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Research for Sustainability

- An analysis of key factors supporting strategic decision-making -

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Abstract

Current sustainability issues such as climate change are characterized by their multidimensional nature as they impact social, economic and environmental spheres simultaneously. An integrated whole-systems understanding is needed to acknowledge their highly complex dynamics and develop comprehensive responses. However, traditional disciplinary approaches to research deliver highly fragmented and specialized knowledge, which is often different from the kind of information needed by decision-makers. This disconnect hampers their ability to effectively act upon pressing issues.

For sectors such as agriculture, the implications of this impasse are significant. The development of relevant strategies to address climate change is crucial for the sector as its performance is highly dependent on climate. Adapting to new conditions requires information on projected climate variability, agricultural, environmental and social systems that is locally and regionally tailored and at the same time considers the global linkages inherent to the sector.

If sustainable responses are to be developed, it is argued that the inclusion of diverse disciplinary perspectives as well as use-inspired research efforts lead to holistic understanding and pertinent decision-making. In this project, key success factors, challenges and general dynamics of interaction and participation were explored through a case study of a Dutch research project called Climate Change and Agriculture Northern Netherlands, which features a strong collaborative component.

Based on this analysis, it can be argued that collaborative research efforts –in which a forum for frequent and open interaction between science, society and policy making exists- result in information that is more actionable and makes for salient, credible, legitimate input for programs and policies. However, given the current traditional approaches for knowledge production and the lack of flexibility in current institutional arrangements, the success of such initiatives hinges on carefully orchestrated boundary work.

Key words: collaborative research, sustainability, decision-making, climate change, agriculture.

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1. Introduction

Complex dynamics, high interconnectedness as well as strong reciprocity among variables are key characteristics of current global sustainability challenges such as climate change. To address them, integrated whole-systems understanding is needed to develop comprehensive responses that acknowledge and systematically manage social, environmental and economic goals (Perrings, 2007; Rockström, 2009). However, traditional institutional arrangements within research commonly apply disciplinary and reductionist approaches that deliver highly focused information. This compartmentalization in research is ill fitted to acknowledge the multifaceted nature that resides in the interactions within socio-environmental challenges (Max-Neef, 2005).

Decision makers are dealing with environmental questions integrally, while disciplinary research initiatives usually provide highly fragmented and specialized knowledge. The poor compatibility between the information needs and what is being supplied decreases the actionability of research outputs (Meinke, et al., 2006). Consequently, decision makers need input that invariably involves a broad array of disciplinary perspectives as well as relevant sources of expertise as these allow for a more holistic understanding that is rooted in the context of application. (Gibbons, 2000; Michaels, 2009).

The implications of this disconnection are significant for the development of pertinent responses to climate change, especially for sectors where the long-term sustainable use of natural resources is central. Among them, agriculture is particularly vulnerable as its performance is highly dependent on climate and its connections with food security and livelihoods, clearly visible (Parry, et al., 2007). Projections indicate that agricultural production could be severely compromised by climate variability in the coming decades particularly in Africa, Latin America and Central and South Asia. These regions are expected to be largely affected as they are inadequately prepared to cope with the adverse effects of climate change. For the agricultural activity in northern latitudes, climatic changes are expected to be less detrimental and in some instances beneficial. Although, warmer temperatures will force farmers to cope with increasing number of heat waves and insect outbreaks, soil erosion, water logging and salinization of irrigation water among others (IPCC, 2007). The critical position of the agricultural sector stresses the need for effective research efforts, as much needed adaptation measures require precise information on projected climate variability, agricultural, environmental and social systems at the local and regional levels while considering the global linkages inherent to the sector (FAO, 2007).

Thus, aiming at sustainable responses for such challenges calls for different approaches to current practices; the implications for research are substantial. The urgency with which sustainability challenges need to be addressed requires science to engage with wider audiences and pursue inquiries that stem from current on the ground issues instead of curiosity driven initiatives whose impact might reside mostly in the academic realm (Clark, 2007; Ward, 2010). Supplying decision makers with information that is actionable - that is to say, relevant, credible and legitimate - is key if pertinent strategic action that protects the environment and human development as a result, is to be implemented (Cash, et al., 2003; Meinke, et al., 2006).

1.1 Purpose of Research

Two needs serve as departing points for this study. First the need for relevant actionable research outcomes that inform decisions to address current sustainability problems effectively. Second, the need to better understand the process and dynamics of research that aims at incorporating other disciplines and sources of knowledge with transparency and credibility in a world where disciplinary approaches predominate.

The purpose of this research is to identify the main factors that contribute to obtaining actionable outcomes from collaborative research projects. This is done through the exploration of a collaborative research initiative in The Netherlands. The context that frames this study is that of the Dutch agricultural sector and its efforts to comprehend the interaction with climate change in order to design robust adaptation programs. Further information on the case study will be presented in the following section of this document.

The overarching question that guides this study:

> -What are the key factors that contribute to obtaining actionable outcomes from collaborative research projects?

Further supporting questions include:

> -What are the factors that contribute to an integrative understanding and the identification of feasible and effective climate adaptation measures?
>
> -Are there any factors that commonly hinder the effectiveness of such collaboration projects?
>
> -What are the lessons from this experience that can inform future research projects to better deal with sustainability challenges?

As will be explained below, these questions steered the choices of literature, theories and methods employed for this project. Existing literature provided information on ways to incorporate other perspectives within research, alternative paths to traditional methods and theories on how collaborations are commonly hindered and supported due to institutional arrangements. An in-depth look at the dynamics of a collaborative research effort dealing with climate change and adaptation in the agricultural sector provided detailed information about how initiatives of this kind operate on the ground.

From literature to reality, the results of this case study can provide insights regarding the dynamics and key elements that allow collaborative research projects to achieve integrated understanding and to identify feasible effective adaptation programs. These insights could not only inform further research but might be useful when conducting research for similar sectors such as fisheries and forestry. Moreover, this study may contribute to the debate about methodological aspects and working frameworks for sustainability science initiatives.

Finally, understanding how research can better inform strategic decision-making for a sustainable future should be of interest for academics, policy-makers as well as other decision makers. Bringing these audiences closer already represents a step towards relevant research efforts.

This thesis is structured in four main sections. The remainder of the introductory section consists of a detailed description of the methodology employed and the presentation of the theories and concepts used for the analysis. In section number two of this thesis, an account of both the background as well as the context and description of the case study are presented. Furthermore, the study findings accompanied by the results of their analysis are included in section three. Finally, the research questions presented above serve as a platform to shape the discussion of this research lessons. Concluding remarks incorporate suggestions for further research as well as key recommendations.

1.2 Research Process and Methods

A reflexive approach was employed by the researcher in order to ensure flexibility throughout the study. Moreover, the ontological standpoint that guided this work is that of constructivism. Bryman explains, that from this perspective, the researcher acknowledges the weight of social actors and presents an account of reality that is transient (Bryman, 2004). Furthermore, an interpretivist epistemology steered the methodological approach. Interviewees provided the researcher with views on collaborative research efforts for their analysis. The various perspectives gathered provided the basis from which the researcher presents an interpretation of the studied phenomenon.

The researcher decided to proceed with an initial literature review in order to further understanding of the issue. The literature review consisted of two phases. The initial phase focused on the relation between climate change and the agricultural sector including a global perspective on expected impacts and current policy challenges. Reports by the Intergovernmental Panel on Climate Change (IPCC) and the Food and Agriculture Organization of the United Nations (FAO) were reviewed amongst other sources of secondary data. A more ample successive phase included literature on research dynamics with particular focus upon collaborative efforts, society-science-policy interactions, and knowledge production. Although a full research strategy had been developed, this initial exploration also served to refine the next stages of the study, ensuring an adequate fit between methodology and the identified topic.

The empirical component of the project consisted of the study of an exemplifying case. According to Yin, it is advisable to conduct a case study when a research project addresses contemporary events embedded in real life situations where no control over key behaviors is needed. Furthermore, it allows for a comprehensive look or the unit of analysis as it incorporates diverse sources of information (Yin, 2003). Based on this and having identified the need to obtain first hand information on collaborative research initiatives, a case study was chosen.

The research project that was reviewed is Klimaat en Landbouw Noord Nederland, Climate Change and Agriculture Northern Netherlands. It was selected for its strong participatory component and its focus on climatic changes and adaptation responses in the agricultural sector. The project was initiated by Land- en Tuinbouw Organisatie Noord, a regional chapter of the Dutch Federation of Agriculture and Horticulture (LTO Noord) and Grontmij, an international consultancy firm that specializes in sustainable solutions. The project was carried out within the framework of the Climate changes Spatial Planning research program (CcSP) and had the explicit goal of collaborating with local authorities as well as people from the agricultural sector by means of information meetings and workshops throughout all key stages. The research was carried out by Grontmij and Wageningen University's research centers: Alterra (WUR-Alterra) and Plant Research International (WUR-PRI) under the management of LTO Noord (LTO Noord/Grontmij, 2009). Further details of the case study can be found in section 2.2 of this thesis.

The project has remained hitherto very regional thus documentation about the project in English is minimal. Therefore, the researcher was reliant upon personal interviews with key participants for a more detailed documentation of the origins, organizational dynamics, key findings and the project's general status.

Initial contact was made with project leader and LTO Noord's secretary of the Provincial Board Groningen, Peter Prins. After explaining the researcher's aims and interest in the Climate Change and Agriculture Northern Netherlands project as a case study, access and support in contacting key participants and collaborators was fully provided. Fieldwork in The Netherlands was then carried out in April 7-10th, 2010.

The aims for this phase were to gain understanding about the dynamics, processes of interaction as well as each of the involved group's perspectives on the topic and on the participatory and collaborative components of the project. Therefore, semi-structured interviews, described by Bryman as a flexible vehicle to be used investigate the views and understanding of interviewees regarding the unit of study, that is the Dutch case, were employed as the data collection strategy during fieldwork (Bryman, 2004). For this purpose an interview guide was developed. This guide contained the study's key information needs, main questions as well as more specific sub questions, which were used to direct the interview. Further detail on the interview topics and key questions can be found in Appendix I. Since each interviewee had different roles in the project, customized interview guides were produced accordingly. Further, five days previous to the fieldwork, interview guides were sent to each person electronically; they were accompanied by a brief introduction of the researcher and the project. This communication had the goal of clearing any initial questions in order to make the best use of the time during personal interviews.

All interviews were conducted in English and audio-recorded with consent of the interviewee as it allows the researcher to focus on the conversation and the interviewee's answers and reactions (Bryman, 2004). A brief summary of the key points of the interview was done afterwards. Additionally, each audio was analyzed thoroughly and relevant parts of the conversation were transcribed.

In regards to the sampling strategy, a purposive sampling was employed. The Climate Change and Agriculture Northern Netherlands project leader identified the key participants and collaborators. All the different groups of interest were represented in the sample and given the fact that it was a small group executing the research program the conducted interviews provided an adequate coverage. A table containing the name, institution and role of each of the interviewees can be found in Appendix II.

Subsequently follow up questions were posed electronically to three of the interviewees in order to obtain further details or clarification regarding the information mentioned during the face-to-face interview. Important to note that all interviewees showed a rather open approach during all interactions with the researcher and their cooperation allowed for in depth conversations and valuable input for this study.

Finally, a thorough analysis was made in the light of the selected theoretical framework in order to draw relevant insights and results from the data collected.

1.2.1 Scope and limitations

The researcher acknowledges the following limitations of the present study:

- Generalization is limited given by both the chosen methodology and the specific traits related to the Northern European context.
- Although interviewees included at least one of each of the participating groups, farmers are underrepresented with only one interviewee. Given that farmers constitute a special actor in both the Dutch research project and this study, more interviews would have provided with a broader perspective on their considerations surrounding collaborative research. This limitation however is partially countered by the ample feedback regarding the farmer's role obtained from other stakeholders, especially from observers.
- Furthermore, the Dutch project is currently being finalize, thus a look at the mid- and long-term implications of their approach to research is yet to be seen.
- The language used in interviews was English, a second language for nine out of ten interviewees. Although they all showed fluency, this could be a factor in how they articulated their responses.

This study is delimited in several ways, these include:

- Not using stakeholder dialogue theory to explain the case was an explicit choice taken on the basis that the theory's use has been somewhat limited. Although in has broadened in the past years, its use for purposes such as communicating annual operating results, improving the perception of a business or industry among key audiences of society or disseminating a company's corporate social responsibility strategy, limit its usefulness for this study.
- The researcher acknowledges that power dynamics do play a role in collaborative initiatives however; this is only addressed in terms of epistemological authorities given the fact that participant farmers are highly educated and perceive themselves as knowledgeable agents. It would be important to address this if in another context.

A final reflection on the methodology is included in Appendix III.

1.3 Conceptual Framework

The following is a collection of concepts and propositions for new modes of research and knowledge production. The researcher has used them to analyze the Dutch research initiative and better understand what factors are employed in the case study and what the implications of their use might be. The connection between theory and practice helps the researcher to draw relevant lessons from the data collected.

1.3.1 Knowledge production approaches

1.3.1.1 Use-inspired research

Parting from the observation of a current impasse in the use and production of scientific knowledge, Kristjanson et al. describe a frequently experienced situation where on the one hand researchers claim scientific information is not utilized by decision makers, and on the other policy makers and international negotiators among other members of society express their frustration regarding the unavailability of knowledge to make sensible decisions for society (Kristjanson, et al., 2009). This tension between the supplied and demanded information is well explained by Stokes. He explores the origins of an existing divide within research and proposes a framework to transition from the postwar paradigmatic understanding of the scientific endeavor that currently prevails.

Use-inspired research falls into what Stokes calls Pasteur's Quadrant. Stokes draws the argument for this kind of research on a discussion around the relationship between basic and applied research. He describes the postwar paradigm where the aim of basic research is to understand nature and its laws. Any thought of how this information might be of use is said to ruin the creativity of the process and the purity of the outcome. Therefore, clear distinctions are made between basic and applied research. Since the latter focuses on use, the two exist in separate categories. This paradigmatic understanding of science has been reinforced by the institutional arrangements in Europe and America in the last two centuries (Stokes, 1997).

Furthermore, despite the existence of this divide and significant shares of research being carried out guided by only one of these two approaches, there are projects in which strategic decisions are driven by both basic and applied goals. Such is the example of Pasteur, whose quest for understanding of microbiology was coupled with the goal of solving problems regarding the production of alcohol from beet juice. All his inquiries sought understanding but they also had a strong component of applicability and so in his working not only did he develop the process of pasteurization of milk but he also developed a new branch of science. If mapped in a two-dimensional conceptual plane, the goal of understanding and the goal of use coincide in what is now called Pasteur's Quadrant. Fig. 1 shows the different quadrants where research can be categorized depending on its considerations of use and understanding.

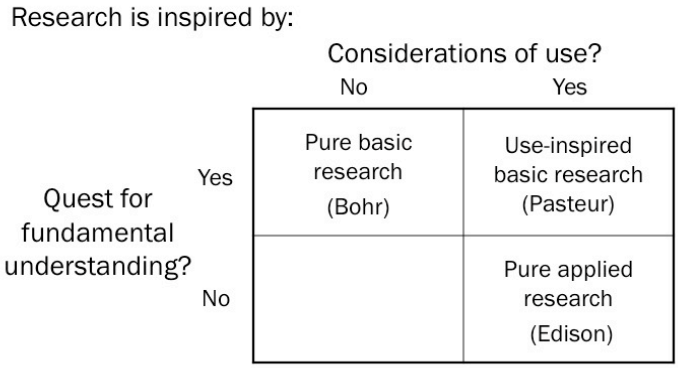

Figure 1. Model depicting different types of scientific research based on their quest for usefulness and/or fundamental understanding. Taken from Stokes, 1997.

The examples used in the remaining quadrants of this model come from Neils Bohr who engaged in a quest to discover the atomic structure solely for the sake of understanding and disregarding the use this could have. Additionally, Thomas Edison's pursuit for a market friendly electric lighting system with no consideration of the underlying scientific implications reflects the spirit of purely applied research. Finally, the quadrant that appears to be left empty is not, here rest efforts that systematically pursue knowledge without any particular objective, neither explanatory nor of any planned use (Stokes, 1997).

1.3.1.2 Mode 2 Knowledge production

Significantly different processes take place in what Stokes would call Pasteur's quadrant. These constitute what can be thought of a different way of knowledge production. Gibbons, et al. describe the characteristics of an emerging distinctive approach, and their conceptualization of Mode 2 will be used in this account to show the broader implications of its use.

Traditionally knowledge is produced by following certain methods and in adherence to particular cognitive and social norms. Inquiries often have an origin in curiosity and are further investigated within the practice of a discipline. These tenets allow scientists to determine which problems to address, who should address them and how to proceed so the product constitutes sound scientific knowledge. This approach is referred to as Mode 1. In the last two decades however, new attributes in knowledge production processes have been observed. These changes are of such nature that the process as such cannot rest any longer under the umbrella of Mode 1 and what hitherto has been considered traditional science. These processes constitute a new path for knowledge production, which has been termed Mode 2 (Gibbons, et al., 1994).

The different dynamics pertaining to each one of these approaches can be understood in terms of how each mode contextualizes research, employs different disciplines, socially organizes and how it controls the quality of the output. In Mode 1 the treatment of the inquiry is strictly academic and disciplinary while in Mode 2 the approach is oriented towards the application and usefulness of the outcome; consequently it draws on various kinds of expertise to address it. Regarding organizational structures, Mode 1 is characterized by being carried out in a more stable and hierarchical group while workgroups in Mode 2 are heterogeneous and feature flexible arrangements. Finally quality control in Mode 2 happens through a more ample set of criteria and context specific factors such as social impacts or commercial feasibility; for Mode 1 knowledge, quality is assessed within the academia, through peer reviewing practices. (Edelenbos, van Buuren, & Teisman, 2004)

Upon close examination, the first distinct feature of Mode 2 is that knowledge is produced with a strong orientation to application and problem solving as opposed to an inquiry that is taken out of its context and inserted within the confines of a particular academic discipline. Having the context play such a large role in the research initiative requires a broader perspective of the issue, such that can only be produced with the involvement of other social actors. The use of negotiation is then key for all interests to be adequately reflected in the project; this also contributes to the production of useful and actionable knowledge outcomes (Gibbons, et al., 1994).

A second feature for Mode 2 is transdisciplinarity. The concept has evolved but already four decades ago Jantsch discussed how given the then-pressing issues, new structures and arrangements would have to be employed within universities in order to deliver pertinent understanding for the development of society at large. He defined transdisciplinarity as the coordination of all disciplines and interdisciplines in a goal-oriented endeavor (Jantsch, 1972). Additionally, Brewer reflected on the difficulty for fragmented disciplinary knowledge to contribute in informing strategies and programs to deal with real-life complex problems. He argued that problem-oriented and interdisciplinary approaches could prove useful since most problems cannot be split in smaller pieces without losing some perspective and understanding of their context (Brewer, 1999). Max-Neef also elaborated on the current way in which the world of knowledge is organized and how that impacts the way the world and the challenges ahead are perceived (Max-Neef, 2005). Gibbons together with other researchers added the participatory element to the concept of transdisciplinarity concluding that it should be a collaborative knowledge production process involving various disciplines and stakeholders of relevant civil sectors (Pohl, 2007).

Transdisciplinarity goes well beyond the mere assemble of a multi disciplinary group; it's the integration of relevant and diverse skills in an agreement on how to proceed in terms of social and cognitive practices. The working framework is generated in the context of application and it's an evolving synergy of existing knowledge, members' expertise and empirical insights. Another trait of transdisciplinarity is that it does represent a contribution to knowledge even if it's linked to a specific setting as it contains empirical and theoretical components. Furthermore, communicating results is taken to another level as dissemination of the generated knowledge takes place as the process unfolds since all key actors are closely involved from the beginning. The dynamism that accompanies transdisciplinary efforts makes it hard to give continuity if a new problem is identified during the process but the network it creates can prove useful in later initiatives (Gibbons, et al., 1994).

A third distinct feature has to do with the organizational component within Mode 2, the group is constituted by people from different disciplines and areas or expertise therefore is characterized by heterogeneity. New sites of knowledge such as research institutes, government agencies and consultancies can be recognized. Further, the team might mutate as the situation dictates; hence work groups are less likely to be institutionalized given their high degree of malleability and transitory nature (Gibbons, et al., 1994).

A large number of people interested in influencing the research process constitutes the fourth feature, increased social accountability. Researchers and other experts work close to the problem context; this increases the awareness on the implications of their work and intended outcomes. The reflective process that is triggered increases the understanding of the problem and strongly engages participants in the process (Gibbons, et al., 1994). The interaction with other disciplines and the practical side of the issue at hand increases, and according to Gibbons, this can also become a very stimulating work environment (Gibbons, 2000).

Lastly, a fifth feature of Mode 2 shows that as opposed to a strict academic peer review assessment where scientific work is judged by other scientific experts in terms of transparency and quality of contribution to scientific knowledge, quality in Mode 2

knowledge production is measured by a more ample set of indicators. Outcomes of this type of knowledge production are expected to be produced in a transparent and sound manner however they are also measured in terms of their applicability and relevance in the light of the particular context. Questions about the cost-effectiveness of the outcome or how it fits within the social context are examples of other criteria that can be used to assess the quality of Mode 2 knowledge (Gibbons, 2000).

Important to note that in Mode 2 the dynamics of demand and supply of knowledge can be recognized more tangibly. On the supply side, there are more qualified professionals than ever before ready to deliver all kinds of knowledge. Additionally, these professionals are undertaking research activities outside the universities, thus there are now many sites where knowledge is produced. On the other hand demand has also expanded with inquiries coming from all sectors of society. As in other dynamic markets, within Mode 2 demand and supply articulate each other and there is a constant evolution in both sides of the equation. A peculiarity to be observed is that in the knowledge world, production and consumption of knowledge might not be so easy to distinguish; it's a moving process where variables can be quite entangled and the process is lead to inform the outcome (Gibbons, et al., 1994).

1.3.1.3 Sustainability Science

From the recognition that the issues we face today call for a different set of approaches in order to address them and contribute to a sustainable development, Kates et al. define sustainability science, as a problem-driven science that aims at improved understanding of the complex interaction of humans and nature. It is a call for a comprehensive understanding that incorporates different spatial and time scales. It acknowledges the nature of the current challenges where a significant degree of interconnectedness to the global systems can be observed in highly local/regional issues. Also, it's stresses how inertia and natural time lags should be taken into account in order to develop adequate solutions, shifting to a larger perspective that goes well beyond the prospect of our lifetime (Kates, et al., 2001).

Being a field of use-inspired research, sustainability science efforts are framed around the problems being studied instead of exploring an issue framed on the basis of what current disciplines are equipped to do. The selection of methods and processes is therefore a careful ensemble of relevant approaches from different disciplines. Sustainability Science lays between the application and the theoretical worlds since it draws from theoretical conceptualization and empirical experience (Clark, 2007). A strong participatory component is employed to allow for interaction of social actors to emerge within the process and for this interaction to feed into the knowledge that is being produced in such a way that the outcome is well designed for the given context. Finally, as sustainability initiatives are kept close to their research focus, processes remain flexible allowing for interaction and reciprocity between exploration and application to take place (Kates, et al., 2001).

1.3.1.4 Adaptation Science

Smit, et al. argue that adaptation science plays a key role in addressing climate change as it serves two purposes: first to assess the impacts of environmental changes and second to examine potential response actions. In its role within impact assessment efforts, adaptation science serves an analytical function in determining the nature and likelihood of expected effects. When considering adaptation measures, it plays more of a normative role of evaluating what adaptation measures should be recommended (Smit, et al., 1999).

Furthermore, within this debate there is a strong call for scientific input to serve as a basis for well-planned and pertinent measures. To move beyond adaptation actions that are based only on tacit understanding and empirical expertise, which has often been the case in agriculture and other natural resource dependent sectors, conceptual frameworks need to be in place to ensure the scientific output is relevant, credible and legitimate (Meinke, et al., 2009).

In order to provide policymakers as well as practitioners with improved understanding and relevant insight that allows them to develop adequate programs, adaptation science is defined as:

> The process of identifying and assessing threats, risks, uncertainties and opportunities that generates the information, knowledge and insight required to effect changes in systems to increase their adaptive capacity and performance. (Meinke, et al., 2009).

Facilitating this kind of processes will increase the system's adaptive capacity, which will result in an enhanced ability to respond to climate changes and related transformations (Tol, 2005).

1.3.2 Knowledge production dynamics and implications

1.3.2.1 Participation and plurality of perspectives

Incorporating a participatory component in a study can take many forms. And while interaction between research, industry and government is increasing, incorporating non-scientific expertise in the production of academic research is not a common phenomenon (Polk & Knutsson, 2008). In projects that follow a transdisciplinary approach, knowledge is produced through the participation of researchers and non-academics. This approach seeks to introduce throughout the process the diversity of views, knowledge structures, norms and perspectives that exist among society in order to obtain valuable insights and find practical solutions to current pressing issues (Siebenhüner, 2004).

For participation to work, a true spirit of pluralism needs to prevail. From rhetoric to reality collaboration proves hard, as epistemological standpoints[1] often become barrier for true partnerships. Even if researchers are part of a collaborative effort, inertia and lack of coordination can impede dialogue across disciplines. Researchers often work within their disciplinary arena and from their epistemological perspectives only to later paste together similar efforts from their colleagues, this is defined as epistemological silos (Miller, Baird, & Littlefield, 2008).

Healy describes how in other cases, there is one epistemological or disciplinary angle that is imposed or overvalued, this is denominated epistemological sovereignty. As other perspectives are marginalized, a holistic perspective and increased awareness of the interconnections of the issue at hand fail to be developed (Healy, 2003).

To integrate disciplinary analyses, it's argued that researchers and scholars need to reflect on how to conduct research in a plural context. An epistemological pluralism perspective recognizes the challenges of bringing together different approaches but it also identifies that this integration leads to a more systemic understanding of complex sustainability issues. Furthermore, the validity and value of different ways of knowing is fully recognized as well as the need for iterative negotiation processes where researches do collaborate and weave together their individual perspectives instead of ruling out or marginalize them (Miller, Baird, & Littlefield, 2008).

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[1] Epistemology is defined as the study of knowledge and so it deals with issues regarding its production and dissemination (methods, validity and scope). Steup, M. (December 14, 2005). *Episteomology (Stanford Enciclopedia of Philosophy)*. Retrieved April 29, 2010 from Stanford Encyclopedia of Philosophy: http://www.seop.leeds.ac.uk/entries/epistemology/

1.3.2.2 Salience, legitimacy and credibility

Cash, et al. expand on the implications of linking research, assessment and decision-making processes by discussing the consequences of bringing together different disciplines and perspectives in terms of the dynamics and the information outcomes. In making use of scientific efforts and available technology for sustainability related strategy development and decision-making, the challenge of operating across boundaries effectively in order to produce salient, credible and legitimate information is therefore key (Cash, et al., 2002).

Salience is defined in terms of the relevance certain information holds for decision-making. The degree of salience will depend on how useful certain information proves to be for the user. Kingdon (as cited in Cash, et al. 2003) explains how the timing to deliver the information is crucial as well as how connected it is to the issues that decision makers are dealing with. Moreover, credibility refers to the adequacy of the processes and the sources used to generate the information. When dealing with contested issues, credibility is harder to achieve as consensus plays an important factor in building it. Finally, the process and the actors involved in producing the information have a significant weight in how legitimate certain information is perceived to be. Fair processes of production, verification and communication of information are seen as more legitimate (Cash, et al., 2002).

Jürgens argues that participation from a broad base of stakeholders has significant positive implications in the quality of the information being produced. Through a causal loop diagram (see Figure 2) he depicts positive relationships between the degree of participation and aspects such as relevance and compatibility of information, general quality of research, transparency, credibility, legitimacy, successful communication and receptivity of research outputs to stakeholders (Jürgens, 2004).

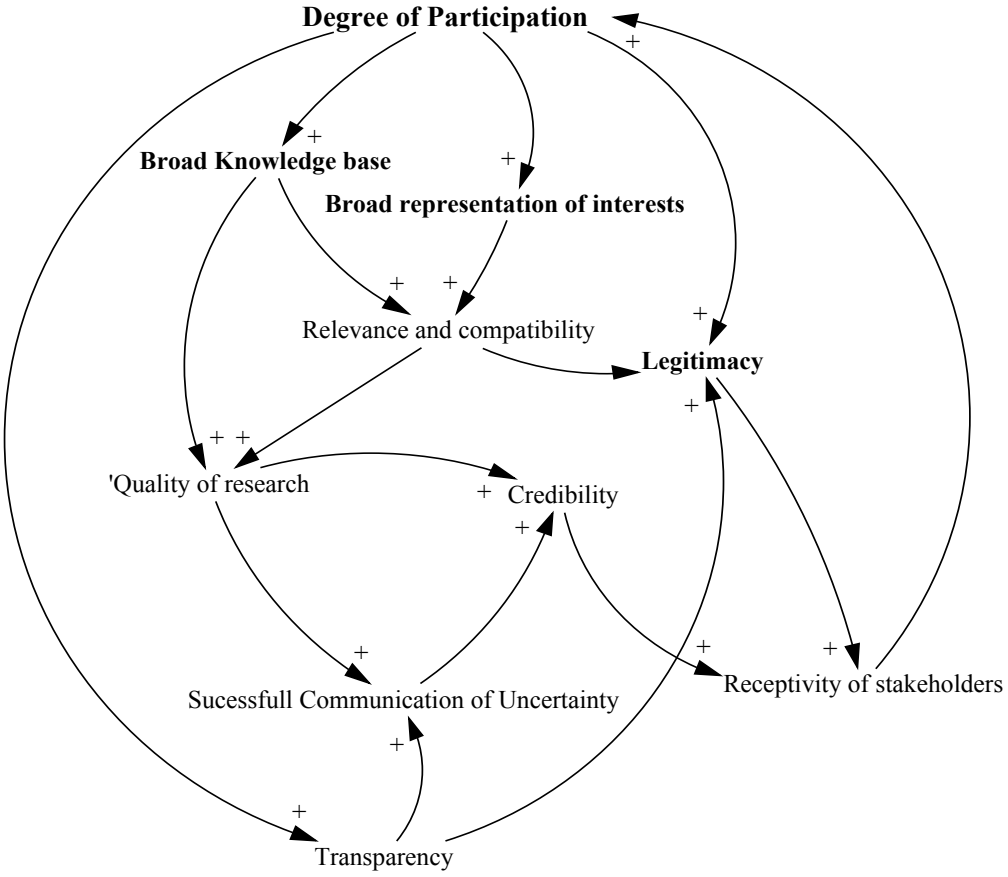

Figure 2. Diagram depicting the effects of a participation in climate change research. Taken from Jürgens, 2004.

These interactions need to be carefully coordinated as efforts to increase one aspect might diminish how the information is perceived in terms of other attributes. Tensions between salience, credibility and legitimacy require good understanding and clear research objectives. Engaging policy makers can increase relevance of the information but also take a toll in how credible it appears to be if the process is perceived as now being biased by their participation. On the other hand if the process is highly isolated from external pressures it can lose salience as it won't be as connected to the decision-making agenda. Other similar circumstances can be observed as the stakeholder participation is broadened or diminished. There are however, complementary relationships between these attributes as well. Actions to increase the legitimacy, credibility or relevance of the information can enhance other variables of this set of attributes. Including a denser array of participants can improve the credibility of the outputs since now formerly dismissed knowledge is present in the study, increase the salience are the research focus is aligned with pressing information needs and enhance the legitimacy by creating a notable sense of ownership of the process among all participants (Cash, et al., 2002).

1.3.2.3 Boundaries and boundary management

The scientific community has strictly guarded its sovereignty and cognitive authority by establishing clear boundaries, especially between research and decision-making so there is no risk of biased outputs. However, Guston argues that some flexibility in these boundaries can result in more productive policymaking processes (Guston, 2001). Other common boundaries are those determined by functionality, jurisdiction, academic disciplines, organizational scales and types of knowledge. Despite their usefulness in providing the opportunity to specialize and achieve efficient coherence, if too rigid they can certainly prove counterproductive. Additionally, perceptions regarding information attributes such as salience, credibility and legitimacy will vary across these boundaries and scales as they demark different perspectives and actors within them (Cash, et al., 2002).

In order to effectively navigate these boundaries and bridge these gaps, boundary organizations focus on managing and serving as mediators. They facilitate communication and participation from both sides (Guston, 2001). Miller identifies the Subsidiary Body for Scientific and Technological Advice (SBSTA) as a boundary organization as it has "played a critical role in helping to coordinate across the various domains of decision-making and knowledge-making authority within the climate regime" (Miller C. , 2001).

Effective boundary management not only supports interaction and dialogue but improves information flows and the transfer of knowledge for strategic decision-making (Cash, et al., 2002). However in order to achieve such results, Cash et al., put forward key institutional functions and traits that include:

-Expanded accountability, ensuring that no interests or perspectives are neglected.
-Use of boundary objects, bringing together audiences through the use or co-production of some document or other device.
-Participation across boundaries, as it increases effectiveness of the process.
-Translation functions, in order to overcome the "language" and jargon barriers.
-Coordination and mediation, as effectively orchestrating and supporting negotiations regarding different interests from actors results in a reduced trade-offs as well as complementary and more congruent outcomes.

It's argued that through the use of these strategies, an effective management structure can support the bridging of existing boundaries and result in the creation of pertinent responses to complex issues (Cash, et al., 2006).

1.3.2.4 Learning

Interaction among actors from both scientific and non-scientific spheres faces certain obstacles as has been described in the preceding sections; however, the exchange of knowledge and experiences increases valuable attributes along with ownership of the research outputs (Miller, Baird, & Littlefield, 2008). Moreover, several researchers argue that planning for long-term sustainability is significantly improved if multi-stakeholder collaborative research efforts serve as input as they create an open space for social learning and an efficient platform for strategic planning (Hartley & Robertson, 2009; Polk & Gustafsson, 2006).

Mutual learning can be seen as a natural adaptation process that emerges from this interaction (Scholz, 2000). Webler (as cited in Siebenhüner, 2004) states how mutual learning is a form of cognitive enhancement as it refers to the process of acquiring knowledge about other kinds of expertise, perspectives and approaches to reasoning. Other learning processes trigger moral development, which refers to changes in principle regarding the perspectives of others or towards further cooperation (Siebenhüner, 2004).

1.3.2.5 Maximization vs. Optimization

Some of the boundaries previously reviewed result from the different groups of stakeholders proceeding from a perspective of maximization, that is, seeking for a certain approach or interest to prevail over others. German argues that within the current scientific research paradigm the search for maximization[2] can be observed. The present disciplinary arrangement facilitates the specialization and maximization of returns in regards to isolated research components. In agricultural research this translates into the compartmentalization of the system in separate boxes such as crops or livestock with the exclusive focus on achieving higher yields. However, the logic of this approach fails to recognize the complexity and diversity of natural systems. Higher yields represent an overall sensible aim if analyzed in isolation, but when efforts to sew back together these components are carried out, plenty of trade-offs are generated as each element has direct effects on the rest (German, 2006).

If analyzed from a broader perspective maximizing yields might not bring the most benefits for the system in general. From an optimization perspective, efforts are geared towards obtaining a balance between gains and losses in the search for an effective as possible outcome. If research is approached from such an angle, trade-offs could be minimized increasing the overall productivity of the system (Holt & Roth, 2004) (German, 2006).

When applying such conceptualization of maximization and optimization to the institutional and group boundaries previously reviewed, it can be observed that a similar dynamic is found when a pressing issue is addressed. Science and decision makers each design efforts from their own arena and goals of maximization overcome the internalization of benefits derived from collaboration. Interaction is therefore often hampered by the lack of compatibility between these approaches (Holt & Roth, 2004).

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[2] Defined as the search for the maximum value of something. maximization. (2010). In *Merriam-Webster Online Dictionary*. Retrieved May 1, 2010, from http://www.merriam-webster.com/dictionary/maximization

2. Case Study

After having reviewed the key concepts surrounding new approaches to knowledge production, their particular dynamics and implications, this section continues with the presentation of the case and useful background information that will serve for the subsequent presentation and discussion of findings.

2.1 Background and setting

2.1.1The agricultural sector in The Netherlands

The agri-industry, which comprises all economic activities related to agriculture and food, is a key component of the Dutch economy. With close to 48 billion Euros and 672 thousand labor units, it represents close to 10% of both the Dutch gross value added and national employment. The sector processing domestic raw materials from agriculture contributes with 5 and 6% of the total gross value added and national employment respectively (Berkhout & van Bruchem, 2009).

The Dutch economy closely interacts with the international market. In 2008, The Netherlands was the second largest exporting country in Europe after Germany (Statistics Netherlands, 2010). The agricultural sector is equally internationally oriented, making The Netherlands the second largest exporter of agri-products in the world, second only to The United States (The Ministry of Agriculture, Nature and Food Quality; Department of Trade and Industry, 2008).

The Dutch agri-sector has experienced considerable expansion and intensification of productivity in the last decades. Mega farms[3] are replacing small farms; which is demonstrated by a decrease of a third in the total number of farms between 1990 and 2006. Out of a total of 79.5 thousand farms, dairy farms make up for the largest sub-sector with 26% followed by grazing stock farms (23%), vegetable and glasshouse farms (18%), arable farms (15%), and intensive livestock together with mixed farms each accounting for 9% of the total. Further, 52% of The Netherlands' 3.7 million ha. of land is dedicated to farming out of which 57% is used for arable and horticulture crops(The Ministry of Agriculture, Nature and Food Quality; Department of Trade and Industry, 2008). Regarding the farm holders population, the ratio of farm holders aged ≥ 65 years old to farm holders aged < 35 years old is 13.2 to 2.8 (Eurostat, 2007). Further, the Dutch farmers are characterized by being highly educated (P. Reidsma, personal communication, April 8, 2010).

2.1.2 Climate Change and its effects on the Dutch agri-sector

The effects of climate change have been visible throughout the past decades in The Netherlands; extremely warm summers for instance in 2003, amongst other events are likely to increase in magnitude and frequency according to the latest studies (Bresser, et al., 2005).

Temperatures are expected to further increase leading to more frequent mild winters and hot summers. The global average warming is thought to be between 1 and 2ºC by 2050, however regional and local factors such as wind patterns could increase this even further (Tank & Lenderink, 2009).

[3] The prefix mega applies to farms that on average have approximately 410 dairy cows, 12,800 fattening pigs, 186,000 layers or 385 ha. of arable land.

Scientific observations show that annual average precipitation has increased and despite the remaining uncertainty regarding future precipitation patterns, this is a trend that is expected to continue. Increased frequency of days with extreme rainfall will result in wetter winters (Bresser, et al., 2005). Extreme rain showers are likely to occur during the summer, although the total amount of rainfall will decrease leading to dryer summers (Tank & Lenderink, 2009).

Furthermore, the likelihood of flooding is enhanced by the expected rise in sea levels (between 20 to 110 cm. by 2100) and the increase in the river discharge (Bresser, et al., 2005). This has particular significance to the Netherlands as 20% of the land lies below sea level and is populated by 21% of the total inhabitants (Centraal Bureau voor de Statistiek, 2009).

This results in significant effects in the agricultural sector. For instance, a longer growing season can currently be observed. Compared to the average length of the season between 1961 and 1990, the current season is more than three weeks longer (Bresser, et al., 2005). In the coming decades, the IPCC concludes that higher yields in colder regions are virtually certain (IPCC, 2007).

Additionally, the Dutch agricultural sector will face rising sea levels which pose a threat to very productive low lying lands as well as dryer summers where water management will be challenging (European Commission, 2008). Moreover, issues regarding sowing and harvesting as well as crop damage due to extreme precipitation and hail will increase.

Other climatic related effects include insect and fungal pests as well as challenges with pollination. On the other hand, market opportunities will rise as southern European agriculture might face bigger production challenges compared to northern European countries (Bresser, et al., 2005).

2.2 The Climate Change and Agriculture Northern Netherlands project

2.2.1 Origins and description

The project Climate Change and Agriculture Northern Netherlands, referred to as CCANN from this point forward, was born out of the recognition of the need for pertinent knowledge and clear understanding about the effects of climate change in the agricultural sector in northern Netherlands as well as appropriate adaptation measures to be employed in the face of both climatic and market changes in the region (P. Prins, personal communication, April 8, 2010).

Initial discussions about the need for such information for regional decision-making processes were carried out in July of 2004 when the secretary of the Provincial Board Groningen of LTO Noord, Peter Prins and Grontmij's Policy and Innovation manager, Bjartur Swart engaged in informal consultations about the topic (B. Swart, personal communication, April 9, 2010). A first result of these conversations was an informational meeting. Experts from Wageningen University were invited to talk about climate change and its potential effects in agriculture in the region. After the meeting, it was realized that there was a pressing need for more specific knowledge to inform long-term strategic investments and planning decisions in northern Netherlands (P. Prins, personal communication, April 8, 2010).

As parallel efforts were being planned by national and regional organizations, discussions about developing a collaborative research project together with Wageningen University developed in the course of the following months (P. Prins, personal communication, April 8, 2010). After some debate regarding the approach to the initiative, the result was two parallel

projects, the first which is the focus of this study and the second, AgriAdapt-NL, a project that aims at developing a methodology to assess the adaptive capacity of the Dutch agriculture both at regional and farm levels in combination with market and policy changes (Wageningen UR, 2008). The original plan for these two research initiatives was to run in parallel and maintain close interaction; however the AgriAdapt-NL did not start until late 2008 and that had implications for the original time line and how the projects now relate (B. Schaap, personal communication, April 8, 2010).

The project officially started in January 2007 and concludes in June 2010, although final reports will be released in December also 2010. The program acknowledged the lack of comprehensive understanding by policymakers and key stakeholders about the effects and time dynamics of climate change; therefore its main objective consists in the development of strategies and actions plans for agriculture in northern Netherlands for adaptation to climate and market changes (LTO Noord/Grontmij, 2008; P. Prins, personal communication, April 21, 2010).

A detailed timeline of key events of the case is found in Appendix IV. Moreover for a list of all key participants, Appendix V can be consulted.

Key research questions that guided the CCANN project include:

> -How will the competitiveness of the agricultural sector in the northern Netherlands develop in view of global climate change and global economic developments?
>
> -What will be the main consequences for agriculture in the northern Netherlands due to extreme weather conditions and what measures could be taken?
>
> -What consistent adaptation strategies could be used, taking into account other social interests in the northern Netherlands? (LTO Noord/Grontmij, 2009)

The project aimed at contributing with an integral approach that combines an impact assessment of climatic and market changes in the development of adaptation strategies. Further, the strong collaborative nature of the initiative, which will be discussed in detail throughout this study, was employed in order to serve as a bridge between knowledge and practical application at the regional level (LTO Noord/Grontmij, 2008).

Grontmij designed the research project, which consisted of three stages:

Phase I – A study of the potential climate and market changes in the European agriculture sector was carried out. The aim of this stage was to better understand the European context and its likely evolution in the coming decades in order to assess the place of the Dutch agriculture within the region. The study focused on wheat, potatoes and grassland, which are key crops in the Dutch agricultural sector (LTO Noord/Grontmij, 2009; Hermans & Verhagen, 2008).

Phase II – Consisted of an impact assessment for 15 crops that are currently grown -or could be grown in the coming decades- in The Netherlands. The assessment studied the frequency of weather extremes as well as the consequent potential crop damage. Moreover, some alternatives for measures to prevent crop damage were discussed during this stage (LTO Noord/Grontmij, 2009).

Phase III – This stage is currently being finalized. A collection of measures was design for eight subareas of the northern region of The Netherlands. Measures were tailored to address the specific characteristics of each subarea. A distinction regarding the level at which the measures should be implemented was included with the objective of informing farmers about

the actions that they can employ themselves and those measure which have to be implemented by the local/regional authorities or water boards (LTO Noord/Grontmij, 2009).

2.2.2 Strong collaboration

The CCANN project is characterized by a strong collaborative component. From the setout the assumption that has served as platform for the dynamics and methodology of the project is that collaboration between science, public and private sectors is crucial in the development and implementation of effective plans. Consequently for the creation of pertinent adaptations strategies for the region, the study was designed so the different groups could participate in the formulation of plans that have a solid scientific base but are also relevant in that they acknowledge the needs of stakeholders as well as the contextual limitations and opportunities (LTO Noord/Grontmij, 2008). Participation from farmers was sought throughout the project in order to obtain feedback as well as valuable region and farm-specific information as input for the study (P. Prins, personal communication, April 8, 2010).

The participatory element during the first phase consisted of an evaluation by key stakeholders of the study findings on the potential climate and market changes in the European agriculture sector. The process was carried out as a workshop based on a Participatory Integrated Assessment[4] approach. It aimed at creating common understanding based on scientific knowledge and stakeholders' expertise and perceptions as well as relevant priorities for the subsequent stages of the project (LTO Noord/Grontmij, 2008).

During the second phase, several thematic meetings were held in order to identify extreme climate events, the potential risks associated with them, the activities that are most vulnerable to this changes as well as possible agricultural and non-agricultural adaptation strategies. These meetings had on average 15 participants with a strong farmer component of approximately half of all attendees. Subsequently, workshop sessions provided a forum for farmers to assess, based on their experience, the magnitude of these weather extremes, the associated risks and the proposed measures. With this feedback, risk maps and possible adaptation strategies were presented in a second workshop to policymakers and other stakeholders. Their observations were also taken into account and included in the report for phase II (B. Schaap, personal communication, April 8 & May 3, 2010; P. Prins, personal communication, April 26, 2010; LTO Noord/Grontmij, 2008).

For the third phase, several sessions with experts, farmers and other stakeholders were held in order to assess the proposed adaptation measures in terms of their effect on the non-agricultural sectors such as nature conservation, housing and recreation. This input served as basis for the development of action plans. Policymakers and other stakeholders reviewed these results and concluding remarks will be included in the final report, planned to be finalized December 2010 (P. Prins, personal communication, April 21, 2010; LTO Noord/Grontmij, 2008).

2.2.3 Project leadership

The secretary of the Provincial Board Groningen of LTO Noord[5], Peter Prins together with Grontmij's Policy and Innovation manager, Bjartur Swart[6] initiated the project. After several

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[4] A methodology that allows experts to integrate input from stakeholders (non-scientific knowledge) including their perspectives on the origins, relevant dynamics, and solutions to the problem. Kloprogge, P., & van der Sluijs, J. (2006). The Inclusion of Stakeholder Knowledge and Perspectives in Integrated Assessment of Climate Change. *Climatic Change , 75* (3), 359-389.

[5] LTO Noord is the regional division of the Dutch Federation of Agriculture and Horticulture, an entrepreneurs and employer's organization. Its core task is to promote its members' collective interests

talks with Wageningen University as well as other organizations a consortium was formed. The steering committee is chaired by deputy Douwe Hollenga from the Province of Groningen while Peter Prins from LTO Noord chairs the workgroup that includes as core members:

- Geert Boesjes, Province of Friesland
-Willem Huizing, Province of Drenthe
- Peter Smale, Province of Groningen
- Peter Roozenbeek, Water Board Reest en Wieden
- Jan van Berkum, Water Board Velt en Vecht
- Bart Muntjewerf, Ministry of Agriculture, Nature and Food Quality
- Jan Verhagen, WUR-PRI and Bjartur Swart from Grontmij (LTO Noord/Grontmij, 2008).

2.2.4 Funding

In December 2006 initial funding came from the province of Friesland followed by regional funding coming throughout 2007 from Provinces and Water boards in the Northern Netherlands. It was not until March 2009 that additional funds were secured from the National Climate Changes Spatial Planning Program through its research incentive program, Besluit Subsidies Investeringen Kennisinfrastructuur, Grants for Investment in Knowledge (Bsik). In total, 45% of the funding came from Bsik while local parties financed the remaining 55% (LTO Noord/Grontmij, 2009; P. Prins, personal communication, May 4, 2010).

2.2.5 CCANN's Results and project evaluation

Through the CCANN project it was concluded that despite the climate and market changes, potatoes, wheat and grass (dairy farming), key in the Dutch agriculture, will continue to be staple crops in the coming decades. Furthermore, the northern Netherlands is the region expected to reap the most benefits in the face of projected variability within the European production by 2050 (Hermans & Verhagen, 2008; LTO Noord/Grontmij, 2009)

Moreover, results showed that there will be a higher frequency of climate related extremes and consequent crop damage. However, most adaptation measures will happen at the farm level and at least within the short and mid-term, farmers can adapt through changes in crop varieties and ultimately crop choice (B. Schaap, personal communication, April 8, 2010).

Although the main goal of the study was to develop regional adaptation plans, the results showed that there is no need to formulate integrated regional plans for the next 30 years. This is due to the fact that farmers can carry out about 80% of the adaptation needed in the coming three decades by changes in their farm management. These changes do not impact

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at the local, regional, national and international levels. LTO Noord operates in the provinces of: Groningen, Drenthe, Fryslân, Flevoland, Utrecht, Gelderland, Overijssel, Noord-Holland and Zuid-Holland and has 22,750 farmers (representing 19,777 farms) among it's 31,000 members which also include former agricultural land owners and associate members. (P. Prins, personal communication, April 27, 2010); LTO Nederland. (2008). *Dutch Organization for the Agriculture and Horticulture* [Brochure]. The Hague: LTO Nederland.

[6] Bjartur Swart held his position at Grontmij, the fourth largest engineering consultancy in Europe focusing on sustainable design and management, until April 2010. (B. Swart, personal communication, April 9, 2010); Grontmij. (ND). *About Grontmij*. Retrieved April 24, 2010 from Grontmij: http://www.grontmij.com/AboutGrontmij/Pages/Mission.aspx

significantly other sectors such as tourism and nature conservation; therefore, no integrative rural adaptation plan is required (P.Prins, personal communication, April 24 & May 26 2010).

In terms of the overall project evaluation, it will be focused on reviewing the potential adaptation measures that the different collaborators, including and specially farmers can take (P. Prins, personal communication, May 17, 2010). A preliminary glance back at the project as a whole shows that other valuable information such as a sectoral view of the farmers' perspectives was gathered throughout the project. This input can certainly be incorporated in the design of strategies for climate change planning. Furthermore, the methodological approach with participatory tools such as the adaptation workshops carried out at the grass root level is part of the contributions of the study as it can be applied in similar research programs. Finally, the project has developed an extensive network of farmers who are familiar with climate change debate and can be used as valuable resources in policy-making processes. (P. Prins, personal communication, May 17, 2010).

3. Study Findings and Analysis

After reviewing the CCANN project, results will be presented by an initial in-depth look at the case study's processes and dynamics. Weaved into the presentation of this study's findings will be the implications of project dynamics in terms of information attributes such as salience, credibility, legitimacy. Moreover, the identified challenges as well as strong points of the project will be used to complete this analysis. Finally the stated research questions for the present study will be revisited in order to summarize the findings.

3.1 Key identified factors and dynamics

3.1.1. Contextualized on application

A characteristic feature of the CCANN project is that based on the recognition of a problematic lack of information, it established from the outset the aim of generating useful outputs for the agri-industry sector in the region. The context clearly framed the focus and design of the project; the actionability of the outcomes was kept as a reference point throughout the progression of the project (P. Prins, personal communication, April 8, 2010; B. Swart, personal communication, April 9, 2010). Observable traits are the problem driven nature of the inquiry as well as the attention paid to the given context, both which are recognized in Mode 2 research processes (Gibbons, et al., 1994).

3.1.2 Heterogeneous partners

The search for partnerships was conducted in order to integrate an adequate set of different expertise, input and support. Given their experience, the university of Wageningen was an evident choice to carry out the research however the leadership of the project remained outside Wageningen's research centers and additional regional and local partners were involved (B. Swart, personal communication, April 9, 2010). The diversity among the collaborators reflects a search for complementarities, an initiative that can be traced back to the consultancy firm's expertise with participatory processes. Bringing together different perspectives through the creation of a diverse consortium reflects according to Clark, the complexity of current issues and enhances the ability of such initiatives to generate improved understanding as well as better policy programs (Clark, 2009).

A solid starting point to create a wide spectrum of voices can be found in the partnership arrangement that was procured for the project. As Gibbons argues, the heterogeneity of a group enhances, the robustness of the information and the integration of valuable perspectives in the study (Gibbons, et al.,1994). Special attention was given to creating an environment

where farmers and other stakeholders would feel comfortable enough to voice their opinions, suggestions and critiques (P. Prins, personal communication, April 8, 2010). Creating this engagement is argued to result in actionable outcomes as well as increased perceptions of legitimacy of the process and credibility of the information outputs (Clark & Holliday, 2006).

3.1.3 Collaboration and epistemological pluralism

As stated in the previous sections, the project had a strong collaborative component where participation from farmers and other stakeholders was supported through open meetings and thematic workshops (B. Schaap, personal communication, May 3, 2010). Meetings of different nature were carried out and facilitated by Grontmij's Bjartur Swart. Through these forums the research team and project coordinators were able to obtain valuable feedback that served as input in different components and levels of the process (J. de Kraker, personal communication, April 26, 2010).

3.1.3.1 Gaining direction and perspective

As different perspectives coincide in one place, both science and society tend to reflect more on the topic, other existing mind frames as well as on different spatial and time scales (Gibbons, 2000). As Pytrik Reidsma from Wageningen, who participated as an observer in several meetings described, this interaction provides insight and useful specific information that complements the study. Additionally, it "improves the thinking, thinking out of the scientific box because with models you lose sight" (P. Reidsma, personal communication, April 8, 2010). Additionally, by linking models with information from stakeholders the study is guided towards more relevant research paths. Jan Verhagen, also from Wageningen, adds on by stating "we use the process to get a focus on research priorities and action priorities for different stakeholders" (J. Verhagen, personal communication, April 8, 2010).

3.1.3.2 Incorporating stakeholders' input and epistemological considerations

Within the project, it could be observed that there was a certain degree of flexibility regarding the perceived validity of different knowledge sources; epistemological resolutions would revolve around considerations on degrees of expertise and availability of information. Several stakeholder meetings were held where general feedback from farmers and other local and regional partners would be gathered. This information although highly valued by researchers was carefully incorporated. "We were a bit conservative about that (including stakeholder's input)…we tried to include all the stakeholders and all their ideas about the research, but then we took it (stakeholder's input) back and chose our own focus" (B. Schaap, personal communication, April 8, 2010). Clear expectations from the process and this interaction were provided to farmers and other stakeholders from the outset.

> I told the farmers that they (researcher team) took their remarks very seriously but…there are researchers who can think differently and if there is a disagreement we take it with us and we make a decision on what is wrong and what is right and they (farmers) accepted that. (B. Swart, personal communication, April 9, 2010)

However, for the thematic workshops on climate change related risks and management alternatives where explicit input from the farmers was sought, the epistemological authority was allocated in the farmers who with their vast practical knowledge and experience were able to provide farm- and soil type-specific information.

> When we made some proposals on measures they (farmers) did comment on that and they would say if something was a real problem or if they could handle something by themselves. And this, they (research team) took really seriously and in some cases we changed our minds and in some cases we thought: "ok, we didn't think about that". (B. Swart, personal communication, April 9, 2010)

> The researchers did a good job in being really respectful with the farmers and saying, you know about this better than we do and we need you for this. Sometimes they would have follow up questions to have farmers be more specific but they never questioned their views or the information they provided. (J. de Kraker, personal communication, April 26, 2010)

The aim of these workshops was achieved as rich and detailed discussions took place, resulting in very concrete feedback for the research team. The information that was provided was specific to their farms and sub-regions[7]; therefore, farmers constituted a valuable source for this type of input. "This is the type of information that is not available in the literature or at least the scientific literature so the researchers would have never found it anywhere but consulting the farmers themselves and other people in the sector" (J. de Kraker, personal communication, April 26, 2010). The incorporation of stakeholder's input in the study reflects the recognition of a plurality of valid sources of knowledge and the search for integration to produce increasingly relevant information outcomes. As Jasanoff argues, this co-production of knowledge constitutes a way to avoid strategic omissions (Jasanoff, 2004). It also enhances the efficiency of the process as inadequate adaptation measures or research paths are discarded based on the input from farmers and other stakeholders regarding the reality of the context.

Furthermore, reflecting on these complementarities regarding information and knowledge from practice, most interviewees pointed out the level of education and often, specialization of Dutch farmers.

> What is special in this case is that the farmers in the Netherlands are highly educated and we as scientists do not have more knowledge than they have…(they) know they have a lot of knowledge and…they were really happy that they were involved in this process. (P. Reidsma, personal communication, April 8, 2010).

> Practical thinking is something that farmers know very well and sometimes they also have better ideas than we have. You should accept that they have ideas as well and just by talking you can learn from them… you have to work with them and so far it's working well. (A. Rispens, personal communication, April 7, 2010).

This contextual feature has significant implications for the interaction; despite the dissimilar nature of the information, it results in an advantageous starting point for fruitful exchange (H. Meinke, personal communication, April 8, 2010).

3.1.4 Quality control

Aside from following transparent methods to conduct the study, the collaborative arrangement and flexible incorporation of stakeholders' input served as a continuous control of the process. Feedback on feasibility of identified adaptation measures guided the research towards viable and relevant measures (B. Schaap, personal communication, April 8, 2010; J. de Kraker, personal communication, April 27, 2010). Furthermore, realizing that most adaptation measures can be taken at the farm level results in outcomes that are relevant to the reality of the context; creating unnecessary regional plans on this matter would reflect poor quality of the research process.

[7] Classified by soil type. (Joop de Kraker, personal communication, April 26, 2010)

3.1.5 Identified boundaries and boundary work

The following are what the researcher of this study identified as the main challenges or boundaries through the process of this collaborative research project. Presented here are also the strategies and actions developed by the project management team to work around and across them when possible. A key agent in the recognition and management of these boundaries was the consultancy firm Grontmij. They served as a bridge between the research team and the different stakeholders in facilitating and creating a broader sense of accountability of the project.

3.1.5.1 Translation

The frequent clash between science, policymaking and society described in literature was confirmed by remarks made by all interviewees. They articulated this clash as a communication barrier for efficient interaction; "(the challenge was) getting a real dialogue on the grass-root level between scientists, local government and farmers (since) they are not used to speak each others' 'language'" (P. Prins, personal communication, April 27, 2010). Moreover, it was stated, "we have a lot of meetings and you see how it is difficult for scientist to talk to farmers because they each have different vocabulary…and different levels of thinking" (B. Swart, personal communication, April 8, 2010). What can be described as a visible degree of incompatibility or different *languages* among groups is explained for this case in terms of differences in lingo, time perspectives, levels of analysis and problem framing approaches.

3.1.5.1.1 Lingo

Although used to preparing reports for non-scientific audiences, the research team paid special attention to the use of scientific jargon when interacting with stakeholders during the presentations and workshops. When dealing with this particular audience, the high level of education among farmers proved challenging to cater as some of them not only understood but used some scientific terms with ease (P. Reidsma, personal communication, April 8, 2010). Some farmers are very knowledge driven and they often hold highly specialized farming related knowledge (J. de Kraker, personal communication, April 27, 2010). However, this cannot be generalized for all farmers. Thus, reports were written in a very accessible way so not only the average farmer could interact with the information but other stakeholders as well (P. Prins, personal communication, April 8, 2010). During the early development stages of the project and before the introduction of stakeholders, the proxy for farmers' voice was LTO Noord's secretary of the Provincial Board Groningen, Peter Prins. Further, he has also provided feedback and validation regarding the clarity of contents when designing material to be used or shared with farmers and other stakeholders (B. Swart, personal communication, April 9, 2010; P. Reidsma, personal communication, April 8, 2010).

3.1.5.1.2 Short vs. Long-term perspectives

Within science a long-term perspective is usually incorporated if not central, especially when studying complex issues regarding socio-ecological systems as there are important time lags to acknowledge (Kates, et al., 2001). This time perspective certainly differs across different groups and within the CCANN study this disparity was clearly observed; "It's difficult because farmers are thinking four or five years because they have the rotation in the crop system" also, "(it's challenging) getting farmers involved in a problem that will occur in the longer term" (P. Prins, personal communication, April 8 & 27, 2010). Not only was this discrepancy identified but also the concern about the implications of a prevailing short-term vision among farmers arose through the interviewees' remarks.

> A lot of farmers think economically and they want to make money in the short term and in a way that is the wrong direction because we (farmers) only focus on getting the most money out of our soils, so first of all we need to think about the soil. (M. Schuiringa, personal communication, April 8, 2010)

This obstacle checks the fluency of the conversation. "Farmers were very technically and operationally oriented in terms of measures, it was difficult for them to think in strategic terms, that is, long-term and drastic changes. Their point of departure is the current situation" (J. de Kraker, personal communication, April 27, 2010). If not managed correctly, the valuable practical and farm specific perspective that complements the more ample analysis of science can be in itself an obstacle for a fruitful debate.

In order to bring the dimensions of climate change related events closer to the farmer's mindset, experiences with extreme weather events of the past in the voice of the farmers themselves, were used to exemplify what the region might face in the next decades in a scenario-like exercise.

> Farmers have a lot of experience with flooding and drought. It has happened before, 10, 30 years ago. Now we are doing some publications in our newsletter to bring that back and say: look do you remember what happened back then? It will be worse in 30 years from now. And that is the way we try to make it more real for the farmer and to make them think about the possibilities ahead. (P.Prins, personal communication, April 8, 2010).

The limitations of seeking engagement by emphasizing the negative consequences of climate change have been debated lately (Leiserowitz & Fernandez, 2007). However this approach can prove useful if relevant issues are presented in a transparent and relatable manner (Godet & Roubelat, 1996).

3.1.5.1.3 Holistic vs. fragmented levels of analysis

Farmers operate in a very specific reality, where different market variables, weather conditions and resource availability among other factors are in constant interaction and as such are incorporated in daily farm management and decision-making. On the other hand, the tendency to compartmentalize issues in order to perform a close examination is commonly found in science. These perspectives were also observed to have constituted a challenge through the participatory sessions with farmers.

> One of the things that struck me was the different ways of thinking of the farmers and the scientists…they have a different view. (During the adaptation workshops) the scientists neatly presented all the information in a scientific way so everything was split up into different sectors, different risks and different measures. The first thing that farmers do in response is to connect it again to the rest of the factors in farming. They don't like to isolate a single factor or a single risk or a single measure. They really have this typical holistic approach…they see it all connected. So for every sector, every risk and every possible adaptation measure that was presented by the scientists, they immediately started placing it in the broader wider context of their whole farm management. (J. de Kraker, personal communication, April 27, 2010).

This phenomenon also served as feedback in the interaction for both science and practice. As an observer, de Kraker also noted "(it was) sort of difficult for the scientist but it's good as a reality check, because that is the reality of farming, farmers don't perceive separate risks and think in isolated measures".

3.1.5.1.4 Problem vs. opportunity framing

Climate change has been the center of vast research efforts that study its implications and likely effects. These however have had usually a strong focus on the negative impacts and threats to social and environmental systems (Leiserowitz & Fernandez, 2007). Still, for the Northern part of The Netherlands, a large share of the expected consequences of climate change will be in general terms, beneficial for agriculture and most of the adaptive management for the likely negative effects can be done at the farm level. This is something that farmers are increasingly aware of; "the experts predicted that a lot of bad things would happen but for us it's the opposite because climate change is good for us. There are fewer chances of diseases with dryer summers and as for the other problems, we can solve them" (M. Schuiringa, personal communication, April 8, 2010). From his experience in the project, de Kraker describes how in the sessions he attended, the tendency for the discussion to have, as main focal point the negative side of climate change, was present. "Climate change was very much framed as a threat, other than during the introduction, when both opportunities and threats were discussed…the discussion was all about risks nothing about opportunities" (J. de Kraker, personal communication, April 27, 2010). This bias was something that was acknowledge from the setout and incorporated as a challenge for the project; "to present chances for enhancing the strategic position of farmers in the Northern Netherlands, not only focusing on al kinds of threats, which is most common, was one of the main challenges" (P. Prins, personal communication, April 27, 2010).

3.1.5.2 Expanded accountability

Producing actionable information outcomes requires the efficient integration of the actual users' perspectives and concerns regarding the topic. The development of a joint process from the outset is therefore key (Meinke, et al., 2006). Grontmij, who as mentioned before was in charge of the design and the facilitation of stakeholders meetings, did so in an open and integrative way. From single meetings to the project at large facilitating interaction and negotiation remained one of the vital tasks for Grontmij.

> Each participant in a project has its own focus and wants to talk about it. Sometimes there is one more prominent participant that wants to establish his or her own agenda over the others and the others lose interest, they act as if they had no purpose in the project. But you must want something for yourself. (B. Swart, personal communication, April 9, 2010)

Most interviewees commented on the value of having strategic facilitation throughout the project. Not only in terms of steering the discussions and preventing any sidetracked conversations but also for harnessing the plurality of perspectives within the project (P. Reidsma, personal communication, April 8, 2010; B. Schaap, personal communication, April 8, 2010).

Moreover, to increase the ownership of the aims and project outcomes, Grontmij consulted key actors to capture their opinions and particular information needs in order to efficiently incorporate this input in the design of the project.

> It's very important to make it so that every participant can see himself or herself in the project. The biggest problem was to try to bring together all these different perspectives from science, farmers, policymakers and LTO because they all have different opinions regarding methods and practices. But it is always more challenging to make your own story and try to sell it to others. (B. Swart, personal communication, April 9, 2010).

3.1.5.3 Mediation

As argued by Clark and Holliday, successfully managing the gaps between supply and demand of knowledge requires boundary organizations that serve as bridge at two levels, that is, between use and production of knowledge as well as various disciplines (Clark & Holliday, 2006). The observed basic discrepancy around the issue of climate change and its effects on agriculture on the region can be seen in the different approaches of each end of the knowledge supply chain. "A farmer sees a problem when he faces it and looks for a solution within his reach. A researcher thinks in a very high level and wants to know everything first" (B. Swart, personal communication, April 9, 2010).

Although difficult, coordinating and facilitating negotiation is highly valued as it moves the project's outputs one step closer to actionability. Policymaking is situated between science and practice; it needs the former's input to legislate for the later. Obtaining workable input is key as Willem Huizing from the Province of Drenthe further describes:

> We need science to make policy for practice (agriculture)…when we have just science it's very hard for us to translate it to policy. For us is very useful because when you have the influence of practice then it makes science move to practice, when we get a pure scientific outcome it's hard to translate it to policy and to implement it. Most governmental organization use very less scientific work because of this problem with the translation they don't know how to fit it or how to make a link with their policy.

What could be described, as maximization inertia, requires careful mediation and the facilitation of educated trade-offs.

> In my opinion science has its own rules and one of the problems in the project was that when you make a scientific proposal, then you make a proposal from the beginning till the end. When you talk about collaboration then you have, stage one and you listen to your stakeholders and then design your stage two incorporating their ideas from practice and that was the essential part of the project but that doesn't fit with science…collaboration is a good thing but it gives practical problems. (W. Huizing, personal communication, April 9, 2010)

Other interviewees also pointed out this clash of perspectives on how to conduct the project and their limited navigation skills for this type of collaboration. This in turn accentuates the significance of boundary work that assesses each argument and strategically facilitates a decision regarding a way forward. In the case of the CCANN project, most interviewees recognized the labor of Grontmij in navigating this collaboration (J. de Kraker, personal communication, April 27, 2010; P. Reidsma, personal communication, April 8, 2010; P. Prins, personal communication, April 27, 2010; B. Schaap, personal communication, May 3, 2010; H. Meinke, personal communication, April 9, 2010).

3.1.5.4 Boundary objects

The value of boundary objects, argues Cash, lies in their capacity to bring diverse audiences together. They are powerful in that they can be used by stakeholders from different groups with ease. Furthermore, they can serve as starting point for collaborative tasks between producers and knowledge users. Such processes can result in increasingly rich, transparent and relevant outcomes (Cash, et al., 2002).

This was pursued and valued within the project, "the workshop format is very good because working together for example with maps or other documents informs policy very well" (W. Huizing, personal communication, April 9, 2010). Additionally, according to the interviewees' experience, it increases participation and ownership of the outcomes.

> You have to have something on paper, a map, scenarios or a draft of a plan. If you come with nothing then it's too vague for farmers and they lose interest, if it's too specific and more less finished then that plan or initiative is not theirs and they don't feel connected to it so you also lose participation and cooperation to do it. You have to have something to serve as starting point to the conversation. (A. Rispens, personal communication, April 7, 2010).

3.1.5.5 Institutional rigidity

As described in section 2.2, initial discussions between LTO Noord and Wageningen University revolved around a common research initiative. The method for the project was long debated, as the way the scientific and practical approaches were designed to interact was contested. The practical orientation of the project was something that the regional donors, which provided 55% of the funds, explicitly sought and supported. After several rounds of outlining a research proposal an agreement was still not reached and discrepancies on the weight that the scientific and practical components of the project should have, remained. Consequently, the original single project split into two: AgriAdapt-NL, which is referred to as the *scientific-oriented* project and Climate Change and Agriculture Northern Netherlands, referred to by the interviewees as the *more practical-oriented* project. In 2009 the CCANN project received, after long deliberation, the remaining funding from the National Climate Changes Spatial Planning program, which usually sponsors more traditionally structured scientific programs. (B. Schaap, personal communication, May 11, 2010; B. Swart, personal communication, April 9, 2010; P. Prins, personal communication, May 17, 2010).

Despite the project split, the partnership with Wageningen remained throughout the CCANN project. The research initiatives were meant to run in parallel and in close contact so important feedback could be included. AgriAdapt-NL program experienced some delays and started later, in 2008, affecting the interaction between projects, however some research staff currently participates in both projects, injecting some continuity and ensuring key outcomes inform the AgriAdapt-NL study (B. Schaap, personal communication, April 8 & May 11,2010).

Current institutional and funding arrangements shape how research is designed, executed, employed and communicated. Even if born out of the recognition of a pressing information need within a specific context, research initiatives might take different forms and distance themselves from the original demand once they are taken up by knowledge producers. This usually leads to a disconnection between what is needed by decision makers and what current arrangements are able to supply (Meinke, et al., 2006). In this case, failing to agree on an optimal balance of science and application resulted in two funded research initiatives. However, that might not be always the case. The complications that less traditionally structured projects face when trying to secure funding or other institutional support could lead to significant compromises in their nature and to lost opportunities to create more integrative ways to supply decision makers with pertinent outcomes.

> It's hard when there are strategic decisions to fund strict scientific projects. If they (sponsors) would say let's maximize the implementation focus of our projects then it would be much easier. They prefer generalizable and transferable knowledge. (W. Huizing, personal communication, April 9, 2010).

> For that (problem based research) you need institutions that are actually supportive of these types of, by necessity, cross-institutional partnerships and we don't have the institutions to do that. It would help if there was more recognition of this types of issues at the highest levels so that we can come up with institutional arrangements that help us to easily work across these sorts of boundaries, to share resources and generate income for the research that we need. (H. Meinke, personal communication, April 8, 2010).

Furthermore, Jürgens points out how scientists, policymakers and stakeholders all respond to different interests and motivations. Considerable work is needed to find common integrated and interactive research models and Jürgens points to science to sort out a balance (Jürgens, 2004).

3.1.5.6 Key leadership

It was pointed out that a key aspect of the project and its performance has been the dedication from the project leadership team, LTO Noord's Peter Prins and Grontmij's Bjartur Swart. They have provided continuity and pertinent follow up as well as crucial boundary work and more recently, further national and international exposure for the project. (W. Huizing, personal communication, April 9, 2010). Given the challenges that such a project might face in the current context, success in developing it heavily resides in the persistence of its leader or leadership team; "If he stops it will collapse, it is the enthusiasm of the man" (B, Swart, personal communication, April 9, 2010). Elkins and Keller described how leaders who engage in boundary spanning and championing for the project constitute a key success factor within research efforts (Elkins & Keller, 2003).

3.2 Byproducts of collaborative efforts

3.2.1 Mutual learning

Past studies show how in collaborative processes where different interests and approaches tend to collide, participants can develop an enhanced awareness of the others' needs and perspectives as well as further their knowledge base with a more systemic understanding of the topic at hand (Siebenhüner, 2004).

Interviewees expressed how they could observe these learning processes throughout the project. This was commonly identified as the complementarity of practice and theory.

> We are working together and this makes the scientists learn from farmers and farmers get information from scientists. There is an evolution from the very first meeting where probably the expectations were really low but now. (We see that) there is something going on here and we can learn from each other. I think it's very important to continue, especially to get scientist and farmers together about the practical experience that farmers have and the knowledge that scientist have. It's interesting to know how the changes will happen in order to adapt to the new context. (M. Schuiringa, personal communication, April 8, 2010).

> Through this collaboration agriculture gets knowledge from science and science learns from practice. In science they like to work using models, at a certain level this is good but when you look at the farm level it doesn't work because the farmer knows his land better than a model. (W. Huizing, personal communication, April 9, 2010).

The exposure to other types of information and perspectives also triggered critical reflection. From CCANN researchers' perspective, the process prompted considerations about how stakeholders use research outcomes and the role of science in delivering knowledge to different audiences (B. Schaap, personal communication, May 3, 2010).

> It's a kind of awakening, being in such a project. It's like holding a mirror in front of you and you look at yourself and say do I really understand what is going on? Do I take actions to solve the problems for the future? (M. Schuiringa, personal communication, April 8, 2010)

The frank and very articulated acknowledgment of mutual learning processes could be related to the stage of the project in which the interviews were conducted. As described by Swart, expectations about rapid mindset changes within these processes are erroneous. The focus should no be allocated in trying to force a change in the stakeholder's mind but in facilitating an open exchange of knowledge and visions.

> When there is a discussion it is good to work out the differences between the two visions and then leave it. After a while you can hear from people if that affected their vision, but when they are not sitting at the table and they don't have to admit a defeat because people see it often as a defeat, then they will say, yeah maybe we should think about it in a different way. It's these little steps. (B. Swart, personal communication, April 9, 2010).

As Polk argues, the key task for the transdiciplinary researcher is to expose the diversity of value and instrumental rationalities. Learning based on this dynamic of open exchange and reflection serves as a solid foundation, according to Polk, for knowledge that is legitimate and whose accountability is more spread out in society (Polk & Knutsson, 2008).

Finally, the second component of social learning, moral development, was identified. This was reflected mainly in the participants' valuations of the process and their willingness to cooperate in the future (Siebenhüner, 2004).

3.2.2 Impacts on salience, credibility and legitimacy

The origin of the CCANN research project resided in an articulated need to know more about the potential climate change effects on agriculture in the northern region of The Netherlands. This knowledge need stemmed from a conjunction of increased awareness and the occurrence of unusual weather events such as heavy rains, floods and especially dry and hot summers in the preceding years (P. Prins, personal communication, April 8, 2010). The fact that this research initiative was generated on the end user's context, translates into increased relevancy of the project. Having as base the information needs of the user world, in this case, the Dutch agricultural sector, makes the research outcomes that much more compatible with the current context (Cash, et al., 2002).

Regarding the timing, several stimuli from coverage on television and other media to informal talks and odd weather events, created a juncture where the need for information was fully internalized (P.Prins, personal communication, April 8, 2010). Therefore the information outcomes come at a time when they are highly needed to develop pertinent adaptation measures in advance and avoid erroneous investments or decisions.

In addition to these factors, another aspect that increased the salience of the program was the close collaboration with farmers and other stakeholders. Through this frequent interaction the focus of the project was redefined according to the input from the practical hands on knowledge. It could be described as an iterative process where the research team would present their research outcomes in order to obtain feedback from stakeholders on the topic. This input was of great value as it allowed the research team to follow the agreed pertinent research paths as well as present the information that would be relevant to their audience (B. Schaap, personal communication, April 8, 2010; J. de Kraker, personal communication, April 27, 2010).

Implications of the collaboration of different stakeholders within the research program include the increase credibility of the knowledge outcomes. While not all the information had an academic source, various interviewees admitted that the input from stakeholders is considered valuable and serious as they hold great practical knowledge and long experience in the sector.

Furthermore, there was an explicit effort to create a plural partnership from the outset, however given the context that framed the project, a strong farmer presence in most stakeholder sessions was observed. Despite this fact no major concerns regarding the legitimacy of the process were raised during interviews. There was only one observation regarding unrepresented groups during some of the adaptation workshops. After consultation with the project management it became clear that there was no explicit desire to make exclusions within different farming sub sectors however a cap on government official was set to prevent other stakeholders from openly voicing their opinions (P. Prins, personal communication, April 26, 2010).

Managing different project variables in order to find an optimal balance between the tension and complementarities of information attributes such as salience, credibility and legitimacy can be a difficult task (Cash, et al., 2002). When dealing with different stakeholders and project partners some voices tend to be heard more than others. In this case, the number of government stakeholders was limited in some sessions with the aim of creating a comfortable environment for the farmers to freely express their concerns and feedback for the study. A trade-off between salience from specific guiding input and legitimacy of the process can be identified.

On the other hand, having LTO Noord as head coordinator of this project had a positive impact on both the salience and legitimacy of the outcomes. Throughout the program, the presence of LTO Noord ensured the goals and research aims remained close to the context and the information demands of the targeted end users. Additionally, it enhanced the perception of legitimacy of the process in the eyes of its key audience; “to have the involvement of LTO Noord gives a lot of trust” (B. Schaap, personal communication, April 8, 2010).

4. Discussion and lessons

4.1 Revisiting the research questions

The initial inquiry that guided this study is revisited after having reviewed the case dynamics in detail. By drawing from the findings, among the key factors that contribute to obtaining actionable outcomes from collaborative research projects, it can be said that some factors support integrative understanding, while others add to the identification of feasible adaptation measures, that is, to the actionability of outcomes. However they all operate simultaneously and strategic boundary work provides careful and tactical orchestration for this type of knowledge production to flourish.

These factors include:

-Rooting research efforts in participatory dynamics where a heterogeneous spread of voices coexists is essential for integrative understanding. This arrangement ensures that all important perspectives are well incorporated and a more systemic view of the issues that the agricultural sector faces is generated. In addition, creating open and receptive spaces to interact is a necessary condition to create a fruitful discussion. Finally, quality of the research efforts becomes, to some extent, inherent. For the Dutch project this meant not wasting resources on

an irrelevant integrated rural adaptation plan as most of this work will be done at the farm level.

-Designing efforts that remain close to the context where research outcomes are expected to be used. This forces the study to acknowledge the specific challenges of the sector and other contextual variables. An efficient identification of adaptation measures was achieved in the CCANN project by maintaining research close to the demands of the context.

-Recognition of other valuable and valid sources of knowledge. The integration of other relevant disciplines and different kinds of expertise is crucial as they have the potential to contribute aptly to the research aims in combination with frequent and well facilitated collaborative sessions. Flexibility regarding validity of other sources of knowledge, allowed the Dutch researchers to incorporate very farm specific and valuable information that otherwise would have been omitted as it's not available in the academic literature.

-Strong and motivated leadership, which in this context should be understood as strategic vision and facilitation with no epistemological authority over other sources of information is also essential.

-Effective identification and strategic management of boundaries. These can be identified as cornerstone for the operation and success of the research project. In dealing with barriers effectively, both the process and findings gain relevance, credibility and legitimacy, which in turn results in pertinent action.

However, through the study of this case, several challenges that commonly hinder the effectiveness of such collaboration projects were observed. These boundaries can be grouped under the lack of flexibility in current institutional arrangements and include, disciplinary funding incentives and operational inertia. This refers to a conventional focus on specialization and traditional approaches to research activities. Additionally, boundaries such as the quest of each group for the maximization of interests and traditional structures can hinder the efficient development of this kind of collaboration projects.

In the case of CCANN, boundaries between researchers, stakeholders and private partners did constitute a challenge for this project. As described before, not only do they have different perspectives and levels of analysis about the issue at hand but there are palpable barriers to collaboration. Based on this case, there is a need for scientist to be better equipped to liaise and work efficiently with non-academic sources of expertise. The link can be accomplished through strategic boundary work; in any case, scientists need to further their ability to communicate with broader audiences, that is, to summarize and present their work in simple terms, acknowledge the potential validity of sources of information outside the academic realm as well as immerse themselves in the conversations that the ultimate users of their research are having.

4.2 Key lessons

Although the generalizability of this case is limited by the specifics linked to the context and the actors involved, the results of this analysis serve as an indication of general lessons on collaborative research efforts. Similar problems are faced by other sectors such as forestry or fisheries and similar contexts such as the Northern European context could obtain useful inspiration to guide their approaches from the conclusions drawn from this study.

The main lessons that can be distilled from this case reside mostly in the benefits of designing research initiatives that acknowledge the complexity of issues such as climate change and let their approaches be inspired by the use and context of the information outcomes. The aforementioned factors contribute to reducing the gap between the information need of policy

and decision makers and the information being supplied to them as key attributes are enhanced. This confirms the theories reviewed earlier that argued such benefits generally result from more plural approaches to research.

However, the magnitude of the boundary management observed in the Dutch case was unanticipated. Especially when in comparison to other settings, there are tangible factors that give it a head start. For instance, participants were highly educated and experienced farmers and stakeholders. Additionally, the sustainability debate has been well incorporated in the Dutch scene for some decades now resulting in comparatively high awareness of the general concepts linked to sustainability issues.

The implications of different settings, would call for very intense boundary work. For example, while in developing countries farmers do possess practical knowledge, some discussions might be hindered by the inability to find a space where research and stakeholders get passed a unidirectional conversation and engage in true dialogue and collaboration. Furthermore, issues regarding governance, health and poverty among others, generally place climate change at a lower priority as the lack of resources force a short-sighted focus.

Boundary work seems to be key within collaborative research projects and its weight in less prepared contexts would be even greater. Literature on the topic seems to limit the debate of boundary work to only boundary organizations and objects. This study points that in addition, the need for highly motivated practitioners within those organizations is paramount. By respecting the role of boundaries to ensure quality and transparency of research while creating certain porosity and flexibility, practitioners allow for other agents and sources of expertise to be included when pertinent. Having the sensibility to map knowledge needs and supply efforts across boundaries to coordinate appropriate efforts requires strategic brokering. These sustainability brokers, as termed here, should posses sharp process management capabilities for facilitating dialogue and collaboration, be knowledgeable about pressing socio-environmental issues as well as highly committed and motivated to create sustainable change.

4.3 Conclusion

In the face of complex sustainability issues, research efforts need to incorporate a thorough acknowledgment of the context, a wise orientation to use and facilitate educated trade-offs if actionable outcomes are to be obtained. Current institutional arrangements are not fully ready to support that, thus barriers for cross-disciplinary work include institutional structures, funding incentives, and boundaries that reflect a continuous quest for maximizing research outcomes into one particular direction, theory versus application.

Conducting research that is close to the context of its application and the integration of a heterogeneous group are key factors that enhance the usefulness of the information outcomes. Further, strong leadership and commitment is essential. If sensible boundary work is carried out for the integration of pertinent information and knowledge, research is more equipped to provide valuable input for decision-making.

Based on the findings of this study, some recommendations include funding incentives that encourage collaborative research projects and transdisciplinary initiatives as well as further research that explores the role of sustainability brokers in boundary work. Important questions include:

- Who should conduct this work?
- What characteristics should a sustainability broker have in order to better conduct the interaction with stakeholders in different sides of boundaries?
- What are the further limitations of such an endeavor?

Addressing these key questions would shed light in what currently seems to be a task conducted in the background. The focus on boundary work stems from the recognition of its role as a buffer and key facilitator when conducting collaborative research efforts in context where boundaries might be plentiful. The amount of boundary work can be adjusted to fit for example, the developing/developed country context continuum. Additionally, it constitutes a key pillar for collaborative and epistemologically plural research and will remain so as long as institutional structures and other barriers continue to hinder true integrative use-inspired research.

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6. Appendices

Appendix I: Interview topics and key questions

Research project basics and dynamics

-What is the context that frames the study?
-What is the aim of the study?
-What was the methodology of the study?
-What was the decision-making process like within the study?

Factors related to better understanding for problem definition and research needs

-How was the study initiated?
-How was the process of problem formulation?
-How was the input from stakeholders obtained and used?

Factors related to the identification of effective adaptation measures

-How were the adaptation measures identified?
-How was the input from stakeholders used and how was this process carried out?

Factors related to the ownership and implementation of effective adaptation measures

-How is the project equipped to further the effectiveness of the knowledge produced?
-How is the knowledge produced used in regional strategic planning?

Factors that constituted a challenge in the process

-What were the factors that posed a challenge during the study?
-How did the project management dealt with them?

Dynamics of knowledge production and mutual learning

-Did the collaboration process created a site for knowledge production?
-What were the tenets during collaborative sessions?
-How was the input from stakeholders viewed by researchers and how did this impact its incorporation in the study?

Appendix II: Information on case interviewees

Information on the ten interviewees of the present study

Name	Organization	Role in case study
Peter Prins	LTO Noord	Project Leader
Bjartur Swart	Grontmij	Facilitator/Researcher
Ben Schaap	WUR-Plant Research International	Researcher[a]
Jan Verhagen	WUR-Plant Research International	Researcher[b]
Willem Huizing	Pronvincie Drenthe, Regional Government	Workgroup member
Aaltje Rispens	Wetterskip Friesland, Water Board	Participant
Menno Schuiringa	Wieben Farming	Participant
Pytrik Reidsma	WUR-Plant Production Systems Group	Observer[c]
Joop de Kraker	Open Universiteit Nederland	Observer[d]
Holger Meinke	WUR-Centre for Crop Systems Analysis	Not involved[e]

a= Researcher in both CCANN and AgriAdapt-NL projects.
b=Researcher in CCANN and project leader of AgriAdapt-NL.
c= Observer in CCANN and researcher in AgriAdapt-NL.
d= Observer in CCANN and researcher in AgriAdapt-NL.
e= Advisor in the AgriAdapt-NL.

Appendix III: Final reflection on methodology

A final reflection on the methodology chosen for this study results in considerations of the use of comparative cases to complement the robustness of the outcomes. In this study, the framework serves as the basis for analysis, while useful, further comparisons with other case(s) would help to better discern between factors inherent to the context and systemic variables.

Appendix IV: Timeline CCANN

July 2004 Initial talks between Grontmij and LTO on climate change and agriculture.

Sept 2004 Expert's meeting about climate change and agriculture.

Oct 2004 Decision to design a collaborative research project on the issue.

2005 CCANN gets green light from LTO and search for funding starts.

Dec 2006 Funding secured from province of Friesland.

2007 Funding secured from other regional partners (provinces and water boards).

Jan 2007 Phase I begins.

Jan 2008 Stakeholder meeting regarding Phase I.

June 2008 Phase I concludes and respective report is released.

Jan 2008 Phase II begins.

Apr 2008 Stakeholder meeting Phase II: dairy farms.

May 2008 Stakeholder meeting Phase II: arable and horticulture farmers.

June 2008 Stakeholder meeting Phase II: horticulture/greenhouses.

Feb 2009 Stakeholders meeting on Phase II results; assessing adaptation measures.

Mar 2009 Funding secured from BSIK, National Climate Changes Spatial Planning Program.

June 2009 Fieldtrip to Italy (Veneto region) with farmers, scientists and project leader.

Dec 2009 Phase II concludes.

Dec 2009 Phase III begins with adaptation workshops ateliers for several regions/activities:
-Northern Friesland and Groningen / Arable farming.
-Central Northern Netherlands / Dairy farming.
-Oldambt, Veenkolonien / Arable farming.
-Flevoland / Arable and cattle farming.

Mar 2010 Adaptation workshops conclude.

Apr 2010 Special meeting on climate related crop and animal diseases and pests.

June 2010 Special meeting with bulb growers.

June 2010 Phase III concludes.

Dec 2010 Final reports.

Appendix V: Key participants CCANN

For the CCANN project, a consortium was created which included the following members:

Key collaborators
- LTO Noord
- Grontmij consultancy firm
- Wageningen - Alterra
- Wageningen - Plant Research International

Additional project partners
- Province of Friesland
- Province of Groningen
- Province of Drenthe
- Friesland Waterboard
- Noorderzijlvest Waterboard
- Hunze en Aa's Waterboard
- Reest en Wieden Waterboard
- Velt en Vecht Waterboard
- Zuiderzeeland Waterboard
- Northern Agricultural Council
- Ministry of Agriculture, Nature and Food Quality

(LTO Noord/Grontmij, 2008).