seeds towards seed saving)*	Regional seed saving network	G-3.1; G-3.4; G-6.4	G, O	Farmer community; NGOs	N/X
	Farming knowledge and equipment availability *(Learning object no. 6)*	III *(New cooperative paradigms for knowledge and equipment management)*	Cooperation to share equiment	G9	G, O	Farmer community; NGOs; Public organizations	N
			(Online) bridging technology for exchange and coordination	G-10.1	G, O, P	Farmer community; NGOs; Public organizations	N/X
			Farmer Research Center (Research and extension for small, diversified farms; topics: equipment; pest management)	G-10.1; G-10.2	G, O, P	Farmer community; NGOs; Public organizations; policy-maker	N
	Fertility management (group) *(Learning object no. 7)*	III *(New paradigms for Fertility management)*	Cooperation of neighbouring farms	G9	G, O	Agricultural enterprise; Farmer community	N
.	Lack of skilled labor in the agriculture sector *(Learning object no. 8)*	II *(New strategies for to find skilled labor)*	Marketing that help people to find ways to contribute to a local food system	G-6.4	I, G, O, P	Farmer community; NGOs; Public organizations; citizens;	N/X

Table 1. *Cont.*

Learning Contexts	Learning Objects	Learning Intensity *I: Routine Learning II: Reframing III: Paradigm Change (Specification of Underlying Learning Object)*	Supportive/Impeding Learning Factors (Solutions/Barriers to Solutions)	Comparison to Learning Factors from Systematic Review, cf. Halbe et al. [25]	Links to Other Learning Contexts	Roles in the Implementation of Learning Factors	Endogenous (N); Exogenous (X); Ambiguous (N/X)
Organizational context	Hart to start with farming (expensive/low revenues) *(Learning object no. 9)*	II *(Strategies to deal with start-up phase)*	Training programs for new farmers (e.g., understanding of standards; farming + business skills...)	O-16.1	G, O, P	Farmer community; NGOs; Public organizations; policy-maker (e.g., funding)	X
			Programs/Subsidies for small-scale farmers (costs of buying a farm)	O-3; O-15.1	O, P	NGOs; Public organizations; policy-maker	X
			Reduce financial risks (e.g., minimalization of production costs)	O-10.4	O	Agricultural enterprise	N
	Increase/assure customer base despite higher prices compared to conventional products *(Learning object no. 10)*	II *(New marketing strategies)*	Production of high-quality premium products for customers who accept higher prices		I, O	Agricultural enterprise, Consumers	N/X
			Develop tight connections to consumers	O-11.4	I, O	Agricultural enterprise; Consumers	N/X
			Upscaling of organics to decrease price difference		O	Agricultural enterprise	N
			Consumer education	O-16.1; O-2	I, G, O, P	Schools; parents; NGOs; farming community; Agricultural enterprise; citizens	N/X
			Willingness of Stores/Restaurants to take Produce		I, O	restaurants; retailers, customers (demand)	N/X
	Work and equipment requirements on farm *(Learning object no. 11)*	III *(New planting strategies)*	Planting of perennial crops that require less cultivation and use of equipment		O	Agricultural enterprise	N
	Fertility management (on-farm) *(Learning object no. 12)*	III *(New paradigms for fertility management)*	Integrating lifestock on farms		O	Agricultural enterprise	N
			Increase crop rotation		O	Agricultural enterprise	N
	Lack of proper distribution system for local food (accessibility for consumers needs to be increased) *(Learning object no. 13)*	III *(New strategies and paradigms for food distribution)*	Practical marketing models that improve access to local food (community-supported agriculture; small super fresh markets; farmers markets; wholesale)		I, G, O	Agricultural enterprise; Farmer community, retailers; consumers	N/X
			Programs that teach business and marketing skills	O-15.1; O-16.1	G, O, P	Farmer community; NGOs; Public organizations	X
	Lack/vanishing of regional processing facilities (e.g., abattoirs) + storage facilities *(Learning object no. 14)*	II *(New business models for regional processing facilities)*	Legislation that supports local food systems (e.g., food safety)	O-3	P	Policy-makers	X
	Limited financing opportunities *(Learning object no. 15)*	III *(New financing strategies and paradigms)*	Increased grants and microloans tailored to SC farming	O-15; O-15.1	O, P	NGOs; Public organizations; financial organization; policy-maker	X
			Community-supported agriculture		I, G, O	Agricultural enterprise; Farmer community; Citizens	N/X

Table 1. *Cont.*

Learning Contexts	Learning Objects	Learning Intensity *I: Routine Learning II: Reframing III: Paradigm Change (Specification of Underlying Learning Object)*	Supportive/Impeding Learning Factors (Solutions/Barriers to Solutions)	Comparison to Learning Factors from Systematic Review, cf. Halbe et al. [25]	Links to Other Learning Contexts	Roles in the Implementation of Learning Factors	Endogenous (N); Exogenous (X); Ambiguous (N/X)
Policy context	Availability of affordable land for farming *(Learning object no. 16)*	III *(New land planning paradigm that considers arable land)*	Rezoning of urban + suburban lands for small-scale production (e.g., through "small farm enterprise zone")	P-7; P-10.7; P-11.1	O, P	Policy-makers; urban planners	N
			Protection of agricultural land from construction into residential areas	P-7; P-11.1	O, P	Policy-makers; urban planners	N
			Land planning by landscape design to achieve productive ecosystems that do only require limited external input	P-16.2	O, P	Policy-makers; urban planners; landscape designers, researchers	N/X
	Power of regime actors from conventional agriculture (with respect to distribution infrastructure, legislation, funding opportunities) that constrain niches, such as local food systems *(Learning object no. 17)*	III *(New power structures that involve local, organic food actors)*	Government subsidies to diversified, organic farmers (esp. young farmers; help with transition towards organic; land purchase) or payments for ecosystem services	P-7; P-10.7; P-11.1	P	Policy-makers	N
			Subsidization of organic food	P-7; P-11.1	P	Policy-makers	N
			Organizations that lobby for local, organic food	P-12.6	G, O	Farmers community; NGOs	X
			Legislation that supports small scale, organic farming (e.g., quota exemptions; on-farm housing regulation)	P-7; P-10.7; P-11.1	P	Policy-makers	N
			Practice democracy: Vote for people who support sustainable agriculture; write to representative (e.g., ministers)	P-2	I, G	Citizens; citizen groups	X
	Lack of research regarding local food systems, as research/funding is more focusing on conventional agriculture *(Learning object no. 18)*	II *(Reframing of research agenda)*	Research on organic, small-scale farming/local food systems (potential research topics: fertility management; processing/distribution infrastructure; pest management; risk management)	P-7; P-10.7; P-11.1; P-16	G, O, P	Researchers; Farmers community; NGOs; Public organizations; policy-maker (funding)	N/X
	Integration of knowledge and management levels to find best practices for specific locations *(Learning object no. 19)*	II *(Integration of frames towards an encompassing frame)*	Integrated assessment of solutions (e.g., combination of conventional andorganic systems to utilize both advantages)	P-16.2; P-10.7	G, O, P	Researchers; NGOs; Public organizations; Farmer community; policy-maker (funding)	N/X
			university research on sustainable agriculture (e.g., on soil fertility, distribution systems; water use)	P-16	G, O, P	Researchers; policy-maker (funding); Farmer community;	N/X
	Lack of dialogue between regime (conventional agriculture) and niche actors (e.g., organic, local agriculture) *(Learning object no. 20)*	III *(Acceptance of alternative worldviews and willingness to start dialogue)*	Research on (a mix of) alternative farming approaches and education of farmers	P-7; P-16.1; P-10.7	G, O, P	Researchers; NGOs; Public organizations, policy-maker (funding); Farmer community;	N/X
			Knowledge sharing between countries	P-9.6	G, O, P	Researchers; NGOs; Public organizations; policy-maker (funding); Farmer community	N/X

The individual learning context (i.e., learning objects are related to individuals) deals with improving the consumer awareness for local and organic food. Contemporary *consumer preferences and values* (learning object #1) focusing on the price of products (i.e., food has to be cheap) and its outer appearance (products have to look perfect) have been determined to constrain the development of a sustainable food system. Interviewees found that consumers need to acknowledge the benefits of a regional and organic food system in order to develop the willingness for paying higher prices. Various factors have been proposed to address this issue, such as rising public attention through the media, clear labelling of food (e.g., local food labels) as well as actions that support people to regain connectedness to nature and place. Interviewees complained about a general lack of *knowledge with respect to food and agriculture* (learning object #2) that can be addressed through consumer education, active communication of alternative farming approaches and healthy nutrition as well as translation of research findings into a generally understandable wording. Another related issue is the *resistance of people to take action (e.g., getting informed and developing new habits)* (learning object #3). Stakeholders proposed to develop a clear vision of a desirable future as well as demanded leadership of public organizations (e.g., by offering local food in cafeterias).

The group learning context (i.e., learning objects are related to groups) contains the issue of lacking *cooperation within the farmers' community*, due to a more individualistic lifestyle of farmers (learning object #4). Cooperation can gain momentum through actions that offer visible results and tangible benefits for farming. A farmer community research center or an alliance to educate the public have been mentioned as potential starting points to initiate and coordinate joint actions within the farmer community. In addition, programs that connect young farmers are seen as critical intervention points. A number of specific options for cooperation have been proposed, such as exchange networks for *seeds* (learning object #5), *knowledge, equipment* (learning object #6) and *fertilizers* (learning object #7). The lack of *skilled labor* (learning object #8) can be tackled through a marketing and information platform (e.g., an online platform) to help people to find ways to contribute to a local food system, which can be implemented in a group effort. The aforementioned activities are sorted to the group learning context, as a local food system bases upon a more personal exchange between farmers (organizational actors) and other stakeholders (e.g., consumers).

Most of the objects of learning are related to the context of a farming business and thus were sorted to the organizational learning context. First, *starting a new farming business* in the organic/local food sector is challenging due to high costs and initially low revenues (learning object #9). Stakeholders suggest special programs or subsidies for diversified, organic farmers to bear the costs of buying a farm or to transition to organic. Another issue is related to the need to *increase the customer base despite higher prices compared to conventional products* (learning object #10). This can be achieved by producing high-quality premium products for customers who accept higher prices. Active consumer education (e.g., by information campaigns) is another complementary solution to inform customers about the production process and particular quality of products. The planting of perennial crops was suggested to lower *work and equipment requirements* on a farm (learning object #11). *On-farm fertility management* (learning object #12) can be addressed by integrating livestock or increase crop rotation. The lacking *food distribution infrastructure* (learning object #13) is a major problem of local food systems. Stakeholders propose the application and improvement of practical marketing models that provide access to local food, such as community supported agriculture (CSA), super fresh markets, farmers markets or wholesalers that offer local food. There is also a lack of *regional storage and processing facilities* (e.g., abattoirs) (learning object #14), which require the strengthening of local food production as well as specific regulations that are adapted to smaller facilities. Interviewees pointed to limited *financing opportunities* (learning object #15), which require more opportunities for grants and microloans tailored to small-scale farming.

In the policy learning context (i.e., learning objects are related to policy actors), current land planning policies are mentioned as an issue, as they reduce the *availability of affordable land* (learning object #16) due to the proliferation of residential areas and land speculation. Some stakeholders

demanded the rezoning of urban/suburban lands for small-scale production (e.g., designating a "small farm enterprise zone"). Another important issue was mentioned to be the contemporary *power of the conventional agriculture regime* which is reflected in legislation, standards, infrastructure and funding opportunities (learning object #17). The establishment of lobbying organizations for local food systems can contribute toward the broadening of this focus by pointing to the importance and (synergetic) benefits of local/organic food systems. This can result in the development of specific regulations for small scale farmers (e.g., with respect to safety management or quotas) as well as subsidies for local/organic agriculture and products. As a consequence of the contemporary regime power, stakeholders demand more *research on local food systems* (research funding is currently more focusing on conventional agriculture) (learning object #18). A further key issue was mentioned to be the *integration of knowledge* to find the best practices for specific locations (learning object #19). University research on local/organic food systems (e.g., on soil fertility, distribution systems or water use) can play a key role in solving this issue. In addition, integrated assessments of sustainable agriculture and food systems, which also consider the possible synergies between local and international food systems, is proposed by stakeholders. This is impeded by a lack of *dialogue between regime* (conventional agriculture) *and niche actors* (e.g., organic, local agriculture) (learning object #20), which could be addressed through integrated research as well as the identification of the best practices between countries (i.e., best practices that demonstrate the benefits of integrated food systems).

3.3.2. Comparative Analysis of General and Case-Specific Learning Factors

The comparison of learning factors from the stakeholder interviews (see Table 1) and learning factors from the literature review (see Table S1 and Halbe et al. [25]) reveals several coincidences as well as complementarities. In the following section, factor identifiers are provided, which can be related to literature-based learning factors in Table S1. The capital letter stands for individual (I), group (G), organizational (O) and policy (P) learning context; the factors are grouped into factor categories (first number) and subcategories (second number) (see Table S1).

Most of the stakeholder-based factors can also be found in the literature-based factors (cf. Table S1). For instance, stakeholder and literature-based factors comply that a drastic crisis in society (I-1, G-1, O-1 and P-1) is a key factor to weaken the current regime and support the development of alternatives. Given the tendency of destabilizing landscape pressures to rise (e.g., climate change and depletion of fossil fuels and phosphate), pressure on the political system might increase in the future as well as the willingness of regime actors to consider alternative approaches. Physical resources (I-9, G-9, O-15 and P-15), information and knowledge (I-10, G-10, O-16, and P-16) are also found to be relevant in all learning contexts. From the 50 stakeholder-based factors, only 9 factors are not contained in the general, literature-based factor list. These factors are specific for the study topic, such as community supported agriculture as a specific financing and distribution approach. This underlines the value of participatory research, as general, top-down analyses might have overlooked these case- and topic-specific factors.

With respect to the individual learning context, environmental values (I-2) are considered as important in the development of a local food system according to case study and review results, as people have to regain connectedness to nature and place. Further compliant factors are a clear vision of the future (I-4) and inspirations by others (I-6), for instance through role models that lead by example or TV shows about local food. Interactive concepts are another supportive factor (I-8.1), which can be achieved by using the internet. Public organizations can furthermore support individual learning (I-9.3), for instance, by actively promoting local food in their cafeterias. Finally, knowledge exchange is another compliant factor in case study and review results (I-10.2), which might be achieved by citizens who actively communicate about healthy nutrition in everyday lives (i.e., "spread the word") or by parents and teachers who educate children. However, the list of factors from the literature review point to gaps and further important aspects that can influence individual learning objects. First, educational efforts (e.g., from schools or citizen groups) should use simple and honest messages

without a bargaining mentality attached (I-8.1) and should require continuous observation, evaluation and reflection of the process and its outcomes (I-7.2). Second, campaigns should highlight relative advantages as well as compatibility to current consumer practices in order to reach a broader customer base (I-3).

In the group learning context, consistent stakeholder and literature-based factors underline the relevance of tangible community actions (G-3.1) (e.g., exchange of seeds) that address urgent problems (G-3.4) (e.g., lack of locally-adapted plants). Some activities also require active networking with group-external actors (G-6.4), such as a seed-saving networks or marketing activities to attract skilled workers. A clear and inspiring future vision is a further important factor (G-7.8). Further case study results point to the relevance of measures for exchanging physical resources (e.g., farming equipment) (G-9) and knowledge (e.g., education programs for young farmers) (G-10.1). Knowledge integration is another compliant factor (e.g., connect scientific findings with experiential knowledge through a famer-led research center) (G-10.2). Several learning factors from the literature review were not mentioned in the case study results. In the following, we present only some examples of promising learning factors that should be considered in the design of effective group learning processes. The complexity of joint actions and experiments should remain manageable in order to have time and resources to reflect on the social aspects of the process as well, such as potential conflicts and group dynamics (G-5.2). A continuous process monitoring and evaluation should furthermore be conducted (G-7.1) to select the viable from less viable solutions (G-5.1). A purposeful stakeholder selection (G-6.1) and design of an involvement strategy (G-6.2) are further important supportive factors.

In the organizational learning context, compliant factors include a societal appreciation of sustainable products (O-2), a supportive institutional context (e.g., regulations tailored to local food systems) (O-3) and networking skills to cooperate with actors along the value chain (O-11.4). In addition, low regret experiments (O-10.4) that only imply a low financial risk are mentioned as a supportive factor. Further compliant factors are related to programs that provide resources (O-15 and O-15.1) to local/organic food systems (e.g., subsidies or funding of education programs) and support knowledge exchange (O-16.1) between farms as well as other actors in the food system. However, the literature review revealed a number of further factors that were not mentioned in the interviews and questionnaires. Thus, a supportive factor suggests the consideration of capability and expertise in choosing potential innovations (O-6.2) and the ability of being open towards different solutions (O-10.1). A number of additional factors are related to a purposeful design of participatory processes within organizations, such as aligning the process and solution strategies towards opportunities in the landscape (O-12.3) rather than sticking to ideal solutions. This can also involve the active exploration of experiences in other countries through networking organizations (O-12.6). An overarching vision of a local food system (O-13.5) can be helpful to guide activities within and across organizations.

In the policy learning context, stakeholder and literature-based learning factors consider a change of government as a potentially supportive factor for policy learning (P-2). In addition, results comply with respect to a visionary leadership by policy-makers (P-7) that considers the benefits of local/organic food. An important role is, furthermore, seen for networks that connect local with (inter-) national lobbying efforts to share experiences (P-9.6). The implementation of supportive contextual factors (P-11.1) is important to foster the development of local food systems (e.g., through tailored legislation, subsidies or land planning). This requires the acknowledgement of diversity in food systems (e.g., a mix of local and international food systems) (P-10.7). Knowledge exchange and integration (P-16.1; P-16.2) is also seen as pivotal, for instance, to allow for integrated land planning and integrated assessment of measures. Governments can, furthermore, provide resources to research and initiatives in the local food system (P-15.1). Case study results also confirm some impeding factors, such as the dominance of a command-and-control approach (e.g., with respect to food safety) (P-10.4) and lock-in effects due to encrusted power structures (P-10.5). The literature review adds further potentially important factors to this list. The existence and active involvement of frontrunners in the case study region can support policy learning (P -8). Policy entrepreneurs could also play a key role in fostering

local/organic food (P-10.1). Transdisciplinary research processes (P-11.4) can support the integration of knowledge and the achievement of tangible outcomes. Public involvement programs require a neutral party for process design and facilitation (P-12.1), which actively addresses power asymmetries (P-13.4). Participatory policy processes also require a long-term continuation and institutionalization (P-13.12), for instance by actively fostering capacity building (P-10.6).

For each learning factor, the susceptibility to purposeful change has been rated on an ordinal scale from endogenous (i.e., the factor can be directly influenced by learning processes within the respective context) to ambiguous (i.e., susceptibility unclear) and exogenous (i.e., factor cannot be influenced) (see Table 1). Intervention points are factors that can be addressed in a transition governance process. Hence, exogenous factors are excluded from the subsequent integrated governance system analysis. The following section describes the analysis and design of a transition governance process in the Ontario case study.

3.4. Integrated Governance System Analysis

The various linkages between learning contexts, as revealed in the previous analysis, have to be considered in the initiation and design of transition governance processes. The results of the governance system analysis are presented below, distinguishing between two different levels of analysis (cf. Section 2.3): (1) at an overall systems level to specify the interactions across learning contexts (Figure 5A) and (2) at a more detailed context-specific level to define action situations within learning contexts (Figure 5B).

The structural inter-context analysis results in an overview of learning contexts and their linkages, as depicted in Figure 5A. The action situation in the individual learning context is named "*consumer awareness and engagement*" and comprises learning objects #1–#3. Consumer awareness and engagement can be actively facilitated by individuals, such as citizens (e.g., lead by example) and parents (e.g., teach the importance of healthy food to their children). However, the other learning contexts also play an important role. Thus, policy actors can foster a clear labelling of local/organic food, offer local/organic food in public cafeterias and demand a translation of research findings from projects that are funded by public funds. In addition, actors from the local food system can contribute by engaging consumers (e.g., through a CSA model) and bringing agriculture to people (e.g., through urban farms). In this respect, community gardens run by citizen groups can also be an important element. The group learning context addresses the overall learning object of "*cooperation within the local food system*", which comprises learning objects #4–#8. Learning in the group context can be supported by consumer awareness and engagement (individual learning context); local food infrastructure (organizational learning context); as well as general physical infrastructure (including cyber infrastructure), regulations, payment schemes and research/training programs (policy learning). The organizational learning context addresses "*supply of local/organic food*" and includes learning objects #9–15. The organizational learning context can be influenced by a supportive legislation, subsidies and applied research projects from the policy learning context. Learning in this context is, furthermore, supported by a cooperative mind-set of actors in the local food system as well as infrastructure (which depends upon the cooperation of food system actors as well as the availability of sufficient supply). Finally, the policy learning context addresses the overall learning object of "*setting an enabling context for local/organic food systems*", which comprises more specific learning objects (i.e., learning objects #16–20). Policy learning can be fostered by outcomes from the individual learning context, including consumer knowledge and preferences that could lead to pressure on the political system to take action (e.g., by an increasing number of voters that are interested in food topics). Lobbying organizations from the group learning context can also support policy learning.

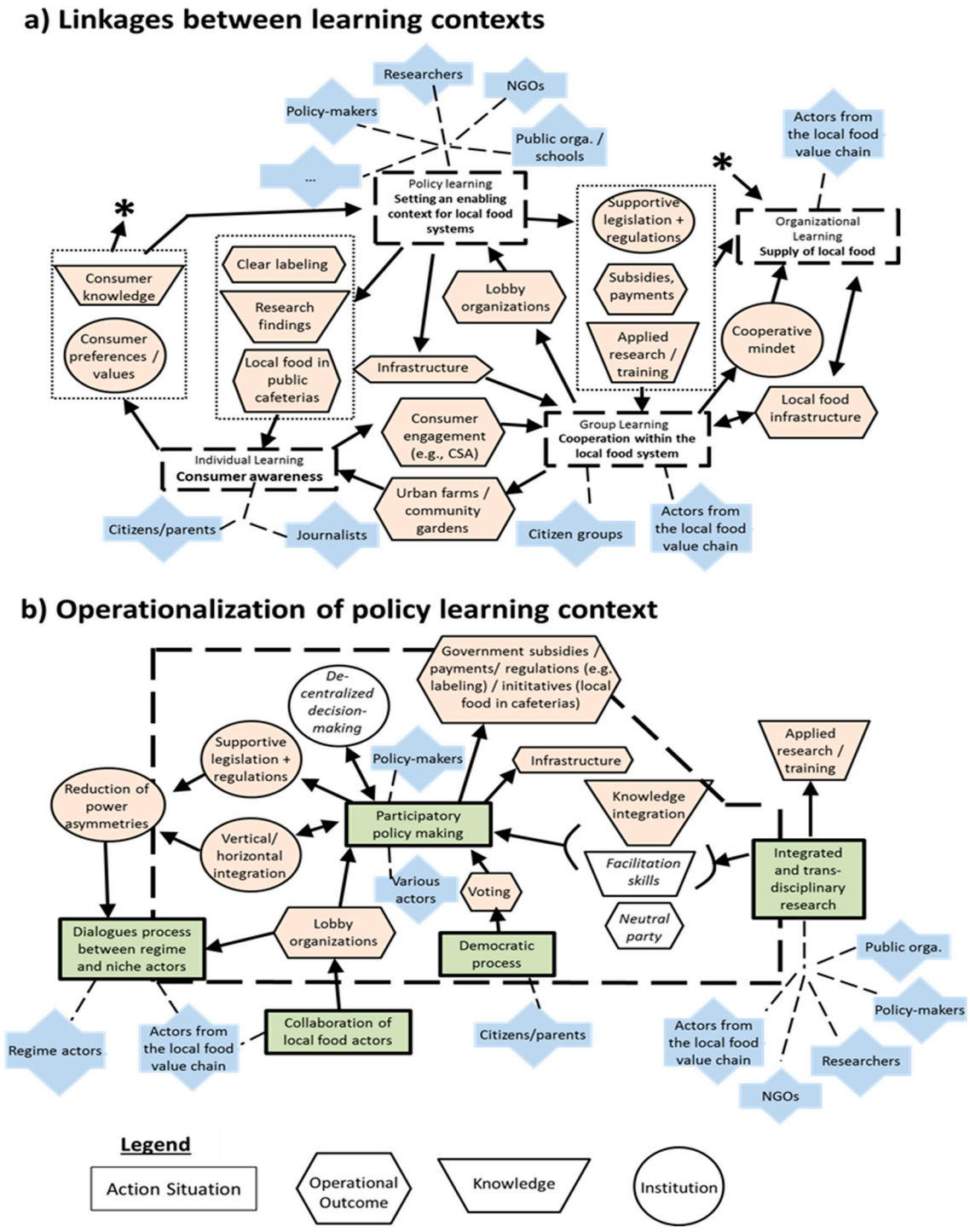

Figure 5. A visualization of the transition governance process design from an overall systems point of view (i.e., overall inter-context analysis, cf. Figure 3A) and a context-internal perceive (i.e., detailed intra-context analysis, cf. Figure 3B). Orange-colored elements are derived from case study research, while white-colored elements stem from the general literature review.

Figure 5B shows a structural intra-context analysis for the policy learning context. Specific action situations are identified for each learning object. Thus, a participatory policy-making process is required to tailor subsidies, payment schemes, land planning and infrastructure investments to local food systems. Supportive legislation and regulations as well as vertical/horizontal integration can reduce power asymmetries and thereby foster a dialogue between regime and niche actors. The

democratic process is another action situation within the policy context that allows citizens to influence the policy process (e.g., voting for policy-makers that favor local food systems). Some action situations are located at the border of the policy learning context to express that these action situations also include external actors. For instance, the interaction process of integrated and transdisciplinary research has an integral function by bringing actors from different learning contexts together. These "inter-context action situations" can support participatory policy making, e.g., through integrated and transdisciplinary research (e.g., to provide facilitation skills) or more informal dialogues between regime and niche actors.

4. Discussion

The presented methodological framework guided a case-specific analysis of multiple intervention points and actor roles to support the implementation of sustainability innovations. The learning perspective allowed for the specification of objects, processes and supportive factors of learning, as well as social units that have the ability to implement learning factors. Therefore, the integrated governance system analysis highlights opportunities for proactive engagement and the necessity of collaboration of multiple actors (ranging from consumers to producers and policy-makers). Based upon this "big picture", initiators of transition governance processes can purposefully select forerunners and initiatives in a particular place. Irrespective of whether initiators belong to the policy, organizational, group or individual learning contexts, the integrated governance system analysis shows opportunities to support sustainability transitions within a learning context (i.e., intra-context analysis) as well as requirements for cooperation with other social units (i.e., inter-context analysis). Thus, transition governance processes can be initiated from any societal level (i.e., individuals, groups, organizations and policy-actors) and develop towards a multilevel learning process by considering the requirements for cooperation and coordination.

The application of the methodological framework does not result in simple solution strategies to initiate sustainability transitions. Instead of providing a small number of actors with power and responsibility to lead the process, the methodological framework reveals multiple practical starting points and actor roles. Thus, this methodological framework is a promising approach to broaden the perspective from singular engagement processes towards transition governance processes that build upon broader societal engagement and distributed leadership. The implementation of endogenous learning factors points to the requirements for *self-leadership* within social units (see Section 2.4). As an example, consumers can lead by example by following a healthy diet or buying local food products. The relatively low share of endogenous learning factors (individual context: 20%; group context: 33%; organizational context: 31%; policy context: 38%, see Table 1) in the case study results however underline the need for *shared leadership* that addresses interactions between individual, group, organizational and policy contexts (cf. Reference [4]). As an example, the labeling of food products would allow consumers to make more conscious decisions, but the implementation of meaningful food labels depends upon other social units. *Transformational leadership* extends the perspective on social units and its interactions towards a network governance approach, which also consider place-based dynamics and initiatives (cf. Sotarauta et al. [60]). Actors from various contexts can assume this kind of leadership through the organization of transition governance processes that systematically facilitate and coordinate existing initiatives and set new impulses through purposeful action.

Several success factors from the literature review were congruent to factors identified by stakeholders in the case study on sustainable food systems in Southwestern Ontario. Various literature-based factors complement the list of stakeholder-based factors, and vice versa. Thus, stakeholder knowledge was substantiated through scientific knowledge on the one hand and complemented by findings from the scientific literature on the other. The methodological framework presented in this article supports a collaborative research process of citizens, farmers, policy-makers, university scholars and other societal actors. The farmer research center proposed by stakeholders in the Ontario case underlines a trend towards a rising engagement of non-scientists in research

(cf. Reference [61]). This trend is reflected in the recent development of participatory research concepts including citizen science, crowdsourcing and transdisciplinary research, which enables the participation of non-scientists in all research phases [62].

The collection of learning factors from the systematic literature review needs to be tested and verified through further research in the future. Up to now, studies are lacking that are explicit about the contexts, processes, objects and supportive factors of learning (cf. Hand [63]). Methodologies are needed to systematically analyze the context of transition governance processes, monitor the process and evaluate the outcomes [64]. The approach for integrated governance system analysis presented in this article supports such an analysis of learning processes and their outcomes and allows for the identification of general success factors through the comparison of multiple case studies.

While the analysis of the governance system was focusing on the linkages between action situations (see Figure 5), the transition governance process can also be analyzed through time (see References [15,26] for temporal analyses of a transition processes). In addition, more research is required on assessing stakeholder visions in order to test the plausibility and sustainability benefits of visions. While the research presented in this paper focused on governing the process of transformation, a sustainability assessment of visions (i.e., assessing the sustainability benefits of visions) is required to analyze the interactions of different system designs (e.g., between local and global food systems) [65]. Research on assessing sustainability visions of stakeholders through integrated modelling is at an initial stage (e.g., References [65,66]) and requires innovative approaches to handle complexity, data limitations and ambiguity.

5. Conclusions

Transition governance approaches are expected to play an important role in dealing with the complexity of global change and achieving a societal transition towards sustainable development. This article presented a methodological framework supporting the initiation and design of case-specific transition governance processes. The methodological framework bases upon a conceptualization of sustainability transition processes as multilevel learning processes that include learning objects (What needs to change?), contexts and subjects (Who needs to become active?) and learning processes and factors (How can learning be actively supported?). The methodological framework is comprised of four steps: In the first step, existing frontrunners and sustainability innovations are analyzed for a particular transition topic. Second, a participatory modeling process is conducted to examine case-specific learning factors. Third, stakeholder-based and literature-based learning factors are compared and synthesized. Fourth, interactions between learning contexts are analyzed using integrated governance system analysis.

An example application of the methodological framework was provided to a case study on sustainable food systems in Southwestern Ontario, Canada. The comparison of factors from literature research and participatory modeling, on the one hand, showed conformity of several factors, and, on the other hand, revealed the ability of literature-based factors to complement factors derived from stakeholder interviews. In addition, a number of learning factors were identified that were not reported in the literature, which shows the benefit of combining a participatory method with an expert-based approach (i.e., a systematic literature review). The results from the case study, furthermore, demonstrate the ability of the methodological framework to support the initiation and design of case-specific transition governance processes by identifying multiple entry points for interventions and the roles of several actors across societal levels. Some intervention points can be implemented within a particular learning context (e.g., an individual who considers sustainability aspects in her/his consumption behavior). However, most intervention points link learning contexts and thus require cooperation between social units (e.g., organizations might be urged to invest in more sustainable production technologies due to changing consumer values). Thus, the methodological framework points to (1) specific opportunities for different social units to assume the leadership in a self-reliant way (including individuals, groups, organizations and policy actors) as well as (2) the

importance of shared leadership to address intervention points that link learning contexts. The methodological framework also supports (3) the assumption of transformative leadership by helping to initiate and design transition governance processes that facilitate and coordinate existing place-based initiatives and set new impulses through purposeful action.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/11/3/844/s1, Table S1: Detailed results from literature review [25] (Table S1.1: Individual learning context; Table S1.2: Group learning context; Table S1.3: Organizational learning context; Table S1.4: Policy learning context).

Author Contributions: Conceptualization, J.H. and C.P.-W.; methodology, J.H.; formal analysis, J.H.; investigation, J.H.; resources, J.H. and C.P.-W.; data curation, J.H.; writing—original draft preparation, J.H.; writing—review and editing, J.H. and C.P.-W.; visualization, J.H.; supervision, C.P.-W.; funding acquisition, J.H. and C.P.-W.

Funding: The case study research was financially supported by an Agriculture and Agri-Food Canada Grant (grant number: 299548-KTT) from the Ontario Ministry for Agriculture, Food and Rural Affairs (OMAFRA) held by Khosrow Farahbakhsh and Jan Adamowski.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Adomßent, M. Exploring universities' transformative potential for sustainability-bound learning in changing landscapes of knowledge communication. *J. Clean. Prod.* **2013**, *49*, 11–24. [CrossRef]
2. Pahl-Wostl, C. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Glob. Environ. Chang.* **2009**, *19*, 354–365. [CrossRef]
3. Ardoin, N.M.; Gould, R.K.; Kelsey, E.; Fielding-Singh, P. Collaborative and transformational leadership in the environmental realm. *J. Environ. Policy Plan.* **2015**, *17*, 360–380. [CrossRef]
4. Sotarauta, M. Shared Leadership and Dynamic Capabilities in Regional Development. In *Regionalism Contested: Institution, Society and Governance*; Urban and Regional Planning and Development Series; Sagan, I., Halkier, H., Eds.; Ashgate: Cornwall, UK, 2005; pp. 53–72.
5. Mayntz, R. Governance Theory als fortentwickelte Steuerungstheorie? MPIfG Working Paper 04/1. 2004. Available online: http://www.mpifg.de/pu/workpap/wp04-1/wp04-1.html (accessed on 14 December 2015).
6. Voß, J.-P.; Kemp, R. Sustainability and reflexive governance: Introduction. In *Reflexive Governance for Sustainable Development*; Voss, J.-P., Bauknecht, D., Kemp, R., Eds.; Edward Elgar Publishing: Cheltenham, UK, 2006; pp. 3–28.
7. Lee, K.N. Appraising adaptive management. *Conserv. Ecol.* **1999**, *3*, 3. [CrossRef]
8. Berkes, F.; Colding, J.; Folke, C. *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*; Cambridge University Press: Cambridge, UK, 2002.
9. Pahl-Wost, C. The implications of complexity for integrated resources management. *Environ. Model. Softw.* **2007**, *22*, 561–569. [CrossRef]
10. Kemp, R.; Loorbach, D. Transition management: A reflexive governance approach. In *Reflexive Governance for Sustainable Development*; Voss, J., Bauknecht, D., Kemp, R., Eds.; Edward Elgar Publishing: Cheltenham, UK, 2006.
11. Voß, J.P.; Bornemann, B. The politics of reflexive governance: Challenges for designing adaptive management and transition management. *Ecol. Soc.* **2011**, *16*, 9. [CrossRef]
12. Loorbach, D. *Transition Management: New Mode of Governance for Sustainable Development*; International Books: Utrecht, The Netherlands, 2007.
13. Foxon, T.J.; Stringer, L.C.; Reed, M.S. Comparing adaptive management and transition management. *ÖkologischesWirtschaften* **2008**, *2*, 20–22. [CrossRef]
14. Foxon, T.J.; Reed, M.S.; Stringer, L.C. Governing long-term social-ecological change: What can the adaptive management and transition management approaches learn from each other? *Environ. Policy Gov.* **2009**, *19*, 3–20. [CrossRef]
15. Halbe, J. Governance of Transformations towards Sustainable Development—Facilitating Multi-Level Learning Processes for Water, Food and Energy Supply. Ph.D. Thesis, University of Osnabrück, Osnabrück, Germany, 2016.

16. Stringer, L.C.; Dougill, A.J.; Fraser, E.; Hubacek, K.; Prell, C.; Reed, M.S. Unpacking "participation" in the adaptive management of social–ecological systems: A critical review. *Ecol. Soc.* **2006**, *11*, 39. [CrossRef]
17. Halbe, J.; Pahl-Wostl, C.; Adamowski, J. A methodological framework to support the initiation, design and institutionalization of participatory modeling processes in water resources management. *J. Hydrol.* **2018**, *556*, 701–716. [CrossRef]
18. Shove, E.; Walker, G. Commentary. CAUTION! Transitions ahead: Politics, practice, and sustainable transition management. *Environ. Plan. A* **2007**, *39*, 763–770. [CrossRef]
19. Roorda, C.; Wittmayer, J.; Henneman, P.; Steenbergen, F.; van Frantzeskaki, N.; Loorbach, D. *Transition Management in the Urban Context: Guidance Manual*; DRIFT, Erasmus University Rotterdam: Rotterdam, The Netherlands, 2014.
20. Wolfram, M. Conceptualizing urban transformative capacity: A framework for research and policy. *Cities* **2016**, *51*, 121–130. [CrossRef]
21. Rijke, J.; Farrelly, M.; Brown, R.; Zevenbergen, C. Configuring transformative governance to enhance resilient urban water systems. *Environ. Sci. Policy* **2013**, *25*, 62–72. [CrossRef]
22. Wolfram, M. Urban planning and transition management: Rationalities, instruments and dialectics. In *Co-Creating Sustainable Urban Futures*; Springer: Cham, Switzerland, 2018; pp. 103–125.
23. Halbe, J.; Pahl-Wostl, C.; Lange, M.A.; Velonis, C. Governance of transitions towards sustainable development—The water–energy–food nexus in Cyprus. *Water Int.* **2015**, *40*, 877–894. [CrossRef]
24. Rogers, E.M. *Diffusion of Innovations*, 5th ed.; Free Press: New York, NY, USA, 1995.
25. Halbe, J.; Pahl-Wostl, C.; Scholz, G.; Thomsen, H.; Vincke-de Kruijf, J.; Scheidewind, U. Learning in the governance of sustainability transitions—A systematic review. In *Governance of Transformations towards Sustainable Development—Facilitating Multi-Level Learning Processes for Water, Food and Energy Supply*; PhD Thesis; Halbe, J., Ed.; University of Osnabrück: Osnabrück, Germany, 2016.
26. Halbe, J.; Pahl-Wostl, C.; Sendzimir, J.; Adamowski, J. Towards adaptive and integrated management paradigms to meet the challenges of water governance. *Water Sci. Technol.* **2013**, *67*, 2651–2660. [CrossRef] [PubMed]
27. Holtz, G. Modelling transitions: An appraisal of experiences and suggestions for research. *Environ. Innov. Soc. Transit.* **2011**, *1*, 167–186. [CrossRef]
28. Geels, F.W. Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Res. Policy* **2002**, *31*, 1257–1274. [CrossRef]
29. Geels, F.W. The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environ. Innov. Soc. Trans.* **2011**, *1*, 24–40. [CrossRef]
30. Auvinen, H.; Ruutu, S.; Tuominen, A.; Ahlqvist, T.; Oksanen, J. Process supporting strategic decision-making in systemic transitions. *Technol. Forecast. Soc. Chang.* **2015**, *94*, 97–114. [CrossRef]
31. Geels, F.W. Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technol. Forecast. Soc. Chang.* **2005**, *72*, 681–696. [CrossRef]
32. Broto, V.C.; Glendinning, S.; Dewberry, E.; Walsh, C.; Powell, M. What can we learn about transitions for sustainability from infrastructure shocks? *Technol. Forecast. Soc. Chang.* **2014**, *84*, 186–196. [CrossRef]
33. Halbe, J.; Ruutu, S. Use of participatory modeling in transition governance processes. In Proceedings of the International Sustainability Transitions Conference 2015, Brighton, UK, 25–28 August 2015.
34. Videira, N.; Schneider, F.; Sekulova, F.; Kallis, G. Improving understanding on degrowth pathways: An exploratory study using collaborative causal models. *Futures* **2014**, *55*, 58–77. [CrossRef]
35. Inam, A.; Adamowski, J.; Halbe, J.; Prasher, S. Using causal loop diagrams for the initialization of stakeholder engagement in soil salinity management in agricultural watersheds in developing countries: A case study in the Rechna Doab watershed, Pakistan. *J. Environ. Manag.* **2015**, *152*, 251–267. [CrossRef] [PubMed]
36. Vennix, J. *Group Model Building—Facilitating Team Learning Using System Dynamics*; Wiley & Sons: New York, NY, USA, 1996.
37. Reed, M.S.; Podesta, G.; Fazey, I.; Geeson, N.; Hessel, R.; Hubacek, K.; Letson, D.; Nainggolan, D.; Prell, C.; Rickenbach, M.G.; et al. Combining analytical frameworks to assess livelihood vulnerability to climate change and analyse adaptation options. *Ecol. Econ.* **2013**, *94*, 66–77. [CrossRef]
38. Pahl-Wostl, C.; Holtz, G.; Kastens, B.; Knieper, C. Analysing complex water governance regimes: The management and transition framework. *Environ. Sci. Policy* **2010**, *13*, 571–581. [CrossRef]
39. Ostrom, E. *Understanding Institutional Diversity*; Princeton University Press: Princeton, NJ, USA, 2005.

40. Sendzimir, J.; Flachner, Z.; Pahl-Wostl, C.; Knieper, C. Stalled regime transition in the upper Tisza River Basin: The dynamics of linked action situations. *Environ. Sci. Policy* **2010**, *13*, 604–619. [CrossRef]
41. Schlüter, M.; Hirsch, D.; Pahl-Wostl, C. Coping with change: Responses of the Uzbek water management regime to socio-economic transition and global change. *Environ. Sci. Policy* **2010**, *13*, 620–636. [CrossRef]
42. Knüppe, K.; Pahl-Wostl, C. A Framework for the Analysis of Governance Structures Applying to Groundwater Resources and the Requirements for the Sustainable Management of Associated Ecosystem Services. *Water Resour. Manag.* **2011**, *25*, 3387–3411. [CrossRef]
43. Halbe, J.; Knüppe, K.; Knieper, C.; Pahl-Wostl, C. Towards an integrated flood management approach to address trade-offs between ecosystem services: Insights from the Dutch and German Rhine, Hungarian Tisza, and Chinese Yangtze basins. *J. Hydrol.* **2018**, *559*, 984–994. [CrossRef]
44. Stewart, G.L.; Courtright, S.H.; Manz, C.C. Self-leadership: A multilevel review. *J. Manag.* **2011**, *37*, 185–222. [CrossRef]
45. Murray, P. Leading by design: Cultivating self-leadership for sustainability. In *Motivating Change: Sustainable Design and Behaviour in the Built Environment*; Routledge: Abingdon-on-Thames, UK, 2013.
46. De Souza, G.; Klein, H.J. Emergent leadership in the group goal-setting process. *Small Group Res.* **1995**, *26*, 475–496. [CrossRef]
47. Metcalf, L.; Benn, S. Leadership for sustainability: An evolution of leadership ability. *J. Bus. Ethics* **2013**, *112*, 369–384. [CrossRef]
48. Hollander, E.P.; Offermann, L.R. Power and leadership in organizations: Relationships in transition. *Am. Psychol.* **1990**, *45*, 179. [CrossRef]
49. Storey, J. Changing theories of leadership and leadership development. In *Leadership in Organizations*; Routledge: Abingdon-on-Thames, UK, 2016.
50. Oborn, E.; Barrett, M.; Dawson, S. Distributed leadership in policy formulation: A sociomaterial perspective. *Organ. Stud.* **2013**, *34*, 253–276. [CrossRef]
51. Cramer, J.; Loeber, A. Governance through learning: Making corporate social responsibility in Dutch industry effective from a sustainable development perspective. *J. Environ. Policy Plan.* **2004**, *6*, 271–287. [CrossRef]
52. Grin, J.; Hassink, J.; Karadzic, V.; Moors, E. Transformative Leadership and Contextual Change. *Sustainability* **2018**, *10*, 2159. [CrossRef]
53. Lopes, A.M.; Fam, D.; Williams, J. Designing sustainable sanitation: Involving design in innovative, transdisciplinary research. *Des. Stud.* **2012**, *33*, 298–317. [CrossRef]
54. Seyfang, G.; Longhurst, N. Desperately seeking niches: Grassroots innovations and niche development in the community currency field. *Glob. Environ. Chang.* **2013**, *23*, 881–891. [CrossRef]
55. World Bank. World Food Products exports and imports By Country 2017. Available online: https://wits.worldbank.org/CountryProfile/en/Country/WLD/Year/2017/TradeFlow/EXPIMP/Partner/by-country/Product/16-24_FoodProd (accessed on 28 January 2019).
56. Statistics Canada. *2011 Census of Agriculture*; Statistics Canada: Ottawa, ON, Canada, 2011. Available online: http://www.statcan.gc.ca/ca-ra2011/index-eng.htm (accessed on 12 January 2014).
57. Halbe, J.; Adamowski, J.; MBennett, E.; Pahl-Wostl, C.; Farahbakhsh, K. Functional organization analysis for the design of sustainable engineering systems. *Ecol. Eng.* **2014**, *73*, 80–91. [CrossRef]
58. Wakefield, S.; Yeudall, F.; Taron, C.; Rynolds, J.; Skinner, A. Growing urbanhealth: Community gardening in South-East Toronto. *Health Promot. Int.* **2007**, *22*, 92–101. [CrossRef]
59. Statistics Canada. *2006 Census of Agriculture*; Statistics Canada: Ottawa, ON, Canada, 2006. Available online: http://www.statcan.gc.ca/ca-ra2006/index-eng.htm (accessed on 30 August 2013).
60. Sotarauta, M.; Horlings, I.; Liddle, J. (Eds.) *Leadership and Change in Sustainable Regional Development*; Routledge: New York, NY, USA, 2012.
61. Hand, E. Citizen science: People power. *Nature* **2010**, *466*, 685–687. [CrossRef] [PubMed]
62. Wechsler, D. Crowdsourcing as a method of transdisciplinary research—Tapping the full potential of participants. *Futures* **2014**, *60*, 14–22. [CrossRef]
63. van den Bergh, J.C.J.M.; van Leeuwen, E.S.; Oosterhuis, F.H.; Rietveld, P.; Verhoef, E.T. Social learning by doing in sustainable transport innovations: Ex-post analysis of common factors behind successes and failures. *Res. Policy* **2007**, *36*, 247–259. [CrossRef]
64. Forrest, N.; Wiek, A. Learning from success—Toward evidence-informed sustainability transitions in communities. *Environ. Innov. Soc. Transit.* **2014**, *12*, 66–88. [CrossRef]

65. Halbe, J.; Adamowski, J. Modeling sustainability visions: A case study of multi-scale food systems in Southwestern Ontario. *J. Environ. Manag.* **2019**, *231*, 1028–1047. [CrossRef] [PubMed]
66. Trutnevyte, E.; Stauffacher, M.; Scholz, R.W. Supporting energy initiatives in small communities by linking visions with energy scenarios and multi-criteria assessment. *Energy Policy* **2011**, *39*, 7884–7895. [CrossRef]