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Managing agricultural nutrient leaching within the EC Water Framework Directive in Sweden

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Linköping 2003

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Stubble field and plowed field

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To the memory of my parents,

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Abstract

Agricultural management practices geared towards reducing nutrient leaching are in focus for the research presented in this thesis. Critical measures for reducing diffuse pollution from the agricultural sector depend on decisions of individual farmers. It is useful to take stock of what different stakeholders are actually doing to reduce nutrient leaching and analyze their reasoning before defining a new administrative process. Stakeholder perceptions about potentials and problems concerning management of agricultural practices are analyzed with a systems approach using various analytical methods, and put in relation to the implementation of the EC Water Framework Directive in Sweden. The methods used include surveys, focus group interviews, model comparison, sensitivity analyses and analyses of climate change implications.

The results indicate a general positive attitude among stakeholders towards the main characteristics of the newly introduced directive. They also reveal that a move towards a pro-active process was perceived as an additional positive factor for the improvement of water quality, where specific activities and measures are carried out according to planning based on local assessments. The respondents pointed out that a national approach would put necessary pressure on local politicians to define environmental objectives and provide resources to fulfil them. The current findings indicate that decision making for farmers is a complex procedure and that the different factors need to be addressed in order to obtain a change in agricultural practices.

Consistent legislation that is clear about power and rights is fundamental for cooperation to function when volunteerism and enthusiasm are absent. Environmental and socio-economic conditions change constantly, and administration has to be flexible to be able to adapt. Having access to and being able to use relevant data is only one important factor for stakeholder involvement. To give farmers the opportunity to further develop production towards reduced nutrient losses, appropriate information provided in all the right arenas is crucial.

Linköping 2003

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Many describe their doctoral studies as a journey. For me it has definitely been a rare station in my life. A station where I caught up with myself and my luggage to ponder about what it amounted to. However, it has been a station with ample opportunities to look for more luggage. Also forgotten and lost bags kept arriving and I dealt with them as well. I collected, sorted, threw away, recycled and treasured. It goes with the trade that I sometimes found myself quite lonely. At other times the station was busy with people coming and going, some kept me company awhile, others rushed on. Some I went looking for, others I found by chance and some came for me. You have all added your piece, so I could finally consider my stay sufficient. Thanks ya'all! Now I am done, and what remains is solely my own responsibility.

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Life itself.

This said, all there remain for me to say about my dissertation is to quote what my mother taught me a long time ago:

Ut desint vires
Tamen est
Laudanda voluntas
Ovidius

I see our train coming into the station, this time I am ready to jump on board. Where do I go from here?

The thesis is based on the following publications, which will be referred to in the text by their Roman numerals and are appended to the thesis:

I. Bratt, A. *Local Knowledge for Management within the EU Water Framework Directive in a Swedish Region.* In Nilsson, T. (Ed) Nordic Hydrological Conference 2000, Volume 2, Uppsala 26-30 June 2000, pp. 463-471.

II. Bratt, A. *Farmers' choices - Management practices to reduce nutrient leakage within a Swedish catchment.* Journal of Environmental Planning and Management, 45(5), 673-689, 2002.

III. Bratt, A., Andersson, L., Sandén, P. *Farmers questions and model answers on nitrogen leakage.* (submitted).

IV. Bratt, A. *Municipal officers on implementing the EU Water Framework Directive in Sweden regarding agricultural nutrient flows.* Local Environment 9(1) February 2004 (in press).

V. Bratt, A., Graham, L.P., Sandén, P. *Potential changes to nutrient leaching from adaptation of Swedish agricultural production to climate change.* (submitted).

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When you get up from your book
dive into what you have learnt
to discover
if there is something
you can transform into reality

Nahmanides

Managing agricultural nutrient leaching within the EC water framework directive in Sweden

(1) Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such.
Preamble Dir 2000/60/EC(European Community, 2000)

1. INTRODUCTION

Studies in local knowledge about environmenal issuess and their management contribute to a better understanding of institutional structures and administrative forms necessary for sustainable resource management (Berkes, 1999; Fisher, 2000; Gibson et al., 2000a; Handmer et al., 2001). Sustainable use of natural resources encompasses use for production in such a manner that future generations can receive the same resource possibilities as those of today (World Commission, 1987). It involves different stakeholders within a geographical area using the resources, possibly having divergent interests. The resource in focus for this thesis is water. The issue of concern is the challenge of changing agricultural production practices in order to reduce eutrophication, a major environmental problem for lakes, rivers and coastal waters surrounding Sweden.

"Zero eutrophication" is a Swedish national environmental quality objective that has not been achieved with present implementation efforts, according to a recent report from the Swedish Environmental Protection Agency (SEPA, 2002). In the Baltic Sea, the principal cause of eutrophication is nitrogen leaching from agricultural production (Arheimer and Brandt, 1998; Hoffman and Johnsson, 2000; OECD, 2000). In contrast to point sources, critical measures to reduce nutrient loads are in the hands of individual farmers who act independently of each other. Farmers ward off further regulation encroaching on their production, while authorities in charge of environmental supervision claim it impossible to check upon each individual (Eckerberg and Forsberg, 1996). Thus, it is in the interest of both the farmers' associations and authorities that water management is carried out with reduced amount of control in the form of rules and regulations (SJV, 2000).

1.1 Impetus for a different approach towards water management

New national rules and regulations are under development to guide stakeholders and authorities in reducing nutrient leaching. With the aim to make an affirmative action to improve the quality of water, the EC Water Framework Directive (WFD) (European Community, 2000) is in force as of December 22, 2000. It is characterized by a landscape perspective, catchment-based authorities

and a participatory approach. The Swedish governmental bill on how to implement the WFD was presented to the Swedish parliament during the fall of 2003 (Government Bill, 2003/04:2). The WFD could constitute an impetus for changed resource management by encouraging a systematic approach to water resource management, as compared with the previous fragmented approach according to separate directives. The EU Commissioner Asger Olsson has described the directive as "An ambitious planning instrument for spatial development, a venture combining spatial planning, water policy and social cooperation". However, analyses of the directive point to the fact that it is a framework with potential, but it needs to be complemented with detailed specific legislation and operative rules and regulations to be functional (Gipperth, 2002; Grimbeaud, 2001a; Grimbeaud, 2001b; Grimbeaud, 2001c).

Important background information is needed to assess where Sweden is currently positioned regarding the WFD objectives, in order to effectively internalize the directive objectives into procedures, regulations and legislation (Gipperth, 2002). It is important to assess how far we are today from the established objectives before it is possible to estimate which measures need to be taken. Research has shown that measures to come to terms with diffuse pollution from the agricultural sector depend heavily on the involvement of individuals. Their attitude towards altering production or changing methods is especially decisive for the outcome (Lundqvist, 2001a; Wittgren et al., 2000). To promote this, a greater understanding of motives and reasons behind decisions taken will better enable construction of well functioning sets of rules and regulations.

In paragraph 14 of the directive preamble, cooperation at all levels is emphasized as a necessary approach to make implementation of the directive successful. This aspect is presently not further elaborated in the directive or in the guidelines. However in article 5.2 of the WFD, the necessity to make information available to all citizens and invite comments at the planning stage is mentioned. Research in Sweden suggests that involvement of stakeholders in water management is crucial for sustainable implementation (Blomqvist, 2003; Burström, 1999). If active public participation is defined as worthwhile pursuit for Sweden, it is of importance to identify stakeholders' perceptions about relevant water management issues and to ensure their participation in the management process at an early stage. Thus, the composite knowledge from stakeholders at different levels is necessary to find efficient ways to reduce nutrient leaching.

Local knowledge provides insights for adaptive management and therefore constitutes a vital factor to be included for sustainability, as suggested by Berkes (Berkes, 1999). Farmers experience constant changes in their local conditions, which they must adapt to in their farming system (Gunderson and Holling, 2002). Socio-economic and/or natural developments constantly cause the environmental system to change at field level as well as at landscape level

(Hoekstra, 1998). These changes have an impact both on the environment and on the sectors of society that depend on the environment. Authorities will have to consider all of the different components affecting water quality within the entire catchment to reach the main WFD objectives. Consequently, reactive actions carried out both by authorities and individual farmers either try to reinstate the previous state of conditions or adapt management to the current state (Berkes et al., 2003; Olsson and Folke, 2001). This requires that rules and regulations guiding management are flexible enough to adjust to such changing conditions.

Before rules and regulations in an administrative process are constructed, it is valid to take stock of what different stakeholders are actually doing to reduce nutrient leaching and analyze the reasoning behind their actions. Concerning management of nutrient leaching from agricultural production, what does the situation in Sweden look like? The farmers' choice of agricultural practices to reduce nutrient leaching is influenced by various factors. Clarification of the different factors that the stakeholders perceive their decisions to be based on, will enhance the potential to move towards sustainable agricultural practices (Lundqvist, 2001a). The farmers' perception of and knowledge about eutrophication and its ecosystem implications is a key aspect guiding their actions (Blomqvist, 2003; Söderqvist, 2001). In addition, standpoints about sustainable water management that are held by stakeholder representatives are important. Examples of stakeholder representatives related to farming within the catchment include farmers' interest organizations, local authorities and environmental groups. Accessible information and decision-support tools also guide farmers' choices of which practice to use and are perceived to reflect current scientific knowledge. Authorities advise and supervise farm activities, thus their perceptions on how to efficiently reduce nutrient leaching are important and highly influential.

1.2 Related research

The research in this thesis is founded on and relates to other studies that raised the issue of diffuse pollution from agricultural production, framed the problem of farmers' involvement and currently work on development of strategies for integrated resource management. The approach of the present study agrees with recommendations from SEPA, where it is described as important *"To develop knowledge about the relationship between ecological, economic and social conditions in the coastal zone and its drainage basins"* (SEPA, 1996).

A government commission was appointed in 1996 to develop a Swedish administrative system for catchment based management of water related environmental and resource issues (SOU, 1997:99; SOU, 1997:155). As a result of this commission, several research projects were initiated to prepare Sweden for the coming implementation of the WFD. Various projects currently work

with objectives related to water resource management. Besides issues related to biogeochemical and technical aspects, the issues of public participation and cooperation between stakeholders are addressed.

In addition, research on nutrient leaching has been initiated by SEPA to respond to national and international demands on environmental monitoring reports. Within the project "Nitrogen from land to sea", the two main models used in Sweden for assessment of leaching losses from arable land, nitrogen flows and apportionment were further developed by the Swedish Agricultural University (SLU) and the Swedish Meteorological and Hydrological Institute (SMHI) (Arheimer and Brandt, 1998; Hoffman, 1999; Hoffman and Johnsson, 1999; Johnsson and Hoffman, 1998; Larsson and Johnsson, 2003; Pettersson et al., 2001; SEPA, 1997). The results have been fundamental in defining the issue of nitrogen leaching, the processes involved and estimation of counter-measures. The development of the models have continued in research projects concerning calculations of the effects of changing practices to reduce nitrogen leaching (Hoffman and Johnsson, 2000). Currently, models for assessment of phosphorous flows are under development by the same research institutes.

Some of the model development is carried out within the multidisciplinary research project VASTRA (Swedish Water Management Research Programme). Within the project, research related to implementation of the WFD concerning planning and management of water resources with focus on the role of institutions, conflict solving, policy development and decision support, is also carried out (Blomqvist, 2003; Collentine et al., 2002; Lundqvist, 2001a; Wittgren, 1998). Within the project, the Genevad simulation game tested a strengthened version of the Environmental Code and the results indicated the complexity behind farmers' decision making (Wittgren et al., 2000). In his analysis of the game, Lundqvist emphasized the importance to take into account that economic incentives does not by necessity overrule collective memories of local history concerning trust and reciprocity (Lundqvist, 2001a). Thus further investigation of the reasoning behind farmer's decisions is supported.

Swedish research on perceptions about management of natural resources is generally limited, especially in relation to farm activities. Internationally, researchers have explored the interactions and relationships among stakeholders involved with natural resource management (Fisher, 2000; Gibson et al., 2000a; Hanna et al., 1996). Many studies on local knowledge among resource users have been done in third world countries and among traditional societies, with a theoretical framework that has not been tried in so called developed countries (e.g. (Agrawal and Gibson, 2001). An exception is the scientific network Resilience Alliance, that in a series of publications developed an interdisciplinary conceptual framework to understand the dynamics of social and ecological systems and their linkages (Berkes et al., 2003; Berkes and Folke, 1998; Gunderson and Holling, 2002). The cases the framework is applied on are taken from different countries and cultures. As an example, Olsson and Folke

investigated the problem of fit between ecosystems and institutions in a Swedish setting and stressed the importance of taking the dynamics of the ecosystem, including social aspects, into consideration to obtain sustainable management (Olsson and Folke, 2001). In their conclusions, local ecological knowledge in collaboration with institutions is proposed as a key factor for development of successful management, which supports the postulate of the present thesis.

2. OUTLINE OF THESIS

The research was conducted in a step-wise process guided by a series of key questions. These questions are outlined below together with the aims of five sub-studies that form the basis for the five appended publications of the thesis (identified by Roman numerals).

2.1 Main objective and research questions

Agricultural management practices to reduce nutrient leaching are in focus for this thesis. It is based on local knowledge and experiences from different stakeholder representatives, farmers and municipal officers. **The main objective for the thesis is to analyze stakeholders' perceptions of the potentials and problems concerning management of agricultural practices. A further aim is to put the analyses in relation to implementing the EC Water Framework Directive in Sweden.**

An initial aim in the research process was the identification of the key stakeholders within the catchment and what they perceive to be the most important environmental problem related to natural resources. Clarification concerning their standpoints about problem solving and responsibilities were considered a necessary basis for further investigations. For the stakeholders within a local context to actively work towards a solution of a problem, the participation in identifying the problem is crucial (Chambers, 1997). **The specific aim here was to identify standpoints held by the different stakeholder representatives, as expressed in their views ─ perceptions and perspectives ─ on major environmental problems and their management in the catchment (I).** An additional aim was to narrow down the focus of further studies. Two major stakeholder groups, farmers and municipal officers acting at different local levels, were chosen for further studies to clarify the picture of what different stakeholders are actually doing to reduce nutrient leaching and analyze their underlying reasoning.

An examination of what the farmers are actually doing today to reduce nutrient leaching, and their underlying reasoning, is useful for future construction of a regulative structure. If their management practices are causing nutrient leaching, it is likely that these practices must be changed. It was critical

to identify the most important internal factors influencing the farmers' decisions, and what external sources they base their decisions on. Likewise, their perceptions about the value of nutrients adds important information to the material collected. **The aim of this study was to analyze the base of farmers individual choices of management practices for reduction of nutrient leaching (II).** The results were used to clarify the picture of farmers' perceptions on the effects that their choices of practice have on their economy and to identify factors that influence these choices.

This lead to queries of whether decision support tools for farm advice currently in use in Sweden produce adequate answers to the farmer's questions? Models are increasingly used in Sweden as a support-tool for decision making, both by authorities and by individual advisers of natural resource managers. This condition evoked the research question of whether the models were answering the crucial questions that the farmers use to base their decisions on? **The aim here was to further understand the relation between basis for decision, risk taking in farming enterprise, local conditions and current scientific knowledge on nutrient leaching used in advising farmers (III).** When the farmers evaluate the alternatives given in advice, they need to take the risk factor into consideration, related to farm production and to status of the environmental good.

Even if farm practices are in the hands of individual farmers, their actions are framed by rules and regulations, and supervised by local authorities. To map and take inventory of administrative boundaries with their established aspects of management adds important detail to the analysis. The farmers are presently interacting with municipal environmental inspectors. All stakeholders should be involved in local processes of decisions and practices according to leading documents on principles of sustainable resource management and the WFD. Would the WFD work as a guideline and framework for execution of authority in the case of nutrient flows from agricultural practices? These issues are expected to be dealt with within the officers' work agenda. How do municipal officers interpret the use of their authority under the new administrative forms of the WFD? What do they perceive as necessary conditions for sustainable implementation? **The aim here was to analyze the municipal officers' perceptions of the potentials and problems in implementing integrated catchment management of water resources, as proposed in the EC Directive (IV).**

From the ecosystem perspective, function and effect of change is an inherent component to take into consideration for management of natural resources (Gunderson and Holling, 2002). Arrhenius argued over 100 years ago that anthropogenic activities or natural variability cause changes in environmental conditions (Arrhenius, 1896). In the case of water, the WFD will set the frame for management in the EU member states from national to local levels of authorities. How can changes in conditions influence the implementation of the

WFD? Based on certain assumptions, how could a changed climate influence farmers' choices of altered agricultural production with corresponding effects on nutrient leaching? By exploring possible consequences of the condition 'climate change' on agricultural production, **the aim of the study was to highlight the impact that farmers' changes in agricultural practice may have on the implementation of the WFD (V).**

2.2 Thesis organization

In the next section, a short presentation is given of the main characteristics of the Water Directive related to the research questions. The following chapter introduces the concept of local knowledge associated to natural resource management. Included is a short background on Swedish agricultural policy. In the subsequent methodology section, the choice of an interdisciplinary study is based on a systems approach. In the same chapter the study design clarifies the relations between objectives and choices of methods and materials. The results are presented and discussed under two thematic headings, followed by conclusions and some words about the future.

3. EC WATER FRAMEWORK DIRECTIVE

In this chapter the background to the WFD and its main principles of sustainable resource management are presented, followed by the most important characteristics of the directive and its implementation in Sweden.

3.1 WFD background and objective

The Directive 2000/60/EG on "establishing a framework for Community action in the field of water policy" was passed in 2000. It has been called EU's greatest effort for the environment, as an indication of the priority given water resources within the Commission. The initiative was taken in 1988 and the contents has been developed and negotiated continuously since then (Aniansson and Vidarve, 2003). The member states could not agree on parts of the text as some issues carried incompatible opinions. The issues under major discussion were mainly related to how groundwater should be treated, which toxic substances to include, what carries most weight between public health and environmental health, and maybe the most important: what legal standing the agreement should carry, whether in form of a directive or only as a recommendation. A major issue for different opinions between the member states was the question of toxic substances, how to define them, decrease the usage of them and trace their sources. Water had previously been dealt with in many separate directives and recommendations, and the WFD is an effort to

make a forceful affirmative action. It contributes to EC compliance of international conventions on protection of water, e.g. the UNECE convention concerning transboundary waters and lakes, and EC's Council Directive 96/61 on Integrated Pollution Prevention and Control (IPPC).

A directive requires the signing member states to transpose the content of the rules to binding rules within a stipulated amount of time (Mahmoudi, 1995). The directive preamble is taken under the principle of subsidiary, i.e. art 5 of the EC Treaty. Referring to the transboundary character of water issues, the most efficient level for decisions concerning the WFD has clearly been defined at Community level. The directive demands that water quality of "good ecological status" should be obtained within 15 years (Art.2), however this is the minimum harmonizing level defining that Sweden and other member states are free to set higher standards than what is stipulated in EC legislation. The directive builds upon Article 174 of the EEC Treaty and accordingly on the precautionary principle, the principle of preventing pollution at the source and the polluter pays principle (OJ, 2002). Additionally, it is stressed that the member states should aim for sustainable water use and management, here understood as in accordance with the definition made by the Brundtland Commission (World Commission, 1987), *"Humanity has the ability to make development sustainable─to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."*.

The member states are formally free to implement directives according to their own preferences (Mahmoudi, 1995). However, in EU history there are numerous examples where member states have not complied with implementation of directives. To avoid the implementation period expiring without compliance, followed by judicial action from the commission, an effort has been launched to facilitate appliance for the member states. The guidance documents are currently published as Common Implementation Strategy reports. According to the integrated approach indicated, stakeholder participation and cooperation is promoted throughout the implementation process of the directive and expressed in the guidance documents to the member states as crucial for successful implementation (CIS, 2003). However, explicit demands for cooperation are not formulated in the directive and consequently depend on national interpretation (Grönwall, 2002).

The main objective of the WFD is to improve and secure water quality for drinking water, for water resources for other commercial uses, and for environmental quality (bio-diversity) (European Community, 2000). The approach to reach the objective is integrated water resource management based on catchments, i.e. geographical borders instead of administrative. Fragmentation of the catchment by different institutional boundaries makes handling resources more difficult (Olivier and McPherson, 1993). In integrated management the entire ecosystem is considered in both legislation and management. The management integrates knowledge and experience from the

different parts of the ecosystem, combining biotic, aquatic, marine and socio-economic aspects. To come to terms with identified environmental issues, legislative, technical, economic and educative measures are applied. The integrated approach follows the guidelines in EU's fifth Action Programme (OJ, 1993).

The WFD contains both preventive and corrective components, of which the most important are listed in Table 1 together with a timetable for implementation.

Table 1. Time table for activities to be implemented by the EU member states.

Activity	Timeframe
Legislation	2003
Propose catchment authorities	
Characterize the catchments	2004
Identify and map water resources within the district	
Register protected water areas	
Establish environmental quality standards for prioritized substances	2006
Comply with established EU monitoring programs	
Establish Programs of Measures in catchments	2009
Issue Management Plans over catchments	
Water charges	2010
Information to and consultations with the general public	Throughout process
Objective accomplished	2015

3.2 WFD implementation in Sweden

The objective of the WFD is a desirable condition to strive for, comparable to a political document as EU's action programs (Mahmoudi, 1995). However it is non-committal if not made operational with quality standards specified with levels over given geographical areas within certain time frames (Gipperth, 2002). In Sweden this task is delegated through the Chapter 5 of the Environmental Code to the authority in charge, the Swedish Environmental Protection Agency (SFS, 1998). SEPA is preparing for the coming implementation demands through the different activities within the Water Project (SEPA, 2003). The Commission for revision of the Swedish Environmental Code proposed changes in Swedish legislation to comply with the demands on environmental objectives, Programs of Measures and discharges to water (SOU, 2002:107).

In 2001, a Government Commission was appointed with the mandate to propose administration for the directive (SOU, 2002:105). At national level the commission proposal suggested four Swedish catchment districts connected to stipulated authorities and directed by Boards made up of three representatives from County Administrative Boards, Municipal Boards and business/industry,

respectively. At local level, the Swedish Meteorological and Hydrological Institute has identified 119 main catchments in Sweden based on size (SMHI, 1994). These 119 catchments would constitute the basis for local management organized in voluntary partnerships with municipalities as initiators, according to the proposal. Local stakeholders such as water management associations, farm holders, sewage plants managers, businesses and interest organisations would make up the partnerships. The partnerships would be instrumental in work related to producing data for decision-making, suggesting measures and promoting cooperation. Two models were suggested at the so called "super local level"— subbasin or groundwater related location — based on either formal agreement or cooperation in joint property units (*samfälligheter)*. The model is influenced by "contract planning" in France (Gustafsson, 1994; Gustafsson, 1996). A joint property unit has legal statutes according to Swedish law. Several County Boards and even more municipalities will exist within a Catchment District. Guidelines for the new authorities are being prepared within SEPA. During the fall of 2003, the Swedish government presented the bill to the parliament, titled "Förvaltning av kvaliteten på vattenmiljön (Management of the Quality of the Water Environment)" (Government Bill, 2003/04:2).

In summary, the following points are pertinent for this thesis and are resumed in chapter 7.

- How does management built on a systems approach to natural resource management correspond with the study results?
- Stakeholder participation and cooperation throughout the implementation process is suggested to be essential to make implementation sustainable. Can crucial stages for such activities be identified in the study results?
- National legislation must be developed including rules and regulations needed for implementation. How is this reflected and supported in the study results?

4. LOCAL KNOWLEDGE AND RESOURCE MANAGEMENT

This chapter defines the concept of local agricultural knowledge that is used as a point of departure to study stakeholders' practices and perspectives on resource management and its implications. The concept is discussed to elevate perspectives not often used in agricultural management or studies thereof. The chapter ends with a brief outline of the Swedish agricultural adjustment policy that has had environmental implications of nitrogen leaching.

4.1 The use of local knowledge

Environmenal issuess have previously to a high degree been treated from a perspective where nature is seen as static, universal, stable and in equilibrium (Berkes et al., 2000). As such, ecological knowledge about interspecies dynamics, landscape and site specifics, and spatial and temporal considerations has not been applied (Dale et al., 2000). Likewise, management suggestions developed solely from policy or socio-economic science have shown to be insufficient to handle environmenal issuess (Murdoch, 1994). As expressed by Ostrom and Wertime, "A singular view of the cause is frequently paired with a singular view of the solution" (2000). Plans, measures and monitoring routines have been developed from these perspectives, but they do not correspond with analyses of the local context (Bucht, 1998). Consequently, it has not been possible to come to terms with the problems of environmental degradation (Gibson et al., 2000b; Homer-Dixon, 1991). An analysis of both natural and social systems gives a more accurate basis for policy governance in resource management (Hjort af Ornäs, 1998). For a more sustainable management, the approach suggested in the WFD is based on the entire system, framed by catchment borders (European Community, 2000). A catchment approach includes natural borders and administrative boundaries, and the different spatial and temporal dynamics related to management of water resources. Thus, it takes into account the whole system, including humans, with its functions based on structure and diversity. Inherent is the notion that sustainable development is an ongoing process of decisions and practices, including both environmental and socio-economic conditions (Robinson et al., 1990).

Ecosystem management is based on current knowledge, scientific and local, of how the ecosystem works (Christensen et al., 1996; Dale et al., 2000). Included in the concept is change as an inherent part of the system. People are not only affected by physical and biological conditions, their livelihoods are also framed by social structures and systems. In an ecosystem management approach, local knowledge is suggested to constitute an important part of managing water resources. As systems are changing there are limits to knowledge and the development cannot be fully predicted (Berkes, 1999). In addition to public and official awareness about ecological issues, existing formal and informal

institutional frameworks and their policies in regard to natural resources are of prime importance from regional, as well as local, points of view. Institution is in this thesis defined as working rules or rules-in-use with formal or informal limitations to shape peoples behavior (North, 1990; Ostrom, 1990). Various sectors of society are giving local knowledge on managing natural resources augmented focus (Gibbons, 1994). It is argued that only a management scheme that effectively integrates all stakeholders will be sustainable (Gibson et al., 2000b). To be able to formulate a more general strategy for natural resource management, it is of utmost importance to understand ongoing processes at a local level. Whether the formal institutional framework is actively working with local people or not in management planning and implementation, is considered decisive for the outcome of plans for sustainable management (Hillbur, 1998; Olsson and Folke, 2001; Putnam et al., 1992; UNESCO, 1999). A principal assumption is that local institutions, informal as well as formal, provide a key for sustainable water management. For the purpose of the studies presented here, it is important to clarify processes at a local level together with the underlying perceptions concerning reduction of nutrient leaching.

In Agenda 21 (UN, 1992), it is explicitly stated that local information and formal institutions "...possess well-established and diverse experience, expertise and capacity in fields which will be of particular importance to the implementation and review of environmentally sound and socially responsible sustainable development". Local agricultural knowledge is here considered as a synthesis of competence based on inherited learning, i.e. indigenous knowledge of local species and land, practices and beliefs as discussed in Berkes (Berkes, 1999), complemented with experience and modern science (Gadgil et al., 1993). Our knowledge is subjective and used when we interpret and understand information, and defines how we judge new knowledge (Gustavsson, 2000; Murdoch, 1994). New knowledge is produced through people's practices in a given context, and through reflection against our pre-understanding influenced by traditions and cultural heritage. New knowledge is presented both as a process in form of development of habits and attitudes, and as external results, e.g. products or actions (Dewey, 1966). Habits and attitudes constitute part of the institutional aspects of management and actions are manifested in the management practices implemented in for instance agricultural production (Gibson et al., 2000a).

Agricultural development and agricultural knowledge, is formed when the social process incorporates technical activity, creating a new knowledge that partly stretches across subject areas (Fisher, 2000; Hillbur, 1998). Thus, knowledge becomes a tool, used in and tightly bound to an activity when applied in practice. Agricultural production is a system-based activity with a collectively created history through communication and cooperation. Habitual routines have evolved, based on convictions of what is the most efficient management. To a great extent it has been changed and developed by actions carried out by

individuals with the purpose to achieve improved production within the agricultural context outlined below. This makes it a dynamic process developed also by the tensions and conflicts involved in altering and questioning accepted practice, and challenging established convictions. Identifying available choices for agricultural practice and analyzing factors behind farm decisions is a necessary starting point to obtain changes in practice.

To enhance further development and change of non-sustainable management it is essential to be able to dissociate from current practices in order to assess the situation critically. From this perspective, understanding the impetus of environmental and socio-economic change on farmers' practices and its implications on management of water resources is important for the studies presented. Local societies and individuals do their own assessment of environmental and societal changes that occur in their surroundings. The expectation of changes in policy and institutional mechanisms, for instance the WFD, bring more uncertainties into natural resource management decisions (Gibson et al., 2000b). Farmers are subject to changes and will adhere to them. They make their own assessment of the risks involved, the risks of altered amount and quality of production, market risks and risks of resource losses. Farmers have to adjust to the environmental conditions on their site, where they in turn exercise a continuous impact. Changes in their conditions, including socio-economic conditions, act as a driving force for development of agricultural practices (Homer-Dixon, 1991; Berkes et. al., 1997). They pursue a pragmatic management strategy aimed at solving the problems at hand.

In summary, the following factors are important points of departure for the study and are resumed in chapter 6.

- Local knowledge is suggested to be important for the process of development of sustainable resource management.
- Local context provides an essential basis for development of attitudes and practices.
- Change in local conditions is an important factor for development of agricultural knowledge.

4.2 Agricultural policy context

Swedish agricultural policy during the last 50 years has gone through major changes that, among other things, have had an effect on nutrient leaching from arable land. The rationalizing epoch started in the 1940s with the main objective to increase agricultural production in the country to a self sustained level, and thereby reach the other pressing objectives of improving farmer livelihood and making production more efficient per unit (Lantbruksstyrelsen, 1990). The means for reaching these objectives were, until 1990, import regulations and

internal market regulation (Rønningen, 1998) in combination with active extension services.

From early 1800 up to 1950 agricultural practice included a crop rotation with ley, which kept soil structure, level of organic material, water holding capabilities and nitrogen fixing at a sustainable standard in the fields. Chemical fertilizers were not commonly used until after 1930, and animals were successively no longer needed on farm for manure production. The agricultural revolution in 1950 included a crop rotation without ley that required a herbicide application against weeds, and a blanket distribution of fertilizer with nitrogen, phosphorus and potassium (N P K) at an increasing rate of 20-80 kg nitrogen ha^{-1} and $year^{-1}$ (Lantbruksstyrelsen, 1990). As a result cereal crops generally doubled between 1950 and 1975. Consequently, nitrogen leaching increased on average 60% during this period (Hoffman, 1999;).

Industrial development in Sweden during this time had been substantial in general, and the agricultural sector was no exception. State support and taxation rules had provided the means for a high degree of mechanization. The dual interests of agricultural policies in market adaptation and social welfare leaned towards market forces. Farming enterprises accepted this information and managed their holdings accordingly by concentrating on the most productive areas, diminishing obstacles in the fields, cultivating larger units and moving away from unproductive areas (Rønningen, 1998).

The Agricultural Reform of 1990 was based on totally different issues than fifty years earlier (Andersson, 1997). Agricultural services were no longer defined solely in terms of food production and securing income for the farmer population, but had other interests for social welfare such as landscape formation and maintenance of biological diversity. The intensive cultivation in cereal dominating production for maximum profit per acreage had an effect on the fields through a significant decrease in organic matter, acidification, high cadmium concentrations and soil compaction from heavy machinery. The new objectives for agricultural policy included a strive for less negative impacts on the environment and a sustainable use of resources (Reg.prop., 1989/90:146, p49). The main objective was to abolish all special support to the agricultural sector, such as price supports and import restrictions (Rabinowicz, 1990). Naturally this meant a reduction of production, which was encouraged to take place not only by decreasing the amount of arable land but also by reducing production per acreage and changing of crops. Thereby, the amount of fertilizers and pesticides used would abate. These measures were designed to bring Swedish agriculture policy closer to the Common Agricultural Policy (CAP) of the European Union.

Organizationally, the intention of agricultural policy has over time moved from state regulations towards a market oriented production. Structurally, the rationalization has led to fewer farms with more acreage on respective holdings and more dairy cows per unit. During the last 15 years there has been both an

increase in acreage of ley and extensive pasturage in the place of cereal production (Statistics Sweden, 2003a). This has resulted in a decrease in nitrogen leaching after 1985 (Hoffman, 1999).

5. MATERIALS AND METHODS

This chapter presents the choice of an interdisciplinary approach and the framing of the research. The geographical area is introduced. The section on study design clarifies the relations between objectives and choice of methods and materials. The methods used in each study are described and finally methodological considerations are discussed.

5.1 Interdisciplinary approach

The study addresses various local perceptions concerning the environmental problem of nutrient leaching and related solutions, which requires perspectives of both natural and social sciences in the academic world. An interdisciplinary study approach was used to respond to the multifaceted focus of the research questions (Klein, 1990). In issues related to agricultural production based on natural resources, using a natural science perspective exclusively does not suffice and concurrently a search for a different scientific approach is essential (Hjort af Ornäs, 1998). Farmers perceive a risk in the changing conditions of their local resources that they must constantly evaluate in their daily production. It is easier to comprehend this risk from the combined perspective of natural systems and their limits together with studies of the socio-economic setting (Homer-Dixon, 1991). A resulting new research approach including local knowledge is by no means part of the current conventional way of producing science, as expressed by Holling *et al.* (1997). Gibbons *et al.* support their statement and added the explanation to "…make use of science in the context of an extremely complex environment, as an expression of development of sciences corresponding to the needs of their time." (1994). Additionally, previous resource management failures are a strong indication for the need of alternative modes of operation based on combined results from various disciplines instead of relying solely on one (Gibson et al., 2000a).

5.2 Framing of the research

The WFD approach is based on a systems perspective with environmental and socio-economic components influencing the catchment. A systems perspective is here interpreted as method of analysis where the different connected components are addressed in order to obtain a comprehensive result (Gustafsson et al., 1982; Holling, 1978). For the research presented in this thesis an

agricultural nutrient management system was defined, as illustrated in Figure 1. Three main components of the system and their interrelations for the study were chosen: the catchment, the authorities and the farmers. Each component is related to factors that are more or less difficult to influence. In the catchment, focus lies on factors influenced by farming systems, and others are assumed more stable. The landowners are individuals who depend on rules, regulations and natural resources in their geographical space for the farming system, but they also influence the environment by their choice of methods. The authorities are appointed civil servants and officials receiving their guidelines from political decisions both at EU, national and local levels. Additionally their framework for action is set by conditions in the catchment, landowners' activities and overall environmental quality objectives.

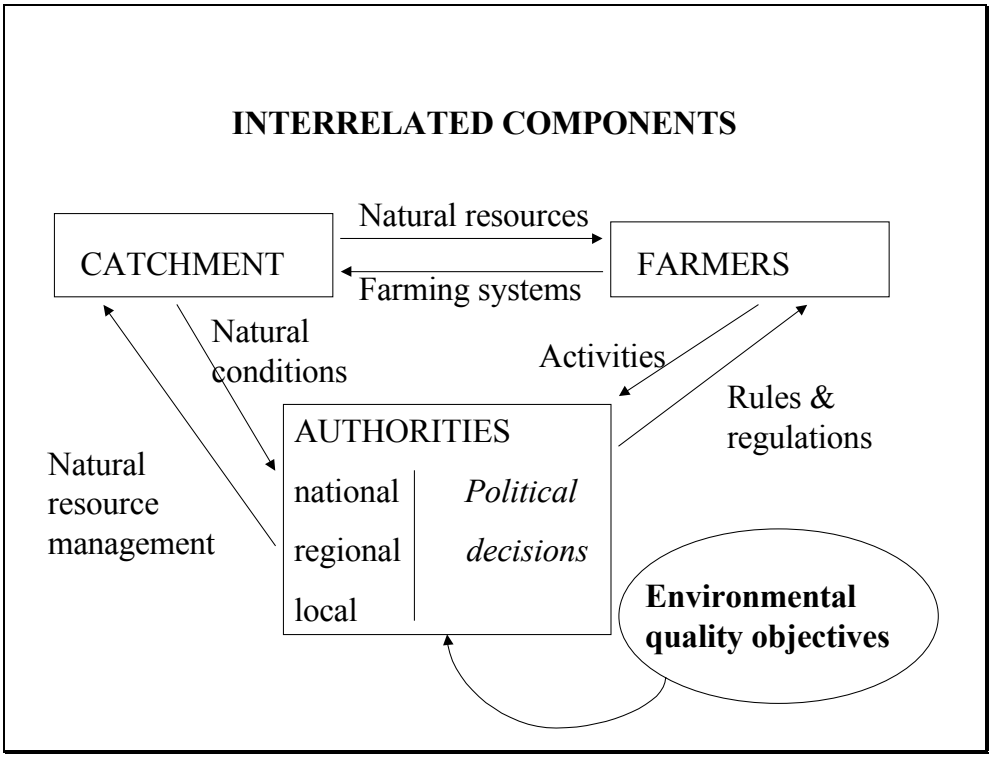

Figure 1. Interrelated components of the agricultural nutrient management system.

5.3 Geographical area

The location of the study areas is shown in Figure 2. Studies I, II, III and IV were carried out at catchment level in two Swedish localities in Southern Sweden. Nyköping River was chosen for its agricultural production, hydrological characteristics and mix of administrative units (I, II, IV). It was previously the site for an integrated pilot project initiated to prepare for the implementation of the WFD with the approach of peoples' participation, Örsbaken project, which was an additional motive for selection.

The hydrological characteristics of the Nyköping River area are dominated by a large number of smaller lakes interspersed in the drainage basins of three rivers –Nyköping, Kila and Svärta Rivers– that form chains of interconnected lakes flowing into the bay of Örsbaken of the Baltic Sea. The westernmost lake, closest to the source of Nyköping River, is Lake Tisaren at 100 m above sea level. Other large lakes are Sottern, Tisnaren, Yngaren, and Båven (SMHI, 1994). The water status of the lakes is dependent on topography and consequent land use patterns. The deep, narrow lakes in the western part of the catchment with steep, forested banks are usually oligotrophic (nutrient poor) with a narrow source area. Lakes further downstream have a wider catchment area through agricultural land and receive more nutrients resulting in eutrophic waters, which have a higher biodiversity. The main part of the basin is agricultural, with forested areas at the headwaters. The holdings in the county are large on average in comparison with the rest of the country with a mean area of 60 ha (Statistics Sweden, 1999; Statistics Sweden, 2003a). Winter cereal is the prominent crop. The herd sizes are large with an average of over 40 heads, but the total amount of dairy cows has

Figure 1. Orientation map for the study areas presented in this thesis. These are Nyköping and Svartå drainage basins and the three selected Swedish agricultural production areas (1-3).

been decreasing during the l990s. The total catchment area consists of 4 500 km^2 covering three counties and 13 municipalities. The three municipalities in study IV were chosen mainly for their high percentage of arable land and a complex hydrological system. Additional conditions for upstream/downstream complications were also taken into consideration.

The study presented in paper III includes an application on the Upper Svartå Valley project area, likewise initiated to prepare for the implementation of the WFD, but with the approach to study communication between stakeholders and researchers through the use of simulation models. The Upper Svartå Valley River Basin is situated in south central Sweden. It is forest-dominated, with 22% of the total area of 857 km^2 used for agricultural production.

Study V did not focus on specific drainage basins, but was applied to three major agricultural production zones in Southern Sweden, defined by Statistics Sweden and the Swedish Agricultural Board. The location of these areas is also indicated in Figure 2. The classification of the areas is based on meteorological data combined with soil profiles and cultivation experience over 100 years in Sweden (Grundberg, 1965; Statistics Sweden, 2003b). The three areas with most favorable agricultural conditions in combination with relevant soil profiles were chosen.

5.4 Study design

This research was implemented in different steps, using various methods that best suit the purpose of each group of questions. An interchange between different methods, such as qualitative and quantitative interviews, model studies, data collection through secondary sources and literature reviews was carried out to move from a general picture towards more comprehensive understanding. The research material consists of different parts, defined by the required tasks of each objective and corresponding method, summarized in Table 2. In section 5.5 the relations between objectives and choices of methods and materials are clarified.

Table 2. Summary of objectives and methods used in the articles

Objectives	Specific objectives	Method	Article
Identify stakeholder standpoints on environmental problems and their management	Potentials and problems with water resource management Role of environmental issues over time Framing for further studies	Interview Quantitative and qualitative analysis	I
Analyze farmer's choices of management practices to reduce nutrient leaching	Identify factors influencing decisions Assess farmer's disposition to change Management effect on economy	Interview Quantitative and qualitative analysis	II
Analyze model results for nutrient transport estimations in relation to farmer questions	Model approach Model uncertainty indication Effect of model uncertainty on output	Model comparison Sensitivity analyses Case study application	III
Analyze municipal officers' perceptions of potentials and problems in implementing WFD	Assess WFD as tool for municipal mgmt of agricultural nutrient leaching Assess necessary conditions for sustainable water mgmt	Focus group interviews Qualitative content analysis	IV
Highlight how possible consequences of climate change on environmental effects of agricultural production may impact implementation of WFD	Assess how a changed climate could result in altered agricultural production	Analyses of climate change scenarios Analyses of meteorological data Literature review	V

5.5 Methods used

This section describes the methods used in each study respectively, after presenting the study aim.

(I) Identify standpoints held by the different stakeholder representatives, as expressed in their views on major environmental problems and their management in the catchment.

As a first step the groups actively involved in water management of the area were identified through newspaper articles, asking key persons, checking project lists, attending a local meeting and a project seminar. Telephone interviews were made with 22 stakeholder representatives, as specified in Table 3.

Table 3. Interview chart

Stakeholder group	Number interviewed
County Administrative Boards (Länsstyrelse)	2
Municipal Environmental Health Authority	8
Federation of Swedish Farmers (LRF) local level	2
Federation of Swedish Farmers (LRF) regional level	1
Rural Economy and Agricultural Society (Hushållningssällskapet)	1
Swedish Landowners Association	1
Forest Service	2
Swedish Nature Conservancy	1
Save Tisnaren interest group	2
Save Lake Hallbo interest group	1
Politician	1
Total number	22

6 of the interviewed were farmers
One interviewee was also the chairman of the local chapter of Swedish Nature Conservancy
One interviewee was also representing the Local Water Association

The checklist of semi-structured questions consisted of three subject groups where the first group of questions related to environmental problem identification, origin of information and effects of problems. The next group referred to capacities, hindrances and responsibility issues concerning problem solving. The last set of questions was associated with views on the role of environmental issues in the future, why they are interested in these issues and if their opinion has changed over time. The interviews lasted about 10-15 minutes while notes were taken and were written out directly afterwards.

(II) Analyze farmers' individual choices of management practices for reduction of nutrient leaching.

Telephone interviews was conducted wherein farming enterprises were contacted to get a general picture of the issues investigated within a catchment. The response rate was high as 104 out of 106 farmers agreed to answer the questions. The intention was to cover most farmers within certain sub-catchments. The sub-catchments were chosen according to a high percentage of arable land and position in the catchment. The interviews were carried out in a structured manner that allowed additional comments to complement the questions at the end of the interview. The set of questions for the interview was structured into four sections. The interview started with questions to categorize the respondents according to size of arable land, type of holding and category of production. Following were questions concerning changes in production during the farming period: if any change had been carried out, when, what kind of change and the reason for it. An example of a change in production is to stop dairy production or to start organic farming. The next set of questions related to

the farmer's choices of methods to reduce nitrogen leaching, ammonia wastage and phosphorous losses. The last section referred to what the most important internal factors are when making decisions about measures to reduce nutrient losses and what external sources supply the relevant information for these decisions. A final question inquired about what would make the farmer want to and be able to carry out additional measures. The questions were structured with given alternatives for answers, except the last one that was open-ended in order to leave room for ideas surfacing during the survey. A farmer could mention several alternatives. The phone calls lasted for about 10 to 15 minutes in general, including a short introduction of the purpose of the survey. The answers were interpreted by the interviewer and recorded directly on forms, and all extra comments were noted

(III) Further understand the relation between basis for decision, risk taking in farming enterprise, local conditions and current scientific knowledge on nutrient leaching used in advising farmers.

Three decision-support models dominate the scene, and their results have an important impact on current and future environmental planning and management: the dynamic soil nitrogen transport and transformation model SOILN, the dynamic rainfall runoff based model HBV-N, and the steady state budget model STANK. Despite their differences, there is value in contrasting their structural approach and comparing the output with the expectations in farmers' questions. The comparisons were made through reviews of model technical descriptions, and tests and validations documented in appropriate scientific literature. The comparison made evident the different model sensitivities documented. SOILN and HBV-N have been evaluated in several sensitivity tests, however such tests with STANK were not accounted for in documentation.

STANK outputs are important for farmers when making decisions on which method to choose on farm. As the second step of analysis, sensitivity tests of STANK were performed on variations in precipitation and soil type to see whether the output is more influenced by model construction of these parameters than actual assessment of farm practices. In the third step of the analysis, the results from the STANK sensitivity tests over alternative farm management were compared with SOILN and HBV-N simulations made for the catchment in order to see the effect of agricultural measures compared with those of climate.

(IV) Analyze the municipal officers' perceptions of the potentials and problems in implementing integrated catchment management of water resources, as proposed in the EC Directive.

The objective in holding focus group interviews was to obtain a deeper understanding of the municipal officer's view of implementing the WFD, in

relation to reduction of nutrient leaching from the agricultural sector based on their knowledge and experience. The method chosen was to place the main objective of the WFD directly in front of the municipal officers in combination with a proposal of water administration for Sweden: The focus questions centered around, What are the potentials and problems of implementing integrated catchment management of water resources, as proposed in the EC directive? The officers selected for the focus groups were all the civil servants working as environmental inspectors, spatial planners and heads of environmental offices in three municipalities. The selections were made in order to interview those in direct contact with day-to-day agricultural production, those involved with longer-term municipal land use planning, and those in charge of implementing water management. In all 13 people participated, divided into two session groups with the 8 inspectors in one, seated at a round table setting.

The Commission Secretary presented the proposal for Swedish water administration at each of the two sessions and opportunity was given to ask questions. The interview sessions following the presentation lasted about two hours. The sessions were audio-taped. An assistant took notes, mainly to simplify decoding of who made what comments. The form was a semi-structured multi-party conversation, where the moderator initiated the discussions without taking active part. An interview guide was used, more as a resource to ensure all aspects were covered than as a steering instrument. Questions were arranged around the main research question according to a pattern based on Krueger (1998): Opening, Introductory, Transfer, Key, Concluding, Final. An evaluative question was added at the end of the session. The key questions were: How would their work change and what would the expected result be? Do they foresee changes in work routines? Additional questions were linked to the current main problems in their work, difficulties involved with implementing the WFD and what is needed to efficiently reduce nutrient leaching. Changes in cooperation with national and regional levels of agricultural authorities are not dealt with in the implementation proposal, and were therefore not a subject for the discussions.

Follow-up sessions were held with both groups to provide the opportunity to further develop questions that had arisen since the first encounter. In general the follow-up sessions did not give rise to any new topics, thus confirming that the subjects were exhausted during the first sessions (Morgan, 1998). This verified that a sufficient number of sessions had been held to explore the subject. The analysis was made in the form of a thematic content analysis (Kvale, 1997), based upon the participants' interpretation of the suggested proposal as expressed during the given sessions. The interview tapes were transcribed with attention to content as aim for analysis; less attention was given to dialogue. Likewise little attention has been given to quantify statements made. Emphasis has been given to the opinions, views and ideas that surfaced, the discussions

they led to and questions put forward on the whole. Themes were discerned and defined based on the data, the codes, the center of discussion and the main research question.

(V) Highlight the impact that farmers' changes in agricultural practices may have on implementation of the WFD.

The analyses done here are based on a combination of results from various sources. The study initiated with an analysis of regional climate change scenarios from SWECLIM (Swedish Regional Climate Modelling Programme), whose primary objective has been to produce and deliver regional simulations for Sweden and the Nordic Region (Bergström et al., 2001; Rummunkainen et al., 2001; Räisänen and Joelsson, 2001). The climate change simulations used here were produced by the Rossby Centre Atmosphere Ocean Model (RCAO) (Döscher et al., 2002). The IPCC (Intergovernmental Panel on Climate Change) SRES-A2 emissions scenario (Nakicenovic et al., 2000) was chosen for analysis as it represents the more severe case of the two emissions scenarios available from SWECLIM. For these scenarios, 30-year time periods were used for the control (present climate) and future simulations. These correspond to 1961-1990 for control conditions and 2071-2100 for future conditions. Review and analysis of the model results were aided by the SWECLIM data and visualization tool (SMHI, 2003).

Three major Swedish agricultural production areas were selected from production zones identified for crop trial experiments and production statistics. The three areas selected for this study are designated or indicated potential nitrate vulnerable zones in the EU classification system defined in the Nitrates Directive 91/676/EEC (EU Commission, 2002). Values of the simulated climate variables for the future climate important for crop production were then compared to present climate conditions within Europe (WMO (World Meteorological Organization), 1996). Potential crops were selected from cultivation patterns in these areas, based on increased Swedish national self-sufficiency interest in forage supply. Agricultural crop data were gathered from areas where the present climate resembles the simulated future climate for Swedish areas. Cultivation practices were compiled from secondary sources and applied to the Swedish areas. Data on present environmental effects of different crops were obtained with a focus on nitrogen leaching. Coefficients based on the SOILN model from various studies were used. These are the leaching rates for area typical combinations of cropping systems and soil types under a normalized local climate and normalized harvests, further described in Hoffman and Johnsson (1999). The SOILN leaching coefficients for the commonly grown crops in Sweden were obtained from a national monitoring report (Johnsson et al., 2002). Maize was selected as an example for a potential future crop. For Sweden, however there are no simulations made for maize. Data for maize were

instead obtained from an article simulating conditions in Pennsylvania, USA (Jabro et al., 1999)

5.6 Methodological considerations

As mentioned above, the main objective for the thesis is to analyze stakeholders' perceptions of the potentials and problems concerning change of agricultural practices with a further aim to put the analyses in relation to implementing the EC Water Framework Directive in Sweden. The word "perception" has been used in the common speech sense of the word (Kvale, 1997), as in "What is your understanding and interpretation of the issue". Further discussion of the word as a psychological analytical term is considered beyond the scope of the thesis. Likewise, the word "perspective" has been used in a similar sense, as in "Where do you stand in this issue, what is your view".

Telephone interviews were chosen to obtain the empirical material needed for studies I and II. They can be carried out fast and with higher response frequency than written surveys. The main rationale for choosing interviews is based upon the concept that direct verbal communication is a basic human interaction to obtain knowledge (Kvale, 1997). The risk with superficial answers to a survey could be counteracted with follow-up questions to include arguments and motivations (Andersen, 1990; Söderberg, 1999). Besides, the different remarks exchanged around the inquiry questions add to further development of the research focus and to familiarize the interviewer with the subject area. It is worth noting that answers given in interviews represent the perceptions the respondents have of the issues at the time of the interview. How they act in real life is beyond the knowledge of the interpreter (Wibeck, 2000). The answers reveal the idea of what is important, not necessarily the factual decisive factors. However, a strict interview structure as used here is regarded to appeal more to common sense than to feelings, and the researchers' attitude should be of confidence in the respondents' intention to be honest (Fontana and Frey, 1993).

The informants were chosen for representing different stakeholder perspectives, either for their formal role as a civil servant, for representing an organization or institution, or for their role as an individual in their profession. In study I relevant representatives of all organizations and institutions within the catchment were chosen. The objective for study II was to interview as many as possible of all farmers within the chosen subcatchments. In study IV all civil servants working as environmental inspectors, spatial planners and heads of environmental offices in the three municipals were invited to the focus groups.

The analyses of the results for studies I and II were done both quantitatively and qualitatively for mutual support of the obtained results. The reason for the combined approach was to address problems connected with involvement of both attitudes and actions. The answer to whether the action has been carried out or not is supported by "What is the perceived effect of the answer to this?".

Hereby the response is supposedly reflecting the perspective of the respondents' different strategies. Quantification is here important for valuing the weight of practice implementation. For instance, if only a few farmers use an efficient practice to reduce nutrient leaching, there exists an implementation deficiency to address. The qualitative analyses chosen were based on content in relation to interview questions, aim of studies and analytical framework (Holme and Solvang, 1997). Tendencies and patterns, similarities and differences in responses are sought and related to the research questions.

For study IV, focused group interviews with municipal officers was used to reflect exchange of ideas in a work mode, as compared to an individual interview or survey. In-depth interviews at individual level can provide valuable data for analyzing perceptions in an explorative nature (Kvale, 1997). However, in interaction with others in a group setting the respondents' perceptions will be taken a step further (Morgan, 1997; Wibeck, 2000). Reflections are reacted upon and associated to, which was valuable for the aim of this study as the officers will use the proposed administration in their daily work routine. Focus groups are an appropriate method to provide requisite data through group interactions in a situation similar to real life working seminars. The focus group method used in the study is based on writings by Krueger (2000) and Morgan (1993), and further developed by Wibeck (2000). The interviews were arranged with the aim of obtaining data for further analysis. However, this method was also likely to be of value to the participants by creating useful knowledge through a collaborative learning process (Fisher, 2000; Ljung, 2001).

An advantage with focus group interviews is that they afford the possibility to explore aspects that are so far unknown to the researcher. Subjects can be brought up outside structured interview questions, to a higher degree than during an interview with one person. On the other hand, it signifies less subject control by the researcher, and sufficient time has to be available to allow exploration of the subject. The participants set the agenda to a certain degree as they determine whether the questions raised are important or interesting to them (Obert and Forsell, 2000), thus allowing unspecified aspects to arise. The analysis is based upon the data obtained, generated from the data itself so that data was not forced into given categories based on existing theories or systems (Wibeck, 2000). Perceptions about what is important can vary strongly between individuals or groups (Obert and Forsell, 2000). This type of analysis is not self-evidently valid for generalizations; it is only valid for the given session (Krueger, 2000; Wibeck, 2000). However, Krueger discusses how the concept of transferability can make the results useful in another environment. Through an analysis, where the context of the study is compared and contrasted to a different context, the findings might or might not be transferable.

Study III is based on queries identified from the analysis of the responses to interview questions in study II. The study could also have been carried out through interviews or in interactive sessions with farmers and modelers

(Holling, 1978). However, the choice was made to answer the research questions through revision and process of secondary research results from Upper Svartå Valley project (Andersson, 2002), and results produced explicitly for this study.

For study V the IPCC (Intergovernmental Panel on Climate Change) SRES-A2 emissions scenario (Nakicenovic et al., 2000) was chosen for analysis as it represents the more severe case of the two emissions scenarios available from SWECLIM (Swedish Regional Climate Modelling Programme). Acquiring relevant comparable data on nutrient leaching proved harder than anticipated. Data on nutrient usage in related areas and related leaching from relevant crops were assessed from literature and databases. None of the contacted organizations concerning European environmental issues had any data on nutrient leaching patterns per crop and region or country (EU Commission, European Environmental Agency, FAO, OECD, French Ministry of Agriculture, French Agricultural Research Center). Results from separate research initiatives presented in the scientific literature are based on studies that vary in set-up (plot versus field), experimental design (crop choice, management practices) and natural conditions, to a degree that makes direct comparison difficult. Rarely are nutrient leaching patterns from different crops in focus, but instead management practices are analyzed (Ferguson et al., 1991; Hergert, 1986; Klocke et al., 1999; Schepers et al., 1995; Spalding et al., 2001). Due to the difficulty to find suitable and comparable data on nitrogen leaching, simulated leaching coefficients were regarded the best solution. Model simulations are by definition limited in relation to reality and made with expressed assumptions to have fewer conflicting factors influencing. For the purpose of this study, simulation results from the same model were preferable for the comparison of potential leached nitrogen under various crops and geographical areas. Other factors than climate will also have an important impact on future agricultural production. However, energy demands, EU agricultural policies, market conditions and global demands on food supply were only briefly dealt with in this study.

6. POTENTIALS AND PROBLEMS CONCERNING MANAGEMENT OF AGRICULTURAL PRACTICES

This chapter presents results and discussions from the five articles related to the following three points. In the analytical framework, it is emphasized that it is important to include local stakeholders' knowledge, both farmer's and municipal officer's knowledge, in order to sustainably manage natural resources. Further, the local context is suggested to constitute an important basis for development of practices carried out to mitigate environmental problems and also of attitudes held towards environmental management. Finally, it is proposed that changes in local environmental and socio-economical conditions to a high degree act as

impetus for the construction of new agricultural knowledge that is manifested in practices.

6.1 Local knowledge

Local knowledge is defined in the analytical framework as a synthesis of information received from a variety of sources and manifested in practices and attitudes. In order to change farming practices, the factors farmers base their decisions on and the sources providing the information needed are identified and analyzed in this thesis. Further, stakeholder motivation is necessary to change practices as regulatory systems do not suffice. Stakeholders' attitudes towards water management are presented as they give an indication of which aspects need to be addressed regarding motivation. In assessing the WFD as a tool for municipal officers, problems and potentials related to the incorporation of their knowledge and experiences in the process are discussed.

Internal factors and external sources of information that were important to the farmers interviewed were identified and analyzed in study II. Not surprisingly, economy was noted as the most important factor to base decisions on, as seen in Table 4. More unexpected is that of second importance came knowledge about nutrient losses. Natural conditions on the farm are also influential when farmers make decisions.

Table 4. *Internal factors of importance for making decisions concerning nutrient leaching from farm (II). The respondent could give several answers to the alternatives given. n=104*

Factors	No.	%
Economy	79	76
Knowledge about nutrient leaching	60	58
Natural conditions on farm	41	39
Tradition	25	24
Available manpower	22	21

Some of the respondents did not distinguish between the different external sources of information but answered that they picked up bits here and there from all (II). Professional magazines for farmers ranked high, as seen in Table 5. The articles in these magazines are based upon current research, often written directly for implementation. The County Boards used to play a more active role in extension services and thus had a stronger input, but their service has been cut back and the information line from authorities is thereby broken. Interest organizations for farmers are important to over a third of the respondents, and it

appeared from comments that they had an increasing importance as being independent from authorities and businesses. Discussions with colleagues and neighbors are central to half of the respondents. This relates to how knowledge is assumed constructed, where input in form of information is interpreted and reflected against our earlier insights and thus dialectically synthesized into new knowledge (Gustavsson, 2000). Personal preconception defines how we judge and analyze new communications, whether we incorporate them into our reality, attitudes and practices, or not. The analysis shows that farmers obtain the information to base their decisions on from an array of sources, a factor which should be addressed when striving for a change of practices.

Table 5. External information sources of importance for making decisions concerning nutrient leaching from farm (II). The respondent could give several answers to the alternatives given. n=104

Information sources	No.	%
Professional magazines	69	66
Neighbors and colleagues	51	49
County Board	43	41
Interest organizations	38	37
Courses	27	26
EU information	22	21
Municipal Environmental Office	21	20
Agro businesses	17	16

Farmers and other stakeholders request reliable information about the effect of different measures to reduce nutrient leaching before risking their time and effort (I, II). They solicit information of effects on farm as well as on the surrounding environment. Uncertainties are obviously part of the agricultural production, however resource managers make fairer decisions with transparent information. To be able to take active part in the process of water management, it is considered essential to develop competence among the stakeholders involved (Johnson et al., 2001). It is also a question of having open and equal access to information and to be able to interpret and use it. The difficulty to obtain nutrient leaching data related to cropping systems (V) clearly indicates how this can create an obstacle for efficient management. As an example, farmers need reasonably accurate data and manageable tools for comparison of environmental implications as well as traditional cost-benefit analyses. In addition to agricultural practices, climatic variables and soil properties also affect nutrient leaching. Interactions between the different factors are complex and a change from one crop to another might lead to increased leaching in one area and decreased leaching in another.

Article III show that it is still difficult to obtain information about these interactions from decision–support tools in a way that is effective for the farmers

to use directly. The issue with models for assessment of nitrogen leaching at farm scale is linked to the intent to combine a dynamic ecological system with static modeling. It is possible to estimate decreases or increases in nitrogen leaching from alternative agricultural practices at a regional scale. However it is impossible with current models to estimate yearly amount and effect at specific farm level as the models have limitations on how they represent climatic variability and local natural conditions. Models are by necessity constructed on averages and estimations. More complex models are not the solution, however increased clarification on uncertainty is expected and indications of the degree of risk are desirable. This argument is supported by the stakeholder representatives interviewed, when they pointed out how necessary reliable information is to increase the motivation level to change agricultural practices (I) .

Insight about the relationship between agricultural production and water quality varies greatly between farmers and, as the municipal officers argued, is closely coupled to motivation for change of production methods, (IV). Healey reinforces the motivation argument with "a change in legislation is not enough, it has to be accompanied by a change in attitudes" (1997). The officers continued the argument by stating that it is impossible to address and supervise people on an individual basis. They explained that it must be possible to use a general approach. This is further illustrated by the quotes from the municipal officers' discussion on why they see the WFD as an issue of comprehension and attitudes. They phrased it as *"When you know and understand, you act",* and *"When interest exists among the farmers themselves and they pursue the issue, they go far"*. The officers declared that the importance of farmers understanding the issues related to agricultural nutrient flows must not be underestimated. Cited examples include manure as a resource instead of waste, the link between agricultural production and the surrounding environment, personal interests in relation to others in the catchment, perspective of time on effects of measures and, not least, that it will favour their own interests. Several of the farmers expressed a new consciousness about their nitrogen use in general and thereby take measures to reduce leaching (II). Over 60% said they set up a balance sheet and adjusted the amounts of added fertilizer to current need by the respective crops. A balance calculation over nutrient cycles on the farm is encouraged by authorities as an efficient measure to economize on the use of nutrients and is required by farmers receiving certain state subsidies (SJV, 1999). Several farmers in the study also expressed the view that their concept of manure had changed from waste to resource. This was noted in the survey as over half of the respondents recognized a positive effect on farm economy through carrying out these measures. It is an example of how crucial the attitude of the stakeholders is to perceive and recognize the benefit of the measures they carry out.

The attitudes held among the stakeholder representatives were generally positive towards catchment-based management (I). However, the respondents

expressed opposing views on how and who is to implement such a management, related to their different positions and perspective on the issue. The municipal authorities found value in listening to farmer's opinions, but considered their own exercise of rules, regulations and control as the only way of efficient management. Other representatives such as officers of the County Board and Forest Service, emphasized the negative impact of demands and regulations, and advocated voluntary cooperation under responsibility as the most efficient approach. The responses from the municipal authorities indicate that they have never questioned their position as an authority, to the effect that there could be other ways to reach environmental quality objectives. The power as an authority is the pre-condition for efficiency and voluntary action is not reliable, they argued. None of the respondent groups referred to cooperation, most likely as it is not part of common procedures in interactions between stakeholder groups. However, demands to include participation of stakeholders are increasing in current societal planning (Healey, 1997; Khakhee, 2000; Soneryd, 2002). The VASTRA project is planning a series of focus group sessions with different stakeholder groups with the purpose of elaborating and testing participation within a catchment during 2004.

The municipal officers participating in the focus group interviews considered the initiative to collect the opinions and experiences from their work laudable, and most relevant if municipalities are to be regarded as key parties in coming implementation. It was considered important that the role of municipalities was clearly brought forward, which to their knowledge had not previously been the case. Their participation in the discussions induced expectations that their views will be taken into consideration in the final proposition. They also called attention to the importance of involving the farmers own interest organizations at an early stage in planning at the local scale. Previous knowledge about the WFD varied among the participants, as did previous attitude. They knew that a directive was under development, but had only vague notions about its content or the implications it would have on their routines. In the evaluation most respondents expressed that they better understood the WFD after the session and looked forward to working under the new conditions. To most it was considered an advantage to have heard others' thoughts and have an opportunity to formulate their own thoughts. For some, the sessions started a reflective learning process around water issues and specifically the WFD, and the follow-up sessions were regarded as constructive. One spatial planner was hesitant about mixing the group with heads of departments, but evaluated the outcome as fruitful. These results indicate the potential that an arena for collaborative learning can have to exchange knowledge from one local context to another or to elaborate ideas to solve complex issues (Hillbur, 1998; Ljung, 2001). Similar experiences came out of the Svartå-project, where farmers and municipal officers discussed nutrient reducing measures in interactive sessions (Andersson, 2003).

6.2 Local context

Site-specific natural and socio-economic conditions influence the agricultural practices to reduce nutrient leaching that are used in a specific area. The practices actually carried out by the farmers are analyzed, as strengths and deficiencies in implementation are important to address in order to improve environmental conditions. The municipal officers' view on the importance of local political support for successful management of nutrient leaching is discussed.

(Gustavsson, 2000; Hillbur, 1998) describe the process of knowledge production as constructed through people's practices and strongly influenced by the local context. It is suggested that the individual farmer's own production methods are the factor that has the strongest anthropogenic influence on leaching from farm (Hoffman and Johnsson, 2000). The appropriate timing of measures in accordance with soil properties, climate and crop development is crucial for nutrient management. The use of this knowledge has been in decline as of late, as farmers have relied on blanket recommendations for fertilizing and feeding schemes, as discussed above under agricultural context. One farmer compared the re-emergence of local aspects to returning to old ways of farming, revitalizing the knowledge his grandfather used at a time when the only nutrients available were those produced on farm (II). Table 6 lists the measures the farmers in carried out to reduce ammonia release (II). Numerous of the measures to prevent ammonia losses are restricted by regulations, however conditional, and thus leave little to the individual farmer's choice (Eckerberg, 1997).

Table 6. Measures taken by farmers against ammonia release in number and percentage (II). The respondent could give several answers to the alternatives given. Livestock was kept by 88 farmers, but all 104 spread manure in field.

Measure	No.	%
Immediate cultivation after spreading manure in field	45	43[1]
Adjustment of forage ration to dairy cows and swine	43	49[2]
Coverage of urine and liquid manure containers	43	49[2]
Filling under coverage of urine and liquid manure containers	37	42[2]
Efficient urine separation in stable	31	35[2]
No measures taken	31	35[2]

[1] n=104, [2]n=88

The Swedish environmental code sets the framework for agricultural production (Rubensson, 1998). The general rule of the code, demands that the farmer has knowledge about his production methods, chooses the best techniques possible, manages resources in a sustainable way and recycles. The

environmental impact from agricultural production in the form of nutrient leaching has resulted in a set of restricting rules, summarized by the Swedish Agricultural Board (SJV, 2000). The rules vary geographically in Sweden with stronger restrictions in the southern region in general. Other areas of production that have an impact on nutrient release are related to soil management and cultivation, and these are to a greater extent depending on the farmer's initiative and own choice. Tables 7 and 8 show the measures the farmers carried out to reduce nitrogen leaching and phosphorous losses respectively. When reviewing the number of farmers that have actually carried out the measures, there is an obvious deficiency in implementation that needs to be addressed. As many as 74% refrained from carrying out any measures to reduce phosphorous losses, 42% had not taken any measures against ammonia release, while only 6% had chosen not to take any measures against nitrogen leaching. These results appear to mirror the research, debate and information given to farmers in Sweden during the last decade that has focused on nitrogen and partly ignored phosphorous.

Table 7. Measures taken by farmers against nitrogen leaching in number and percentage (II). The respondent could give several answers to the alternatives given. n=104

Measure	No.	%
Fertilizing adjusted to crop need	75	72
Spread of manure in spring instead of in fall	52	50
Catch crops	45	43
Wetlands as nitrogen trap	29	28
Delayed or no fall ploughing	28	27
Cultivation system with minimized tilling	15	14
Irrigation	7	7
No measures taken	6	6

Table 8. Measures taken by farmers against phosphorous losses in number and percentage (II). The respondent could give several answers to the alternatives given. n=104

Measure	No.	%
Protective zones	20	19
Less soil compaction	7	7
Plough along contours	2	2
Adjustment of phosphorous fertilizing according to needs	1	1
No measures taken	77	74

Measures of "best agricultural practices" are shown efficient if considerations are given to site-specific conditions, for example microclimate and soil type variations in combination with agricultural practices (Domburg et al., 2000; Ullén and Mattson, 2003). Additionally, the local position in the catchment influences the effect an agricultural practice has on the environment (III) (Arheimer and Lidén, 2000). To be even more efficient, implementation of "best agricultural practice" should be supported by research and extension. As an encouraging example, the Swedish Board of Agriculture and the Swedish Federation of Farmers recently launched the Swedish project Focus on Nutrients (Focus on nutrients, 2003). Further development is still needed for "best management practices" based on estimates of nutrient leaching under various sets of local conditions (V) and efficient extension to implement the developed practices.

Lack of resources for implementation at the local level is a general reality for the municipal officers and is mainly perceived as a result of decisions based on political priorities. This highlights the significance that the decisiveness of local politicians can have on prioritizing and implementing the WFD to abide by EC law. Officers at local levels need manuals and recommendations to support their work. As commented in interviews, *"Resources are needed to accomplish this, both staff and economic incentives. It would be a serious waste if not properly implemented, as it is an excellent and stimulating directive."* The respondents put great emphasis on their perception that accomplishment of the WFD is dependent upon local political decisions for initiative and prioritizing, and upon legislation for implementation. They stressed that today most municipalities lack political environmental objectives as well as concrete objectives for the water resources within their boundaries. A marked lack of strategy at municipal level for integrating environmental concerns is pointed out in a SEPA report and supported in an earlier study (Brandt et al., 1999; SEPA, 2002). Few municipalities have defined local environmental goals for their development work. Among the few having such, they are rarely related to the local environmental situation nor to the national environmental objectives, but to the municipalities' economic priorities. An officer expressed the situation as, *"WFD needs to be launched in a big manner nationally, without being dependent on small municipalities' lack of funds for information campaigns and education, since a broad interest is decisive for implementation."* The stakeholder representatives supported the arguments that available economic resources are fundamental to improve the environmental situation, for different activities such as extension, monitoring and technical development (I).

Article V concludes that it is especially important to assess that the environmental effects for new cropping systems that are developing are not contradictory with local environmental goals. Hence, it is important to clearly express goals for implementing the WFD, with support in legislation, as stressed by the respondents. They perceived this as instrumental to putting pressure on

municipal politicians. The most important instruments for implementation of the WFD towards the goals are the Programs of Measures and the Management Plans to be defined by the Catchment District authorities in cooperation with stakeholders (Government Bill, 2003/04:2). The Programs and the Plans are to be based on thorough identification within the catchments of the different factors affecting water quality. For districts with prominent agricultural production, assessment of current practices and new trends should be of vital interest. In the Management Plan deteriorating conditions are to be noted continuously, thus over time documenting changes in environmental conditions. If introduction of a new crop will come under assessment remains to be tested.

6.3 Change

Three aspects of change, how to deal with change, adapt to it and shape it (Berkes et al., 2003), are related to the results. These are discussed to clarify the implications of farmers' disposition to change for desired environmental effects and to highlight the importance of the assessment of potential effects. Additionally, the municipal officers' perception of the potentials and problems that are coupled with foreseen changes are analyzed, with the purpose of including their knowledge and experience as a contribution for shaping change.

Changes in conditions, including environmental and socio-economic conditions, act as a driving force for development of agricultural practices (Berkes et al., 2000; Gibson et al., 2000b; Homer-Dixon, 1991). A continuous learning process is necessary for farmers to form new knowledge about economy, natural resource management and technology in order to deal with uncertainties brought by ever changing conditions, environmental as well as societal (Berkes et al., 2003). In order for the public authorities to improve the water quality in accordance with the demands of the WFD, it will be necessary to make farmers change not only their agricultural methods, but also possibly their production profiles. The stakeholder representatives pointed out that changes in attitudes and production practices is a process that takes time (I). They also emphasized that it is a complex process requiring inputs of various kind, e.g. technical development, extension, information and education.

As discussed in the analytical framework, considering a change takes a critical reflection on established agricultural practices by the farmer. Furthermore, there is tension and possible conflict involved when challenging accepted practices. To obtain an idea about farmers' inclination to change their farm management, the survey (II) included questions about alteration in production: if any has been made, what kind of change, when it was done and why. Out of the 104 farmers surveyed, 67 had altered their production profile during their farming time. Of these 67 farmers, 40 had changed what they

produce (for instance from milk to beef) and 29 had changed their mode of production to organic farming. This gives an indication that adaptations to changing conditions are common in agricultural production. However, farmers experience low profit margins and operate under constant uncertainty in predicting weather and market conditions. They are not willing to take increased economic risks to improve environmental conditions without some assurance that positive effects will result (I, II). Söderqvist noted similar attitudes in his study of farmers' motivation to participate in environmental projects in Southern Sweden (Söderqvist, 2001).

Farmers commonly take uncertainties into consideration in their production strategy. Environmental aspects and administrative regulations from the WFD are new demands with additional uncertainty to take into consideration. Decision support tools could be useful for considering different production choices. Study III reveals that none of the models currently in use appears appropriate to handle the farmers' questions about effect from farm activities. The models have not been constructed with such a purpose in mind, nor have the two dynamic models been constructed with such a scale in mind. When such tools to support decisions including risk assessment are used, it is expected that they indicate that the effect of climatic variability can overrun the effects from changing agricultural practices under present cultivation systems.

In contrast, study V explores the change of cultivars in a simulated climate change, and a potential increase in maize production for fodder is assumed. Such an adaptation is possible if, for example, maize production boundaries move north. As shown in Figure 4 climate change scenarios indicate a considerable change in growing degree days (Neild and Newman, 1999) and hence a more favorable climate for maize production. The corresponding effect on the environment is suggested to be severe. Table 9 illustrates the different simulated nitrogen leaching amounts per ha, where a change from ley to maize signifies a potential five-fold increase. Development of effective policies to manage assessment of trends such as the impact that new cultivation systems have on the environment is important. Although the initial phase of the WFD only goes up to the year 2015 (Table 1), this should not exclude the possibility for application to be more far reaching. Examination of the effects of potential changes to the climate provides additional support for the argument that implementation of the WFD must build on flexible mechanisms that can accommodate various types of changes.

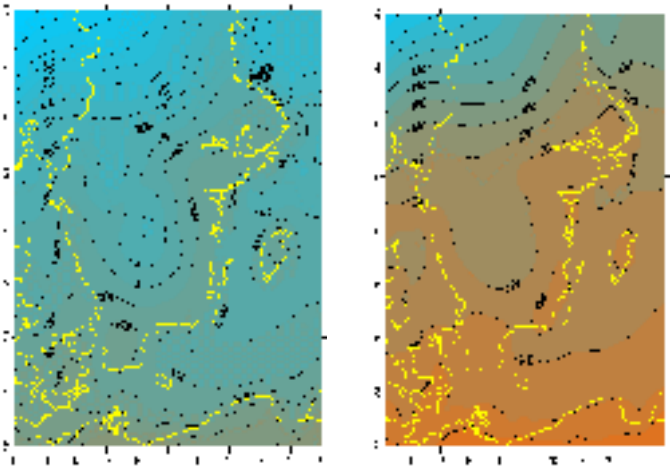

Figure 4. Growingdegree days in Sweden based on the RCAO-Hctrl and RCAO-HA2 for the period 1961-1990 (left) and 2071-2100 (right) (V).

Table 9. SOILN simulated nitrate leaching (kg N ha^{-1}) from different crops at the three agricultural areas in Sweden and SOILN simulated nitrate leaching (kg N ha^{-1}) from fertilized grassland and maize fields in Pennsylvania (V).

	Year Simulated	Fertilized grassland[a]	Grain	Potatoe	Maize
Area 1, Sandy loam	2000	14[b]	42-59[b]	64[b]	
Area 2, Sandy loam	2000	12[b]	40-52[b]	60[b]	
Area 3, Clay	2000	2[b]	11-21[b]	---	
Pennsylvania, silt loam	1993-96	11-16[c]			
Pennsylvania, silt loam	1988-92				71-89[d]
Pennsylvania, silt loam	1988-90				26-54[e]

[a] As 3-4 year fodder crop, ley, harvested 3 times per season.
[b] (Johnsson and Mårtensson, 2002)
[c] (Jabro et al., 2001) (summer feces trial 273-279 kg N ha^{-1})
[d] (Jabro et al., 1999)(fertilizer trial, 200 kg N ha^{-1})
[e] (Jabro et al., 1999) (slurry trial, 132, 158, 264 kg N ha^{-1})

The implementation of the WFD implies considerable changes in work mode for municipal offices and their employees. The interviewed municipal officers expressed a general positive attitude towards the WFD (IV). They appreciated the embracing approach of the WFD as compared to the current lack of conformed water management. Additionally, they were positive about getting beyond numerous eminent investigations and plans, to finally reach concrete activities and measures with the specific aim to improve the water status. There was an air of, "Now it is time for action! No more investigations but measures."

Additionally, the cooperation approach to day-to-day work with farmers was mostly interpreted as a positive change. The WFD suggestions on stakeholders' participation were regarded as a way to negotiate possible solutions. However, these positive perceptions were coupled with strong expressions about the need for political will, manifested in clear prioritization of municipal resources in combination with unambiguous legislation for support, as was also mentioned above. The core of the interviews is concentrated in Table 10. The table summarizes the factors the participants emphasized during the discussions as important for successful management of agricultural practices.

Table 10. Summary of municipal officers perceptions of the potentials and problems related to implementing EC Water Framework Directive in Sweden according to the proposed administration (IV)

Necessary conditions for successful implementation of the WFD: Political decisions for support at all levels. Broadly launched information campaign. Well thought-out process and carefully prepared administration along the entire chain. Use of the same methods in the whole country to be materialized according to each district's assessments. Inclusion of local farmer interest organizations. Adequate resources for implementation. Coordinated and supportive legal system inclusive of efficient regulations and enforcing instruments.
The participants observed the following as unclear in the proposal: Voluntary action versus legal scrutiny. Legislation (under the task force of the Government Commission for Revision of the Environmental Code).
The participants observed the following weaknesses: Structure, responsibility and legal competence. Consensus, when it does not work, then what?
The participants observed the following strong potentials: From plans to action! Changed work mode with negotiations, participation and cooperation. Local assessments coupled with a national approach.

7. IMPLEMENTING THE WFD IN SWEDEN

This chapter puts the study results in relation to three points that are important for implementing the WFD. Firstly the results are linked to a management built on a systems approach to natural resource management. Secondly, stakeholder participation and cooperation throughout the implementation process is suggested to be essential to make implementation sustainable. Crucial stages for such activities are identified in the study results. Thirdly, national legislation

must be developed including rules and regulations needed for implementation. How this is reflected and supported in the study results is discussed.

7.1 Systems approach to natural resource management

The stakeholder perceptions about the WFD approach towards managing water resources are presented to identify which potentials and problems related to implementation are necessary to address.

The Government Commission Report "Ground and Water" of 1971 expressed as a priority that as soon as possible the Swedish management of natural resources should be based on a solid ecological foundation (SOU, 1971:75). The reason for the urgency to assess planning alternatives according to ecological principles was motivated with a need to see the entire system for consideration of possible environmental impacts. Therefore the objective was to instill a longer perspective on spatial planning with reference to ecosystem resilience. A catchment approach was among the strategies discussed at the time (Malbert, 1999; SOU, 1979:54). However, a need for further interdisciplinary research on e.g. ecosystem analysis, model development and environmental monitoring data was declared necessary before such a management could be put in practice. After more than 30 years some of these ideas might finally be applied through the WFD.

When the WFD is about to be implemented, the idea to manage water according to its natural boundaries was considered logical by the stakeholder representatives (I). Several expressed the heritage attitude towards natural resources as a loan from the future. *"We are not users of today, but managers for coming generations"*. As mentioned in the previous chapter, municipal officers expressed enthusiasm over the ability to finally put this work in action (IV). The officers emphasized the positive influence the national and EU scale of implementation will have on the local level. They pointed out that Swedish farmers will not be the *accused*, but will be involved in a partnership to improve the environment together with all other stakeholders within a catchment.

Increased knowledge about ecosystem processes within the catchment was perceived fundamental for successful implementation of the WFD (IV). Where the farm is located in the catchment hydrological system influences the effect of agricultural practices on retention of nitrogen. Tools to estimate the impact of different agricultural practices, changes of practice and its relation to impacts of weather and climate variability is essential for construction of achievable environmental targets that the farmers can respect (III, V). The proposed structure for implementing the WFD with regionally formulated environmental objectives, monitoring of standard parameters and revision of management plans, allows the possibility to observe and include new factors impacting the environmental status. This forms the basis for an adaptive management in

response to environmental change. However, the District authority can make exceptions from the goals for a new activity when other influencing aspects are favorable and carry more weight than the environment. The dubious way the WFD is formulated in many parts signifies that it will be up to authorities at different levels to evaluate and judge which factors are most important for the district (Grimbeaud, 2001c).

7.2 Stakeholder participation and cooperation

Stakeholder perceptions about participation and cooperation are discussed here. Their disposition to, positive and negative expectations of, and suggested improvements for participation and cooperation compared to the present situation, is valid for the development of functioning procedures.

To make the Program of measures effective, the municipal officers stated that it is essential that farmers are part of the implementation process including the stages of planning and formulation of the program (IV). For the farmers to perceive it beneficial to be part of the process, they want to be able to take into consideration the risks involved (II), be it economic, social or technical factors.

Municipal officers are responsible for the implementation of environmental protection regulations in agricultural production. Traditionally in Sweden, the authority has been carried out with preference for communication and advice over legal sanctions (Eckerberg, 1997). EU and national regulations during the last decade have increased demands on the agricultural sector to reduce nutrient leaching. However, the instruments available for officers to pursue such demands on farmers, are to a great degree limited to threats of sanctions and rarely coupled with positive incentives (Eckerberg and Forsberg, 1996). When answering the individual telephone survey (I), the environmental inspectors responded that management of nutrient leaching must be handled with a carrot and whip approach, and did not leave space for dialogue. They gave the impression that the traditional role of exercising authority had no alternative. However, in the focus group discussions for study IV the participating inspectors emphasized the improvement a partnership with farmers would imply for their role as authorities. The differing attitudes could be explained by that the inspectors are unaccustomed with an integrated work mode, and when given the opportunity to discuss the unknown issue it influenced their attitude to become more positive.

Most environmental inspectors interviewed perceived the proposal as a positive change in their work routines towards the farmers. At present, there is mostly a one way communication from the municipal environmental office. The farmers are told what is expected from them and are subject to fines if they fail to comply. The Proposal was perceived as a possibility to provide proactive advice and discussion in the form of a dialogue where you negotiate a solution

with a timetable before sanctions are used. This was considered useful when trying to involve reluctant farmers. With the suggested change the interviewed officers recognized the possibility to work as partners with the agricultural community, which they considered more fruitful in reaching goals of nutrient leaching reduction. This corresponds with study I in the same area where farmers expressed "voluntary cooperation under responsibility as the most efficient way".

However, an important factor for this partnership to be productive is an unambiguous legal system to act as the framework within which negotiations are made. All responding officers put strong emphasis on the need for clarification of the proposed administrative procedures concerning the gap between voluntary action and exercise of authority, although strict regulations have not proven efficient in reducing nutrient leaching in Sweden (SOU, 1997:99). As both Lundqvist and Eckerberg & Forsberg point out, enforceability of an intricate set of regulations is often inefficient (Eckerberg and Forsberg, 1996; Lundqvist, 2001b). A partnership has a potential to become legally formalized, according to the proposal of a new Swedish water administration (Government Bill, 2003/04:2). It is suggested for inclusion in the Swedish Environmental Code that the Program of Measures can contain formal agreements or cooperation in joint property units concerning specific undertakings for a given subbasin or other administrative unit. Just as important is it to build operational and institutional competence within the suggested stakeholder groups, in order for them to take active part in the process, farmers and authorities alike. Data accessibility and handling is discussed in study III and V as an example of a required competence to manage nutrient leaching.

Implementing the WFD imply a shift of focus for the municipal offices work as well as of their routines. Cooperation would not only include farmers, but also other municipalities and County Boards included in the catchments. Different working cultures and standards are likely to collide, as the officers discussed (IV). The prevailing planning practice in Sweden is concentrated on consensus building between stakeholders. Dovlén argues that it can be a constraint for developing sustainability in the system, if alternative kinds of knowledge and perspectives are not allowed to influence the process (Dovlén, 2001). It was discussed among the participants that the way the proposal is written, consensus is needed at all levels. They pointed out that this can be a strong point when it works, as measures ought to be carried out more or less automatically. The other aspect is, what happens when the participants do not agree upon what is to be done? The respondents perceived a gap in this matter between voluntary action and exercise of authority that is not considered functional. One officer said, *"The proposal has to dare to become clearer when it comes to the necessary authoritative powers"*. The question of cooperation over matters concerning agricultural production, with the exception of machinery, was not generally common among the farmers interviewed (II), and

thus remains to be investigated further. The Genevad River role play revealed constraints in the form of negative memories within the local farmer community, that efficiently put an end to cooperation between stakeholders in their work to reach environmental goals within a catchment (Lundqvist, 2001a). The municipal inspectors interpreted their role in the proposed administration, as that of coordinating future stakeholder participation in local sub basin groups (IV). In such a way they would link authority with the agricultural community, which is suggested to create a more functional form of management to handle questions of mistrust. This is in accordance with the ecosystem management Olsson and Folke propose, of combining stakeholder knowledge and experience from authorities and individual resource users for successful management (Olsson and Folke, 2001).

7.3 Rules and regulations

Agricultural practices carried out are discussed in relation to whether they are regulated or not. Views on rules and regulations are analyzed, with the purpose of identifying factors crucial for effective management and compliance.

Although the general perspective on a catchment approach was positive, the perspectives on how to manage the water in the catchment were diverging, spanning from a demand on voluntary action to exercise of strict authority applied by law. Farmer representatives expressed that willingness to change practices would be encouraged if they were entrusted with the responsibility. In the event that there would only be additional rules and regulations the farmer's attitude could well be negative (I). This was supported by study II, where more measures to reduce nutrient leaching were carried out based on awareness of effect than those carried out based on regulations. Farmers are already restricted by law concerning practices related to manure handling (ammonia release), to a lesser extent concerning practices related to nitrogen leaching and to even lesser degree concerning phosphorous losses. Oftentimes the regulatory system is perceived as contradictory and far from based on the environmental situation (II, IV). Only an unambiguous legislation supports "best management practices", otherwise they are considered counteractive and without proper founding.

The role of the Swedish Environmental Protection Agency is to provide guidelines and advice for the implementing units, in cooperation with the County Administrations. The responsibility for implementation of environmental protection regulation lies within the municipalities (Eckerberg and Forsberg, 1996). Consistent with Swedish administration practices, the proposal suggests that the municipal environmental offices perform a considerable part of the implementation. Municipal officers appreciated the recognition of expressed competence (in a legal sense) as implementing

authorities that the proposed administration suggested (IV). They stressed the need for rules and regulation as tools to ensure conformity in the implementation at a national scale. Functional legal tools support implementation and are necessary to internalize the WFD objectives into procedures, routines and tenders. This will be especially important when it is time to turn the Programs of Measures into activities, the officers emphasized. Furthermore, they pointed out that if the WFD is truly based upon the concept of sustainability with a perspective of lasting over generations, the tools needed must be functional along the entire path from setting the objectives, over fieldwork until objectives are reached. *"A systems thinking is needed, then the WFD will be a shift of paradigms"*, an officer declared.

The issue that aroused most remarks among the responding municipal officers was the overall structure for implementation of the WFD. They were unanimous in demanding that the status given to decisions, responsibilities and policy instruments throughout the process of implementing the WFD, is decisive to be able to carry it out at all. There was strong emphasis on a more transparent structure over competencies at all levels, how it will be financed and what legal support exists. The comments can be related to the less stringently regulated Swedish environmental administrative system where directives are issued from the Ministry, and the municipalities are free to decide which organization to establish in order to comply (Lundqvist, 1996).

8. SUMMARY AND CONCLUSIONS

Agricultural management practices geared towards reducing nutrient leaching are in focus for the research presented in this thesis. Stakeholder perceptions about potentials and problems concerning management of agricultural practices are analyzed and put in relation to implementing the EC Water Framework Directive in Sweden. With a systems approach and using various analytical methods, the potentials and problems of implementing integrated catchment management of water resources in reference to nitrogen discharge, agricultural production and municipal authorities, are summarized below.

8.1 Administering a systems approach

The results indicate a general positive attitude among stakeholder representatives and municipal officers interviewed towards the main characteristics of the newly introduced WFD. They approve of the catchment approach where sources of water pollution are systematically identified and managed. Although of international and national concern, the WFD is supposed to be applied based on local socio-economic and natural conditions, which is interpreted as a positive factor. Thus, neither a certain region nor a certain group

of stakeholders are pointed out at random, but are part of a general scheme. The responses indicate that a national approach would put pressure on local politicians to define environmental objectives and provide resources to fulfil them.

The results reveal that a move towards a pro-active process was perceived as a further positive factor for implementation, where specific activities and measures are carried out according to previous planning based on local assessments. The monitoring function would register environmental changes, and negative trends would be detected and counter-measures planned. Flexibility has to be included for the administration to be able to adapt to changing conditions.

8.2 Making decisions for change

Changes in agricultural management practices must be made to improve water quality. The current findings indicate that decision making for farmers is a complex procedure and that the different factors need to be addressed in order to obtain a change in agricultural practices. Farmers base their decisions concerning which practice to use on economic considerations, rules and regulations, and their knowledge about nutrient leaching. Their sources of information include professional magazines, advisers, neighbors and colleagues. In order for the farmer to be able to make an accurate risk assessment, it is essential to provide estimates of uncertainty of the effect of alternative measures. Present models are not always useful to answer farmer's questions about effect of measures, but constitute a solid base for further development. The need for decision-support for farmers increases as the WFD put new demands to reduce nutrient leaching. Farmers commonly pay attention and adapt to changing conditions such as weather, market, regulations and working conditions. The results propose that a possible adaptation to changed climate through the choice of a new crop would effect nitrogen leaching considerably. Consequently, it is important that within the future WFD administration consequences of changes in agricultural conditions are identified and assessed.

Rules and regulations guide the farmers choices, however the results show that more practices are carried out if they know it has a positive effect on reducing nitrogen leaching. A great deal of the interviewed farmers had made changes, even so there remain still more farmers that could change their methods. Thus, providing appropriate information in all the right arenas is crucial in order to make farmers change practices.

8.3 Involving stakeholders

Stakeholder cooperation implies increased trust in the individual's decision making and responsibility for reaching defined objectives. This will only be

possible if farmers perceive a benefit from cooperation and compliance. The cooperative approach to daily routines with farmers was interpreted by the municipal officers as a positive change towards partnership concerning improvement of water quality. It was interpreted as positive with possibilities to negotiate over solutions. The officers need terms of reference that prioritize cooperation, and resources to carry it out. Stakeholders in general need development of their competence to accomplish the proposed work. Having access to and being able to use relevant data is only one important factor for stakeholder involvement. Legislation must define the space for actions on the scale between voluntary initiative and those demanded by law. Consistent legislation that is clear about power and rights is fundamental for cooperation to function when volunteerism and enthusiasm are absent. Rules and regulations are an important factor for increased cooperation. Farmers require consistent regulations that can be included in their production strategy. Municipal officers demand functional regulations as tools for their exercise of authority. These results show how important it is that all stakeholder levels are involved during the whole process of implementing the WFD.

The focus group session started a reflective learning process around water issues and specifically the WFD for the municipal officers. Their collective attitude towards cooperation with farmers differed from the attitudes expressed by the officers interviewed individually. The sessions gave the opportunity to learn about a lesser-known issue, to reflect upon its implications and to discuss unclear procedures with colleagues. They provided valuable comments that improved further development of the proposed administrative forms. The proposed catchment based water associations will require active involvement and cooperation of stakeholders. Utilizing the dynamics inherent to an interactive process is a first step on the long trail to stakeholder participation and cooperation.

This thesis aims to contribute to a more profound understanding of what makes different stakeholders act the way they do. The results constitute a basis for important parameters to be included in the development of necessary frameworks and instruments to facilitate a sustainable resource management. It is for policy makers and management planners to use, to put to immediate test in practice.

9. FUTURE RESEARCH

The research presented in this thesis was produced with the aim to provide indications on what is needed to make integrated catchment management work when the WFD is to be implemented on a national scale. Much remains to be done and some areas for further work are mentioned below.

- Indication on organizational structures and forms with acceptance among all stakeholder groups, landowners and authorities, are needed. This is stressed especially for areas where cooperation among farmers is not generally common, as the local cultural contexts influence the attitude to associate.

- Another area is brought by potential future climate changes of importance for agricultural production and corresponding changes in nutrient release. Farmers' perceptions about potentials and problems related to adaptations to changed conditions indicate scenarios that need to be actively planned in order to avoid environmental degradation while maintaining a future production.

- The current knowledge map on nutrient flows holds both black boxes and white areas to be further explored. Well-founded science is one important component of the base for development of management practices to be efficient and trustworthy.

10. SAMMANFATTNING (Summary in Swedish)

Avhandlingen handlar om ändrade jordbruksmetoder som ett medel för att minska näringsläckage till vatten och därmed minska övergödningen. Övergödningen är betydande i Sveriges vattendrag, sjöar och omgivande hav. Punktkällor som reningsverk och industrier har identifierats och åtgärdas successivt. Diffusa källor består till betydande del av näringsläckage från jordbruket, som står för nästan hälften av kväveutsläppen. Det gör att utsläppen till väsentlig del är beroende av enskilda bönders beslut om vilka jordbruksmetoder de använder. EG har nyligen utfärdat ett nytt ramdirektiv för vattenfrågor, som är en bekräftelse på att vatten är en resurs som EU ska ta ansvar för. Direktivets mål är att säkerställa en god ekologisk kvalitet på vattnet inom medlemsstaterna genom att ta ett samlat grepp om alla vattenrelaterade frågor. Vatten ska förvaltas inom sitt avrinningsområde av nya myndigheter som utses inom kort. Direktivet förespråkar att alla aktörer inom avrinningsområdet deltar i förvaltningen.

Avhandlingens syfte är att analysera aktörernas uppfattning om möjligheter och svårigheter vid hantering av jordbruksmetoder och att relatera analysen till genomförandet av ramdirektivet för vatten. Avhandlingen utgår från att det är viktigt att ta reda på vad olika aktörer faktiskt gör för att minska näringsutsläpp innan man fastställer ett nytt regelverk. Metoder från både naturvetenskapliga och samhällsvetenskapliga områden har använts. Hur resonerar bönderna när de fattar beslut om vilka jordbruksmetoder de ska använda? Vad grundar de besluten på? För att få svar på dessa frågor har intervjuer gjorts inom Nyköpingsåns avrinningsområde. Representanter för olika grupper av aktörer har fått frågor om vilka de anser vara mest lämpade att förvalta vattenresurserna. Drygt hundra bönder har intervjuats om sina jordbruksmetoder. Det finns flera modeller som används av konsulenter och myndigheter för att underlätta beslutsfattande som påverkar näringsläckage. Utifrån frågor som bönderna ställde i intervjuerna, analyserades de vanligaste modellerna som används i Sverige för att beräkna kväveläckage.

Miljökontorens tjänstemän har myndighetsansvar för miljön inom kommunen. Det är de som ser till att lagen efterlevs och att miljömålen uppfylls. Det är omöjligt för dem att kontrollera varje enskild bonde och bönderna önskar inte heller ytterligare kontroll. Hur kommer då direktivet att fungera för tjänstemännens planering av miljöarbetet och utövning av myndighetsansvar? Tjänstemän från tre kommuner har intervjuats i fokusgrupper och har i situationer som liknar arbetsmöten utbytt synpunkter om vad direktivet kan innebära för deras arbetssituation. Vattendirektivet är antaget för att åstadkomma en vattenhantering som är hållbar generationer framöver. Då är det nödvändigt att regelverket konstrueras så att det blir flexibelt nog att hantera framtida förändringar som kan komma att påverka förutsättningarna. Förändringar i jordbruket som påverkar näringsläckaget, och som bönderna

förväntas göra, har analyserats med klimatförändringar som exempel. Scenarier om klimatförändringar i Norden användes för att applicera förändringar i klimatet på tre jordbruksområden i Sverige. Det skedde utifrån antagandet att bönder anpassar sin produktion till ett förändrat klimat och de konsekvenser som det kan tänkas få för näringsläckaget.

10.1 Att förvalta enligt Vattendirektivet

Tjänstemännen och de olika gruppernas representanter var allmänt sett positiva till den föreslagna hanteringen av vattenfrågor. De tyckte det var logiskt att se till hela avrinningsområdet och att det skulle bli lättare att fastställa och åtgärda eventuella problem. I och med att man utgår från de lokala förutsättningarna, både när det gäller naturresurser, jordbruksproduktion och ekonomi, såg de större möjligheter att planera effektiva åtgärder. Samtidigt är det en fördel att det gäller alla avrinningsområden, så att inga regioner känner sig utpekade. Kommunaltjänstemännen ansåg att det behövs påtryckningar uppifrån för att de lokala politikerna ska avsätta tid och medel för genomförandet. I och med kravet på att uppfylla EGs direktiv skulle det lokala miljömålsarbetet kunna definieras bättre. Vattendirektivet kan innebära att miljöaspekter hanteras förebyggande i stället för i efterhand, när de redan utvecklats till problem. Redan på ett tidigt stadium skulle man till exempel kunna bedöma vilka förändringar som nya grödor medför.

10.2 Att fatta beslut för förändring

Jordbruksmetoderna måste förändras för att minska näringsläckaget. Avhandlingen visar att bönderna grundar sina beslut på många faktorer och får information från flera olika källor. Självklart är ekonomin viktig, men bondens kunskap om näringsläckage och hur det påverkas av jordbruket är också viktig. Innan de fattar beslut vill de kunna skaffa sig en uppfattning om hur effektiva de olika metoderna är för att minska läckage. Minskar igenväxningen i den närmaste badsjön om jag börjar plöja på våren i stället för på hösten? Nuvarande modeller för att beräkna näringsläckage är inte alltid användbara för att besvara böndernas frågor eftersom de är konstruerade för större områden. Vattendirektivet innebär nya krav på bönderna för att minska den negativa påverkan på miljön. Det kommer att medföra ett ökat behov av beslutsstödjande modeller och de som undersökts utgör en god grund för en vidareutveckling. Bönder är vana att beakta förändringar och osäkerheter i sitt dagliga arbete, men vill få en uppfattning om storleksordningen. Väder, marknadskrafter, regelverk och arbetsförhållanden förändras ständigt. Resultaten visar att om en ny gröda väljs för att öka självförsörjning av foder kan näringsläckaget öka väsentligt. Det är viktigt att den framtida administrationen identifierar och bedömer konsekvensen av förändringar i jordbruksproduktionen.

De regler och förordningar som finns styr också böndernas handlande, men analysen visar att de genomför fler åtgärder om de vet att det är positivt för miljön, än om det bara är för att följa reglerna. Resultaten visar att åtskilliga bönder i området har förändrat sina jordbruksmetoder för att minska läckaget, men det finns fortfarande bönder som skulle kunna ändra sina metoder. För att få bönderna att fatta beslut om att förändra metoderna så är det viktigt att rikta informationen genom alla de olika kanaler som bönderna använder sig av.

10.3 Att involvera aktörer

Samverkan mellan olika aktörer förutsätter att det finns förtroende för enskilda personers förmåga att fatta beslut som leder till en hållbar utveckling. Förändrade jordbruksmetoder måste dessutom bygga på delat ansvar. För att bönderna ska vilja samarbeta måste de uppfatta att de får något positivt ut av samarbetet. Miljövårdsinspektörerna såg det som positivt att deras arbetssätt gentemot bönderna kan komma att förändras i och med att vattendirektivet införs. Nu ser de arbetet som en envägskommunikation där de enbart talar om vilka regler som gäller och utfärdar böter när de upptäcker brister. De trodde att även bönderna skulle uppfatta ett partnerskap där det finns utrymme för förhandling som fördelaktigt. De påpekade att det föreslagna arbetet med grupper inom delavrinningsområden kommer att ta mycket tid. Därför är det viktigt att det tydligt framgår av arbetsbeskrivningarna och att politikerna tillsätter resurser för detta arbete. Dessutom är det en typ av arbete som de behöver utbildas för. Detta gäller generellt, för att de olika aktörerna ska kunna delta aktivt så måste de tillägna sig nya kunskaper, till exempel både om hur man hanterar olika miljödata och om hur man arbetar i grupp. Avhandlingen visar att det finns behov av ytterligare forskning kring jordbruksmetoder och dess påverkan på näringsläckage.

Resultaten visar hur viktigt det är med tydlighet för de olika aktörerna när det gäller ansvar, beslutsrätt och övervakning. Det blir särskilt viktigt med ett väl genomtänkt system när samarbetet inte fungerar så bra. Både bönder och tjänstemän framhöll att regelverket måste vara entydigt för att de ska kunna använda det som stöd i sitt arbete. Aktörerna ansåg att de skulle komma att känna större ansvar för genomförandet av vattendirektivet om de får möjlighet att vara delaktiga i planering och beslutsfattande på ett tidigt stadium.

Bland tjänstemännen som deltog i fokusgrupperna blev själva intervjusituationen en inledning till reflektion och lärande om vattenfrågor i allmänhet och vattendirektivet i synnerhet. Dessutom gav de som deltog fokusgrupperna uttryck för en betydligt mer positiv syn på samarbetet med bönder än miljökontorens representanter som intervjuades enskilt. Fokusgrupperna gav dem möjlighet att lära sig mer om ett tidigare ganska okänt ämne, att reflektera över vad det skulle innebära och diskutera oklarheter med kolleger. Dessutom användes deras synpunkter på de lokala frågorna som

underlag av den pågående utredningen om vattendirektivets administration. Att utnyttja dynamiken i en interaktiv process utgör ett viktigt första steg på den långa vägen mot medinflytande och samverkan.

Avhandlingen vill bidra till en djupare förståelse för vad som får olika aktörer att agera som de gör. Resultaten kan användas för att utveckla strukturer och verktyg som behövs för en hållbar resurshantering. De ska kunna användas av beslutsfattare och planerare, och omsättas i praktiken.

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