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Sari Autio

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Do we listen to earthworms?

Tools for evaluating the Finnish National Action Plan on the sustainable use of plant protection products

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Do we listen to earthworms?

Tools for evaluating the Finnish National Action Plan on the sustainable use of plant protection products

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Academic dissertation in Environmental Change and Policy

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DO WE LISTEN TO EARTHWORMS? TOOLS FOR EVALUATING THE FINNISH NATIONAL ACTION PLAN ON THE SUSTAINABLE USE OF PLANT PROTECTION PRODUCTS

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Abstract

Sari Autio: Do we listen to earthworms? Tools for evaluating the Finnish National Action Plan on the sustainable use of plant protection products

Qualitative programme evaluation procedures for the National Action Plan on the Sustainable Use of Plant Protection Products (NAP) were developed jointly with the Finnish actors involved in its implementation, using participatory action research. The purpose of the National Action Plan is to reduce the risks to human health and the environment from the use of plant protection products. The structure, organisation, actors involved and the values and expectations of stakeholders regarding its implementation were queried using systems thinking as a complex, purposeful system with goals defined within the framework of the European legislation concerning plant protection products. Due to the multidisciplinary nature of the NAP, the research approach is integrating. Soft Systems Methodology was used to analyse different and even contradictory goals of various stakeholders involved in the preparation and implementation of the NAP to make the implicit pre-assumptions behind it visible, and an explicit programme logic was formulated for it. A range of evaluation questions were derived to focus on gathering appropriate research data and other evidence needed to support qualitative evaluation of the programme's achievements in adequate detail and from multiple perspectives.

To conduct an evaluation on the NAP, existing heuristic tools were explored that initially appeared to be appropriate for framing the goal-setting for a qualitative assessment. Heuristic tools were tested with an expert panel, and based on its experiences four models were selected for the NAP tool box: 1) Critical Systems Heuristics, 2) sustainability screening of National Sustainable Development Strategies, 3) Limiting Factors Analysis and 4) Systemic Programme Logic. These heuristic tools were adapted to consider the specific characteristics of the use of plant protection products, in order to improve their applicability in the evaluation of the NAP, either together or separately according to specific evaluation needs. Proposals for measures and indicators of evidence were collected for different priority areas of the NAP, based on the expert discourse. Several research proposals emerged to measure and assess the achievements.

The NAP was reviewed also from the perspective of stakeholder participation, as a process of collective learning. As regards the actors involved, this process is the linchpin in reducing the environmental and health risks from the use of plant protection products. Users are in prime position to adopt safer application techniques in the long term. The quality of training, extension services and information for the users, as well as the mutual atmosphere of the actors influence the willingness to adopt the knowledge provided. It was notable that the non-governmental organisations were not willing to participate in the running of the workshop convened for this study. A joint co-production of knowledge between all stakeholders should be considered so as to keep the influence from accumulating solely on limited high-level expert circles.

The heuristic tools were aggregated as a separate handbook for practical evaluation needs of governance in Appendix 4 of this monograph. Halfway through the first programme period of the National Action Plan, the actors involved still have time to prepare for the evaluation, which will take place around the year 2020. Finland has to report to the European Commission and other Member States about achieving the goals of the NAP.

Key words: National Action Plan (NAP), sustainable use of plant protection products, reducing environmental and health risks, evaluation, heuristic tool, programme logic, collective learning, participatory action research, system

Tiivistelmä

Sari Autio: Kuuntelemmeko lieroja? Välineitä kasvinsuojeluaineiden kestävän käytön kansallisen toimintaohjelman arvioimiseen

Kasvinsuojeluaineiden kestävän käytön kansallista toimintaohjelmaa (National Action Plan; NAP) varten kehitettiin laadullisia arviointimenettelyjä yhdessä ohjelman toteutuksesta vastaavien suomalaisten toimijoiden kanssa osallistuvan toimintatutkimuksen avulla. Toimintaohjelman tavoitteena on vähentää kasvinsuojeluaineiden käytöstä aiheutuvia riskejä ihmisten terveydelle ja ympäristölle. NAPin rakennetta, organisaatiota, toimijoita ja eri sidosryhmien arvoja ja odotuksia sen toteuttamisesta tarkasteltiin systeemiajattelun keinoin kompleksisena, tarkoituksellisena systeeminä, jonka tavoitteet on määritelty Euroopan Unionin kasvinsuojeluainelainsäädännön puitteissa. NAPin monitieteisen luonteen vuoksi tutkimusote oli integroiva. Toimintaohjelman laatimiseen ja toteuttamiseen osallistuvien tahojen erilaisia ja osin ristiriitaisiakin tavoitteita analysoitiin pehmeän systeemimetodologian avulla saattamalla näkyviksi ohjelman taustalla olevia julkilausumattomia perusoletuksia ja formuloimalla NAPille julkilausuttu ohjelmalogiikka. Laadittiin myös joukko arviointikysymyksiä tarvittavan tutkimustiedon ja muun näytön hankkimiseksi kuvaamaan moniulotteisesti ohjelman tuloksellisuutta.

Arvioinnin toteuttamista varten etsittiin olemassa olevia heuristisia välineitä kehystämään NAPin laadullisen arvioinnin tavoitteenasettelua. Asiantuntijapaneelin avulla testattiin oivalluksen apuvälineitä, jolloin heuristiseen työkalupakkiin valikoitui neljä mallia: 1) kriittinen systeemiheuristiikka (Critical Systems Heuristics), 2) kansallisten kestävän kehityksen strategioiden kestävyysseulonta (Sustainability Screening), 3) rajoittavien tekijöiden analyysi (Limiting Factors Analysis) ja 4) systeeminen ohjelmalogiikka (Systemic Programme Logic). Malleja muokattiin soveltumaan kasvinsuojeluaineiden käyttöön liittyvien erityispiirteiden arviointiin. Asiantuntijakeskustelujen perusteella koottiin ehdotuksia onnistumisen näytöiksi ja indikaattoreiksi ohjelman eri osa-alueille. Useita jatkotutkimusehdotuksia nousi esiin ohjelman tavoitteiden toteutumisen seurantaa varten.

NAPia tarkasteltiin myös sidosryhmien osallistumismahdollisuuksien kannalta, kollektiivisen oppimisen prosessina. Toimijoiden keskinäisellä kollektiivisella oppimisella on keskeinen merkitys kasvinsuojeluaineiden käytöstä aiheutuvien ympäristö- ja terveysriskien vähentämisessä. Kasvinsuojeluaineen käyttäjä on avainasemassa turvallisten käyttötapojen pitkäjänteisessä omaksumisessa. Käyttäjille tarjottavan koulutuksen, neuvonnan ja tiedotuksen laatu samoin kuin toimijoiden keskinäinen ilmapiiri vaikuttavat tarjottavan tiedon omaksumishalukkuuteen. Huomionarvoista oli kansalaisjärjestöjen haluttomuus osallistua tutkimusta varten koolle kutsuttuun työryhmätyöskentelyyn. Jotta vaikutusvalta ei keskittyisi liiaksi ylätason suppeille asiantuntijatahoille, tiedon tuottamiseen yhteisvoimin eri toimijoiden kesken tulee jatkossa kiinnittää huomiota.

Heuristiset välineet koottiin hallinnon käytännöllisiä arviointitarpeita varten erilliseksi ohjekirjaksi, joka on monografian liitteenä 4. Kasvinsuojeluaineiden kestävän käytön kansallisen toimintaohjelman ensimmäisen ohjelmakauden ollessa puolivälissä toimijoilla on aikaa valmistautua ohjelman toteutumisen arviointiin noin vuonna 2020. Suomen tulee raportoida Euroopan komissiolle ja muille jäsenmaille NAPin tavoitteiden toteutumisesta.

Avainsanat: kansallinen toimintaohjelma, NAP, kasvinsuojeluaineiden kestävä käyttö, ympäristö- ja terveysriskien vähentäminen, arviointi, heuristinen väline, ohjelmalogiikka, kollektiivinen oppiminen, osallistuva toimintatutkimus, systeemi

Referat

Sari Autio: Lyssnar vi på daggmaskar? Medel för utvärderingen av det nationella åtgärdsprogrammet för hållbar användning av växtskyddsmedel

Kvalitativa evaluationsprocedurer för det nationella åtgärdsprogrammet för hållbar användning av växtskyddsmedel (National Action Plan; NAP) utvecklades med hjälp av engagerad aktionsforskning tillsammans med finska aktörer som är ansvariga för genomförandet av programmet. Programmets mål är att minska riskerna för människors hälsa och miljön som orsakas av användningen av växtskyddsmedel. Programmets struktur, organisation, aktörer samt olika intressegruppernas värden och förväntningar om dess genomförande undersöktes med systemanalys som ett komplext, målinriktat system, vars syften har definierats inom ramen för Europeiska Unionens lagstiftning om växtskyddsmedel. På grund av programmets tvärvetenskapliga natur var forskningsmetoden integrerande. Olika och dels kontroversiella målsättningar av grupper som deltagade i utarbetningen och genomförandet av NAP analyserades med hjälp av mjuk systemmetodologi för att synliggöra implicita grundantaganden och för att formulera en explicit programmelogik för NAP. Ett antal evaluationsfrågor härleddes för att anskaffa forskningsdata och annan evidens att beskriva programmets konsekvenser mångsidigt från olika perspektiv.

För att genomföra evalueringen söktes existerande heuristiska medel, som enligt preliminära betraktandet tedde sig tillgängliga att omrama målsättningen av den kvalitativa utvärderingen av NAP. En expertpanel testade heuristiska hjälpmedlen och fyra modeller valdes till den heuristiska vertygslådan: 1) kritisk systemheuristik (Critical Systems Heuristics), 2) hållbarhetsscreening av nationella strategier av hållbar utveckling (Sustainability Screening), 3) analys av begränsande faktorer (Limiting Factors Analysis) and 4) systemisk programlogik (Systemic Programme Logic). Dessa insiktväckande modeller bearbetades för att lämpa sig till utvärderingen av NAP. Med stöd av expertdiskussioner sammanfattades förslag till evidens och indikatorer till olika delområden av NAP. Flera fortsatta forskningsförslag kom fram. NAP undersöktes också som en kollektiv inlärningsprocess ifrån perspektivet av intressegruppernas deltagandemöjlighet.

Aktörernas ömsesidiga inlärningsprocess har en central betydelse i förminskningen av miljö- och hälsoriskerna i växtskyddet. Användaren själv har nyckelrollen i att tillägna sig tryggare användningssätt på lång sikt. Kvaliteten av utbildning, rådgivning och information som erbjuds till användarna samt aktörernas ömsesidiga atmosfär likaså påverkar villigheten att omfatta informationen som är tillgängligt. Beaktansvärt är att medborgarorganisationer var ovilliga att delta i workshoparbetet som sammankallades för den här undersökningen. Det är viktigt att engagera olika aktörer i gemensamma kunskapsproduktionen, för att inflytandet inte skulle koncentrera sig enbart inom begränsade expertkretsar på hög nivå.

Heuristiska medel samlades i en separat handbok för förvaltningens praktiska utvärderingsbehov, som finns i bilaga 4 av monografin. Den första programperioden är halvvägs och aktörer kan förbereda sig till utvärderingen av NAP ungefär år 2020. Finland skall rapportera till den Europeiska Kommissionen och andra medlemsländer om genomförandet av programmets målsättningar.

Nyckelord: det nationella åtgärdsprogrammet, NAP, hållbar användning av växtskyddsmedel, förminskning av miljö- och hälsorisker, utvärdering, heuristisk medel, programlogik, kollektiv inlärning, engagerad aktionsforskning, system

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Preface and acknowledgements

I was first introduced to the exciting world of plant protection products during my earliest summer jobs as a garden worker at the Botanical Garden of the University of Helsinki and as a forestry trainee with Puulaaki Oy in the 1970s. In those days, the attitudes of garden and forestry workers towards the safety of operators and the environment were not as cautious as they hopefully are today. Later, after completing my studies in the Faculty of Agriculture and Forestry, I started my career in assessing the environmental risks of plant protection products for the Finnish authorities responsible for chemicals control, a career that has captured my fascination since 1988.

As a result of this work, I was nominated as an environmental expert for the Finnish delegation participating in the European Council negotiations during the first reading of the Commission proposals for the European legislation concerning plant protection products, in 2006-2009. The work started during the Finnish presidency and continued for a couple of years. The proposals were scrutinised in detail with numerous changes drafted by experts from the Member States, the Council and the Commission. Finally, an agreement was reached and the legislation was adopted by the Commission and the Parliament in 2009. I was also nominated for the national committee established by the Finnish Ministry of Agriculture and Forestry to prepare the first National Action Plan (NAP) on the sustainable use of plant protection products for Finland. It has been a privilege and an educational experience to follow this European legislative process from its early stages to its national implementation as a whole.

Alongside the administrative work I have participated in several research projects to study the environmental effects of plant protection products in our northern conditions, which are unique and particularly vulnerable due to our cold and harsh climate and barren soils. Finland has the northernmost agriculture in the world.

My role as evaluation researcher in this study has been shaped by my education as environmental scientist and ecotoxicologist, as well as by my professional career in assessing and mitigating the environmental risks of plant protection products for more than 25 years. The risk assessment methodology and guidance for assessing the environmental risks of plant protection products have developed exhaustively during that time, and this development does not seem to be slowing down.

I also have an ever-growing general interest in ways of measuring the achievements of environmental strategies and action plans. Together with my colleagues, we have participated in several exercises on environmental risk indicators of plant protection products within the OECD and EU, more or less actively since 1990s, and we have gained experience in indicators as measurement tools. However, using solely numerical risk indicators to measure the successfulness of a programme that consists of a variety of different actions and involves a large group of experts from different disciplines, would not be adequate to cover all outcomes of the progress.

Therefore, when an opportunity opened up in my personal life that meant I could step out of administrative work for a while, I decided to test my boundaries in academic research with this study. I thus completed further studies on environmental policy evaluation, attempting to develop appropriate tools and practices for the NAP community to evaluate the achievements of our programme. I hope that this study will be of practical use when required. Consequently, I have chosen my path and cannot be an outsider observer but instead have come into a role as a participatory action researcher to guide my colleagues and stakeholders, as collegial participants, into the world of evaluation research.

I am very grateful to my organisation, the Finnish Safety and Chemicals Agency (Tukes), for granting me study leave for this project, to the directors and especially to my Head of Unit Kaija Kallio-Mannila, who encouraged and supported my efforts to study further, despite the additional workload my absence meant for other colleagues in our work community at Tukes. Numerous colleagues also in many other organisations have helped me in many ways. While it is not possible to mention everybody by name, I would like to firstly express my appreciation to the volunteer focus group participants and the expert panel members, for your enthusiastic ideas and the workload you offered for this study as my collegial action research participants. Without your contributions this study would not have been materialized. Furthermore, the NAP Steering Committee as a whole has been very encouraging and interested in this project, and I thank all of you. My special thanks go to my colleagues Pauliina Laitinen, coordinator of the Finnish NAP activities, who tirelessly answered my numerous questions and happily provided me with information, help and comments during the study, and Eija-Leena Hynninen, who kindly allowed me to rummage in her archives for historical data about authorising plant protection products in Finland. I also owe my gratitude to my other colleagues for our pleasant working environment at the Tukes plant protection products unit. Hopefully, with this study I will be able to give you back something useful for our common efforts to increase the sustainability of plant protection.

The multidisciplinary supervisory group has been very important to me, and I am thankful for the constructive comments, encouragement and advice I received from my supervisors Professor Ilmo Massa and University Lecturer Martin Lodenius from the University of Helsinki, Professor Sirpa Kurppa from the Natural Resource Institute Finland, and Research Scientist Annukka Berg and Head of Unit Jaakko Mannio from the Finnish Environment Institute. I also appreciate the insightful discussions of the environmental policy graduate seminar participants. I am grateful to the pre-examiners of this thesis, Professor Pekka Jokinen and University Lecturer Olli-Pekka Penttinen, for offering your valuable time to review this long manuscript. Thank you for your fruitful criticism and contribution that greatly improved this monograph in its final stage.

I thank Tukes for publishing this monograph. Riitta Viikari and Irina Leväjärvi deserve my warm gratitude for kindly helping me with literature searches and financial calculations when required, and Paula Kuusio for assisting with the layout of the publication. Teemu Willamo and Susanna Lehtonen helped me with the figures, and the English language was checked by Elizabeth Garrison and Angela Rimmer. The research would not have been possible for me in addition to my official duties. Fortunately the adult education allowance from the Education Fund enabled me to take the study leave necessary to undertake this study.

Finally, my friends and relatives have given me joyful moments to disengage myself from the research and work, thank you all for keeping me in touch with everyday life. I am privileged to live in the loving sphere of the Autio and Willamo families. Unfortunately my mother Eila, a proponent for female education, is not still with us this moment, but I am sure she is proud somewhere at the edge of her cloud. My thanks go to my dear godmothers, Aunties Aili and Liisi, for your support and encouragement during my entire life. My children Kerttu and Teemu, you have educated me more than any academic career could. Thank you for the love and joy you brought to my life, and for our increasingly scientific dinner table discussions when you come home every now and then. I am as proud of you as I believe my mother would have been. Last but not least, from the bottom of my heart I am grateful to my husband Ripa for your valuable insights and comments, professional advice and personal support during this study, and for your endless love during our three decades together.

List of abbreviations

ACAP	Arctic Contaminants Action Programme under the Arctic Council
AES	Agri-Environmental Support
AIS	Agricultural Innovation System
AR	Action Research
CAP	Common Agricultural Policy (of the European Union)
CSH	Critical Systems Heuristics
CST	Critical Systems Thinking
EFSA	European Food Safety Authority
ELY	Regional Centres for Economic Development, Transport and the Environment
EPPO	European and Mediterranean Plant Protection Organisation
EQS	Environmental Quality Standard
EU	European Union
Evira	Finnish Food Safety Authority
FANC	Finnish Association for Nature Conservation
FAO	Food and Agriculture Organisation of the United Nations
FAQ	Frequently Asked Questions
FOCUS	FOrum for the Co-ordination of pesticide fate models and their USe
FVO	Food and Veterinary Office of the European Commission
GAP	Good Agricultural Practice
GIS	Geographic Information System
IARC	International Agency for Research on Cancer under the World Health Organisation
ICM	Integrated Crop Management
IPCS	International Programme on Chemical Safety
IPM	Integrated Pest Management
KSS	Finnish Plant Protection Society
LCA	Life Cycle Assessment
LFA	Limiting Factors Analysis
Luke	Natural Resources Institute Finland
Mavi	Agency for Rural Affairs
MMM	Finnish Ministry of Agriculture and Forestry
MDL	Message Design Logic
MRL	Maximum Residue Limit
MS	Member State
NAP	National Action Plan (on sustainable use of Plant Protection Products)
NGO	Non-Governmental Organisation
NSDS	National Sustainable Development Strategy; framework for assessing the NSDSs
OECD	Organisation for Economic Co-operation and Development
OD	Organisational Development
OR	Operational Research
PAN	Pesticide Action Network (a NGO campaigning against the use of chemical pesticides)
PAR	Participatory Action Research
PBT	Persistent, Bioaccumulative and Toxic properties of a chemical
PE	Participatory Evaluation
PNS	Post-Normal Science
PIC	Prior Informed Consent, international agreement to inform recipient countries prior to transport of hazardous chemicals

POP	Persistent Organic Pollutant
PPE	Personal Protective Equipment
PPP	Plant Protection Product, pesticide used in plant production to protect crops against harmful pests
SCP	(National programme for) Sustainable Consumption and Production
SEA	Strategic Environmental Assessment
SPL	Systemic Programme Logic
SSM	Soft Systems Methodology
STM	Finnish Ministry of Social Affairs and Health
SUD	Sustainable Use Directive, 128/2009/EC (EU 2009b)
SYKE	Finnish Environment Institute
TEM	Finnish Ministry of Employment and the Economy
Tukes	Finnish Safety and Chemicals Agency
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WCED	United Nations' World Commission on Environment and Development, the so-called Brundtland Commission
WFD	Water Framework Directive, 2000/60/EC (EU 2000)
WHO	World Health Organisation
YM	Finnish Ministry of the Environment

1. Introduction and background

Finland's agriculture is the northernmost in the world, characterised by short growth seasons and a limited number of crops adapted to harsh climatic conditions (Kurppa et al. 2015). The socio-economic development of agriculture varies a great deal between different regions of Finland (Voutilainen & Wuori 2012). Based on Agricultural Statistics of Finland (2014), there were around 54 000 agricultural and horticultural enterprises in Finland in 2013, with a decrease of approx. 1400 farms since 2012, and an 8.5% loss between 2010 and 2013. Cereals are the main crops on 36% of the farms. Finnish farmers are on average 51 years old. The professional education level of Finnish farmers was practical working experience for 51.1%, agricultural institute or equivalent for 38.5%, and higher education (college, vocational polytechnic, university or equivalent) for 10.4% of farmers in 2013. The agricultural and horticultural sector provides employment for 150 000 persons, one-third of whom are female.

The European Union's Thematic Strategy on Sustainable Use of Pesticides (EU 2006) aims to reduce the risks and impacts to human health and the environment from the use of pesticides (plant protection products used in plant production and biocides used for other purposes to destroy unwanted organisms) in Europe. The strategy is implemented in the Member States through the Directive of the European Parliament and of the Council establishing a framework for Community action to achieve the sustainable use of pesticides (2009/128/EC). In Finland the obligations have been implemented in the Act on plant protection (1563/2011), which requires establishing a National Action Plan (NAP) to improve the sustainability of plant protection. A ministerial working group prepared the Finnish National Action Plan on the Sustainable Use of Plant Protection Products for 2011-2020 (MMM 2011).

The purpose of this study was to test and develop conceptual models and instruments for evaluating the achievements of the Finnish National Action Plan (NAP) on the Sustainable Use of Plant Protection Products. Another purpose of this study project was to provide our stakeholder community involved in its implementation - a community of which I am a member given my official rank - with knowledge on programme evaluation for enhancing our collective learning process and capacity building in evaluating the improvements of environmentally sustainable plant protection in Finland. This study belongs to the disciplines of environmental science and policy, sustainability research and evaluation research.

This thesis is outlined as follows: first I describe my research object, the Finnish NAP, in Chapter 1.1, and my research questions are presented in Chapter 1.2. I then define the central terms in Chapter 1.3, global perspectives of chemical plant protection are presented in Chapter 1.4. and Chapter 1.5 highlights the legislative provisions on the sustainable use of plant protection products.

In Chapter 2 I review literature published within the framework of the sustainable use of plant protection products; the topics are divided to sub-chapters according to the priority areas included in the National Action Plans. Chapter 3 clearly sets out the philosophical, theoretical and methodological framework of this study, while Chapter 4 presents my research process, material and methods. Chapters 5 to 9 are devoted to the results, which are organised according to the research questions along the evaluation circle, as presented in Chapter 1.2. Lastly, the final conclusions are drawn and the results are further discussed in Chapter 10.

At the end of the monograph, the first of the four Appendices summarises the priority areas, key tasks, timetables and responsibilities laid down in the Finnish NAP. The second Appendix presents the details of the cost-effectiveness calculations of two projects, as explained in Chapter 5.4.2. Appendix 3 contains a comparison of

the NAPs from a few countries, as discussed in Chapter 10.2. Appendix 4 summarises the practical tools and guidance to be proposed for the practical evaluation of the NAP, and is intended as a free-standing document for practical use (cookbook) for administrators whose interest does not lie in the theoretical part of this work.

1.1. Research object: The Finnish National Action Plan on the Sustainable Use of Plant Protection Products

The Framework Directive on the Sustainable Use of Pesticides Directive 2009/128/EC (Sustainable Use Directive, SUD; EU 2009b) defines National Action Plans (NAPs) as:

> "Plans aimed at setting quantitative objectives, targets, measures, timetables and indicators to reduce risks and impacts of pesticide use on human health and the environment and at encouraging the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides in Member States in order to facilitate the implementation of the SUD".

The detailed requirements for the contents, measures and communication of the National Action Plans to be implemented in the Member States are set out in the Article 4 of the Directive. When drawing up and revising their National Action Plans, Member States shall take into account the health, social, economic and environmental impacts of the measures envisaged, of specific national, regional and local conditions and all relevant stakeholder groups. Articles 5-15 define specific issues and objectives that should be covered in the National Action Plans.

In Finland, the Sustainable Use Directive was transposed into national legislation by the Act on Plant Protection Products 1563/2011 (MMM 2011b). The Directive requires Member States to establish National Action Plans (NAP) that aim to fulfil the objectives of the SUD. In addition to the European Union, national plans are also a core strategic tool for reducing risks from pesticide uses in other OECD countries (OECD 2009).

The Finnish National Action Plan on the Sustainable Use of Plant Protection Products was published as a Working Group Memorandum of the Ministry of Agriculture and Forestry in 2011 (MMM 2011a). In addition to the objectives of the SUD, the NAP realises the objectives set with regard to plant protection products in the National Programme on Dangerous Chemicals, which was established a few years earlier (YM 2006). The overall goal of the National Programme on Dangerous Chemicals is to implement the global objectives of the Johannesburg World Summit on Sustainable Development (UN 2002a), to ensure that by 2020 chemicals will not cause significant adverse effects on human health or the environment in Finland.

The Finnish NAP consists of a range of different priority areas and actions to be carried out by several responsible parties defined in the NAP. The objectives and key tasks, timetables and responsible parties have been established for each priority area. However, statutory measures to implement the SUD in the Act on Plant Protection Products (MMM 2011b), have not been elaborated in the NAP.

The specific actions agreed in the Finnish NAP can be classified into four main areas concerning following aspects:

- reduction of health risks to users, workers, consumers and bystanders;
- reduction of environmental risks;
- improvements associated with agricultural practices, technologies and cultivation methods;
- increasing the general level of knowledge, education and awareness of the safe use of plant protection products.

The specific actions defined in the NAP are not in fact differentiated so strictly, instead there are usually overlaps between these areas, typically resulting in multi-actor characteristics. However, because the execution of the practical tasks would require different expertise from the responsible parties involved, it is reasonable to characterise the actions by discipline this way.

The NAP is put into practice in three phases. The first phase (years 2011-2014) introduces measures such as implementing crop-specific guidelines for integrated pest management (IPM), training programmes and examination systems, determinating spray drift reducing spraying techniques, information distribution initiatives, including of home gardener exposure in operator exposure assessments and setting environmental quality standards. In the second phase (years 2015-2017), further attempts are made e.g. to advance current knowledge of preventive methods in organic production, to apply comparative assessment in the authorisation of nationally problematic plant protection products and to investigate the effects of changing cultivation techniques. In the final phase (years 2018-2020), actions are envisages such as usage data collection, implementing Community-level risk indicators, gathering information on acute and chronic poisoning events, biological pest management methods for the eradication of invasive species on green areas and adequate environmental monitoring. The detailed summary of the measures, timetables and responsibilities is set out in Appendix 1.

Based on a rough estimate, the total costs over the first 10-year period of the National Action Plan were calculated to be approx. 7.9 million euros, mainly covering maintenance for the administration, training and certification systems, extension services, monitoring and research and development projects. In addition to the public authorities, a proportion of the costs will be divided among the stakeholders participating in the implementation, e.g. advisory organisations and training providers. The National Action Plan is implemented within the Finnish government's spending limits, budgets and productivity programmes.

The achievement of the NAP objectives shall be evaluated at least every five years, and any changes in the content of the plan are notified to the Commission immediately. An interim evaluation was scheduled in 2015 to r update and review the objectives of the plan. The results of the interim evaluation will be reported nationally, and the final achievements will be reported to the Commission and the other Member States in due course.

1.2. Research questions

Neither the NAP nor the legislation behind it gives practical advice on how to evaluate the achievements in reducing the risks and impacts from the use of plant protection products. As a compromise acceptable to all stakeholders involved, it was decided not to introduce exact risk reduction objectives or other numerical targets in the first Finnish NAP, which assumes more qualitative rather than quantitative evaluation procedures. Moreover, the risk indicators referred to in the SUD will be established later, once the Member States have agreed on them. It is therefore it is necessary to first build capacity in the evaluation practice and enhance mutual understanding of the stakeholders involved as regards the common goal of risk reduction. The purpose of my study was to enquire into and propose applicable procedures and practical tools to assist with the evaluation, and to enhance the stakeholders' organisational learning about the practices of programme evaluation applicable to the Finnish NAP situation. The actual evaluation will later be performed separately by a nominated working group, internal evaluator or external consultant, as assigned by the Ministry of Agriculture and Forestry and the Competent Authority, the Finnish Safety and Chemicals Agency Tukes in due course.

Given that there are no exact, numerical targets set in the Finnish NAP, my research problem is to produce systemic means to enable the evaluation if the sustainability of plant protection is achieved overall. As the core objective of the NAP is stated as being to reduce the risks to human health and the environment, my research primarily focuses on this goal. This research problem has been approached using five research questions that reflect different steps along the evaluation cycle of Donaldson & Lipsey (2006), as illustrated in Figure 1.1. below.

1.1

NAP evaluation cycle

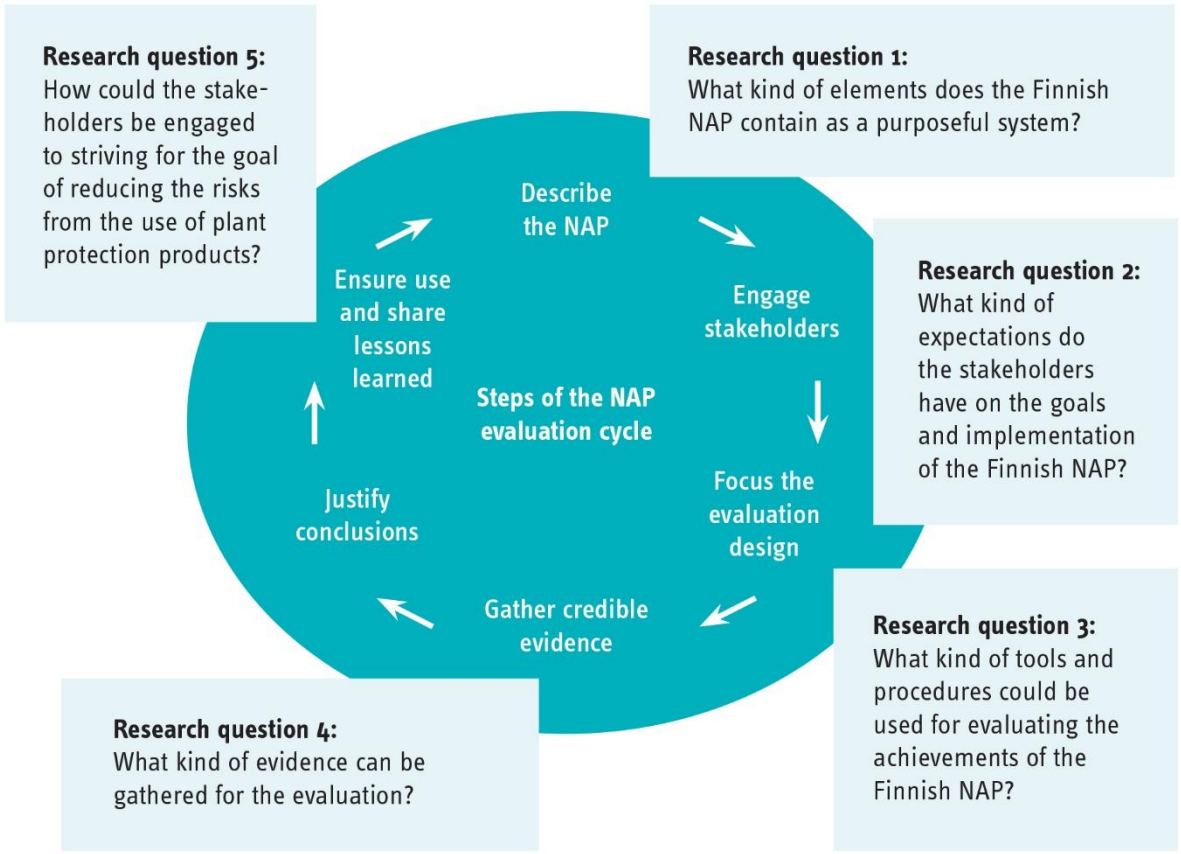

Figure 1.1. Positioning of my research questions along the steps of the NAP evaluation cycle, as modified from Donaldson & Lipsey (2006, p. 68-69).

The research questions my study seeks to answer are as follows:

1. What kind of elements does the Finnish NAP contain as a purposeful system?
2. What kind of expectations do the stakeholders have on the goals and implementation of the Finnish NAP?
3. What kind of tools and procedures could be used to evaluate the achievements of the Finnish NAP?
4. What kind of evidence can be gathered for the evaluation?
5. How could the stakeholders be engaged to striving for the goal of reducing the risks from the use of plant protection products?

In the light of these research questions, I analysed the NAP with a systems theory approach (Ulrich 1994, p. 336), posing further questions about the NAP as a purposeful inquiry system with its problem-solving dimension (What

concept of information and knowledge is built into the NAP design?), as a purposeful action system (What concept of action and what use of knowledge and expertise is built into the NAP design?), and as a purposeful, morally responsible valuation system (What concept of values and what capacity of judging and modifying the normative concept is built into the NAP design?).

The results are synthetised using a systems thinking approach to answer each of my five research questions, in Chapters 5 to 9. The thinking progressed as follows: the two first research questions deal with the actual situation of the Finnish NAP as it is, describing its elements in terms of systems thinking and stakeholders expectations of it, and the three latter ones focus on how the situation should be improved, in line with the two parallel realities to be reflected with Critical Systems Heuristics. Chapter 5 describes the Finnish NAP as a purposeful system of interventions (research question 1), while Chapter 6 illustrates the stakeholders expectations for the implementation and achievements of the Finnish NAP (research question 2). In Chapter 7, heuristic tools and procedures are proposed for evaluating the Finnish NAP (research question 3). Chapter 8 deals with gathering the evidence of success (research question 4), and Chapter 9 discusses the commitment of stakeholders (research question 5).

1.3. Explanations and definitions of central terms

Explanations and definitions are provided for a few central terms to allow the reader to comprehend the core concepts that occur repeatedly in this monograph. Further specific terms will also be defined they first time occur in the text.

Programmes, plans and projects as policy instruments and means of governance

The National Action Plan on plant protection products is positioned as one of a variety of programmes and action plans for executing new public management commitments in different branches. The progress in public management has gone from centrally managed governmental organisations towards decentralised issue-specific governance programmes, where tasks and responsibilities are shared with different actors, governmental authorities and agencies being one partner among others (e.g. Alasuutari & Lampinen 2006; Sulkunen 2006a; Valtiontalouden tarkastusvirasto 2010). Shadish et al. (1991) identified three components of a programme: first, the internal programme structure, which relates inputs to activities to outputs, second, external forces that shape the programmes, such as local economic capacity, external funding agencies, prevailing political sentiments, pressures from powerful stakeholder groups, social mores, logistic or geographical constraints, and the third component, which arises from the understanding of how programmes change to enhance societal goals and how evaluation information can make those changes more functional and effective.

Cassidy et al. (2006) and Johnson et al. (2004) highlighted the organisational capacity of successful policy programmes. Rantala & Sulkunen (eds. 2006) and Sjöblom (2006a-b) focused on the drawbacks of the organisational model of public policy programme and project management taken from the private sector business world, which is not necessarily suitable for public administration as the burden of responsibilities is not always shared transparently between the actors within temporary organisations.

Given the increasing number of stakeholders as accountable partners in programmes, plans and projects, the funders, policy-makers, authorities and public increasingly need to evaluate and control their operations and outcomes accurately (Davies et al. 2006; Dubnick & Frederickson (eds.) 2011; Ferraro 2009; Uusikylä 2013).

Temmes (2006, p. 52-53) has called for the improvement of project management and evaluation skills as keys to improving the quality of governance in Finland, while Kankare (2006) highlighted the ability of evaluation research to assess the long-term effects and dissemination of good practices of project work. In environmental policy, sustainability strategies organised on programme bases in Finland (e.g. Berg 2012; YM 2006) are basically aimed at transforming consumption and production in our society towards more sustainable systems that operate within tolerable limits of the carrying capacity of ecosystems (Mickwitz et al. 2011).

Pesticides and plant protection products (PPP)

Pesticide refers to natural or synthetic chemical substances or microbial products that are intentionally designed to be toxic to living target organisms or influence their fundamental processes and thus may have the potential to kill or control harmful organisms and pests. At the same time they can cause unwanted or unintended adverse effects on other non-target organisms, human health and the environment (Allaby ed. 1985; Miller 2004; Turunen 1985). In the European Union, separate legislation applies to plant protection products and biocides. *Plant protection products (PPP) are pesticides used in plant production*, while *biocides* are pesticides used in other purposes, for instance in households or industry (EU 2009b). The marketing of biological control organisms (beneficial arthropods) is regulated in Finland separately from plant protection products (MMM 2013).

Article 2 of Regulation (EC) No. 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market (PPP Regulation; EU 2009a) defines the scope of the Regulation and hence gives an exhaustive definition of plant protection products, distinguishing between different groups of active substances, as well as between their formulations according to their intended uses as *insecticides* (insect killers), *herbicides* (weed killers), *fungicides* (agents for controlling plant diseases), *nematocides* (agents for controlling nematides), *rodenticides* (rodent killers) and *growth regulators* (agents regulating plant growth). In my work I solely concentrate on plant protection products, meaning pesticides used for protecting crop plants against their pests, diseases and weeds.

Sustainable use of pesticides

To define sustainable use I refer to Directive 2009/128/EC (Sustainable Use Directive; EU 2009 b), the purpose of which is to steer Member States towards the sustainable use of pesticides. The Article 1 of this Directive defines the subject matter as follows:

> "This Directive establishes a framework to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques such as non-chemical alternatives to pesticides."

Aspects of ecological, societal, economic and cultural sustainability are interwoven, and it is not possible to consider these aspects of sustainability in isolation. Sustainability is therefore not a specific feature of the environment or of society, but instead refers to the viability of their relationship over long periods of time (Becker et al. 1999, p. 6). Environmental sustainability was paraphrased by an indigenous leader from Colombia as a state of being in which both environment and people are in harmony (Ahmed & Sánchez-Triana 2008). The scenario of reducing impacts and risks from the use of plant protection products in the National Action Plan presumes the commitment of involved stakeholders (European Commission 2007).

Risks

Much has been published in the environmental policy context regarding the concept of risk in general (e.g. Assmuth et al. 2010; Clarke 1989; Wahlström 1994). Beck (1992, p. 21-24) explained risk as a systematic way of dealing with the hazards and insecurities induced and introduced by modernisation itself. The concept of risk is inherently a human construct, politically reflexive, and therefore the understanding of it varies between individuals and different groups of people (Beck 1996). In modern society, risks are increased due to the intensification and extensiveness of the utilisation of nature. Risks induce systematic and often irreversible harm, generally remain invisible, are based on causal interpretations, and thus only exist in terms of the (scientific or anti-scientific) knowledge about them. They can therefore be changed, magnified, dramatised or minimised within knowledge, and to that extent they are particularly open to social definition and construction (Beck 1995). Metzner-Szigeth (2009) specified the risk-constructivist view as considering risks as constructs of societal communication, explained through cultural processes of change, whereas the risk-realist approach defines risks as objective elements of interaction between nature and society. Hence, the definition of risks (followed by their management) has become a major subject in the arena of social interest-conflicts, where the parties argue about who has to react (e.g. to stop emissions) or needs not to act (e.g. not to ratify conventions). Renn (2008, pp. 1-2) defined risk by denoting the possibility that an undesirable state of reality (adverse effects) may occur as a result of natural events or human activities. The contingency between possible and chosen action (risk management) is crucial. In the decision-making situation there are several options of action to be chosen, each associated with potential positive or negative consequences. More specifically concerning chemical risks, two international organisations IPCS and OECD (2003) give a pragmatic, risk-realist definition that is common in chemicals administration:

> "the probability of an adverse effect in an organism, system or (sub) population caused under specified circumstances by exposure to an agent".

In this work it is appreciated that different actors may have differing views on the risks from the use of plant protection products, depending on their interests and worldviews. Therefore, their expectations about the outcomes of the NAP may also be variable.

Impacts

A consultant study on behalf of the European Commission (FCEC 2012) classified the impacts from the use of plant protection products according to the uses, risk areas, affected compartments and exposed organisms, as presented in Member States' NAPs. The classification is presented in Table 1.1 below.

Directive 128/2009/EC (EU 2009b) defines risks and adverse impacts from the use of pesticides on human health and the environment as *overall potential unwanted side effects* associated with different techniques and practices of using chemical pesticides, including surface water and groundwater pollution, exposure of bystanders, consumers, non-target organisms and sensitive areas. Given that the aim of my work is to develop tools and procedures for evaluating the achievements of the Finnish NAP I maintain the definitions of plant protection product, sustainable use of pesticides, National Action Plan, as well as the risks and impacts, as given in the European legislation as outlined above.

Table 1.1. Classification of impacts of using plant protection products.

Strategy	Use	Risk area	Compartments / subgroups	Organisms & exposure situation
Reduction of impacts	Use of PPP on agricultural areas	Environ-mental	Terrestrial	Soil macro-organisms
				Terrestrial plants
				Soil micro-organisms
				Other terrestrial organisms (including birds and mammals)
				Concentration in soil
			Aquatic (freshwater, marine water, surface and groundwater)	Fish
				Aquatic invertebrates
				Algae and aquatic plants
				Sediment organisms
				Aquatic micro-organisms
				Other aquatic organisms
				Long-term concentration in water
			Air	Concentration
			Non-compartment specific	Bees and other non-target arthropods
		Human health	Workers	Operators
				Re-entry workers
				Greenhouse workers
			Consumers / General public	Bystanders
				Residents
				General public
	Use of PPP on non-agricultural areas	All		
Reduction in use	General use of PPPs	All		

Risk assessment

Although there is no unambiguous definition of risk given in the PPP regulation (EU 2009a), Commission Regulation (EU) No. 546/2011 implementing Regulation (EC) No. 1107/2009 of the European Parliament and the Council as regards uniform principles for evaluation and authorisation of plant protection products (EU 2011) outlines cases when, based on the detailed risk assessment, the risks are considered as unacceptable and the approval or authorisation of a plant protection product is not possible. Hardy et al. (2012) gave an overview of the European risk assessment procedure of plant protection products. Much has been published about the assessment of chemical risks in different environmental compartments and for non-target organisms within the EU (e.g. Alix et al. 2012; EFSA 2013d; Suter 1993), and the methods were presented in Finnish by Koivisto & Autio (2009) and Nikunen & Leinonen (2002). Klein et al. (1993) and Römbke et al. (1996) discussed ecotoxicological testing strategies, while human health risk assessment has been described for instance by Santti (1988), Tuomisto (1993) and Younes (2014). Comprehensive guidance on risk assessment practices for plant protection products is given on the website of the European Commission's Directorate General for Health and Food Safety (European

Commission 2015a). Consequently, only products associated with risks assessed as acceptable should be on the market. However, it must be noted, that the administrative risk assessment procedure deals with single plant protection products separately. Assmuth et al. (2009) and Péry et al. (2013) highlighted the need for integrated treatment of multiple risks with socio-economic analysis. The possible combined effects and risks from multiple uses and products are not yet fully covered in the risk assessment procedures.

Risk mitigation

Risk mitigation includes the necessary *means for reducing the risks* from using plant protection products to a level that is assessed as acceptable. Risk mitigation measures may include instructions and restrictions on use, safety requirements, personal protective equipment, buffer zones, pre-harvest intervals, etc. The need for and applicability of specific risk mitigation measures are highly dependent on the actual conditions where the plant protection products are used, and therefore they may vary between countries. Northern zone Member States have developed their own guidance document on the risk assessment and risk mitigation measures in use in Nordic and Baltic countries (Tukes 2015a). A brief presentation of the Finnish environmental risk mitigation measures for plant protection products is given by Autio (2012). Research on the environmental risk mitigation measures is discussed in more detail in Chapter 2.6.

1.4. Perspectives of chemical plant protection globally

Plant protection products have been regulated for a long time in Europe and other industrialised countries due to their intrinsic toxic properties and hazards to non-target organisms. McEwen & Stephenson (1979) reviewed the history of pesticide uses, focusing on organochloride insecticides as one of the early recognised groups of pesticides causing environmental effects via biomagnification in the food chains. Following the publication of the "Silent Spring" by Rachel Carson in 1962 (Carson 1963; Rantanen 2014), risk assessment and authorisation of plant protection products using scientific data on their impacts and effects in the environment has become a precondition for their release on the market, and the data requirements have increased enormously.

Recently, Pimentel & Burgess (2014) estimated that around 40 % of world food production is lost to pests despite annual investment of around $30 billion to produce and apply about three million metric tonnes of plant protection products, however, the loss would be up to 70 % without chemical and non-chemical plant protection. Nevertheless, they report that in the USA, the share of crops lost to pest insects and mites nearly doubled despite a ten-fold increase in synthetic insecticides during the past 40 years, an era of rapid development in agricultural chemistry. Similarly, Oerke et al. (1994, p. 746) also reported on comparable levels of crop losses in several principal cash crops worldwide due to pathogens, pests and weeds at the turn of 1980s to the 1990s, compared to 1965 data.

Weir & Shapiro (1984) originally introduced the *circle of poison* conceptualization describing the global pesticide complex, where specific pesticides with an inacceptable toxicological and ecotoxicological profile are manufactured in industrialised countries but exported to and used in developing countries, where the farmers and peasants suffer from the environmental load and occupational health problems caused by improper use of these active substances due to less stringent legislative restrictions, and then the agricultural products are imported back to the industrialised world, where consumers are exposed to the high levels of residues from those active substances that were never approved in their own countries.

Since then, there have been attempts to break the circle of poison (Jain 1992). According to Galt (2008), the complex export system for plant protection products from USA to Latin America suggests that the circle of poison is no longer an accurate conceptualization of the global trade of plant protection products. Since 1960s, new groups of active substances have been developed and the authorisation procedures have expanded, including exhaustive data requirements and risk assessments before the release on the market is possible. The agrochemical industry reports of an increase in the average total discovery and development costs of a new plant protection product, from $152 Million to $286 Million between 1995 and 2010-14 (Phillips McDougall 2016). Due to the worldwide development of regulatory obligations in the approval of pesticides, international agreements like the Rotterdam Convention on prior informed consent (PIC, see UNEP 2015a) and the Stockholm Convention on persistent organic pollutants (POPs, see UNEP 2015b), changes in international trade and the development of pesticides have essentially turned the characterization of the global pesticide complex towards a more divergent system subject to own chemical production and market orientation in developing countries over the course of 30 years. Until the beginning of 2000s, Europe was the leading regional agrochemical market worldwide, but since 2012 it has been overtaken by Asia, with Europe showing the lowest growth in agrochemical markets (PhillipsMcDougall 2013).

Yet, today the Galt's view can still be considered rather optimistic. For instance, Grant et al. (2013) detected pesticides in caiman blood in the banana cultivation area of Costa Rica. Seven of the nine insecticides they identified are listed as Persistent Organic Pollutants (POPs), banned under the 2011 Stockholm Convention but obviously currently used in cultivation in Costa Rica. Still more recently, Vorkamp & Rigét (2014) reported on increasing levels of some pesticides in arctic ice cores and bioaccumulation in arctic biota, on account of long-range transport. Due to their persistence, these chemicals will still be detected in the environment long after the withdrawal of their use, and therefore environmental monitoring is needed.

Although concerns about human poisoning and other severe health impacts of pesticide uses are mainly associated with developing countries (e.g. Igbedioh 1991), the injudicious use of pesticides does not necessarily occur in the developing world alone. Settini et al. (2016) refer to exposures to rodenticides and insecticides in Germany, Italy and UK in 2007-12. The World Bank estimated 355 000 deaths annually caused by pesticide poisoning, two-thirds of them occurring in the developing countries, where lack of training and protective equipment is apparent. Nevertheless, one-third of pesticide poisonings today occur in countries where information, training and awareness of the risks are accessible. Working conditions in agriculture can be hazardous and agriculture is one of the three most dangerous occupations, along with mining and construction. (World Bank 2008).

Wilson & Tisdell (2001) discussed the economic paradox of why farmers are entrapped and locked in the unsustainable system of chemical pest control technology despite the increasing longer-term environmental, health and sustainability costs. Increasing use of chemical inputs increases yields to some extent, although it also generates undesired impacts such as pollution, health problems and pest resistance, which should be counted in total cost. While chemical plant protection had previously appeared to be a successful strategy (Cowan & Gunby 1996), the gap between total revenue and total cost is shrinking and impairs the profitability of the output/cost relationship, which in turn requires further inputs and thus locks the farmers in a spiral of unsustainable farming practices, a phenomenon known as path dependency, a concept first introduced in economics by Arthur (1989).

Based on FAO statistics, Schreinemachers & Tipraqsa (2012) reviewed the use of plant protection products in countries with different income levels. Highly dependent on exports of cash crops such as bananas, Costa Rica wants to ensure yields through the maximal use of inputs such as plant protection products. With an annual total mean rate of plant protection products of 24.3 kg active substances/ha, Costa Rica is one of the countries with the highest pesticide consumption in the world. The use of plant protection products varies a great deal in

countries with different economic statuses, and the trend is growing rapidly in countries with middle income levels, such as Costa Rica, whereas use is marginal in the lowest income countries, like in many African countries (<0.1 kg a.s./ha) because the farmers simply cannot afford investing in inputs. On the other hand, only a few of the highest income countries have managed to reduce their use of pesticides. Globally, the annual total mean use rate is approx. 3.6 kg a.s./ha, compared to 0.7 kg a.s./ha in Finland. The authors propose policy strategies to control the dependence on chemical plant protection, including environmental taxes allocated to long-term investments in awareness-raising, integrated crop management methods and setting food safety standards; these are actions included in many countries NAPs.

The yearly statistics on the sales amounts of plant protection products in Finland are published on the websites of the Finnish Safety and Chemicals Agency Tukes (Savela 2015; Tukes 2015g). Figure 1.2 illustrates the trends in sales amounts of PPPs over the last 60 years. Most recent statistics on the use of plant protection products in agriculture (Luke 2014; Mattila 2015) show similar total annual use as calculated earlier by Schreinemachers & Tipraqsa (2012). The Finnish share is approx. 0.04 % of the global annual use, while 3 % of plant protection products sold in Europe are used in its Northern zone (Mäkinen et al. 2013).

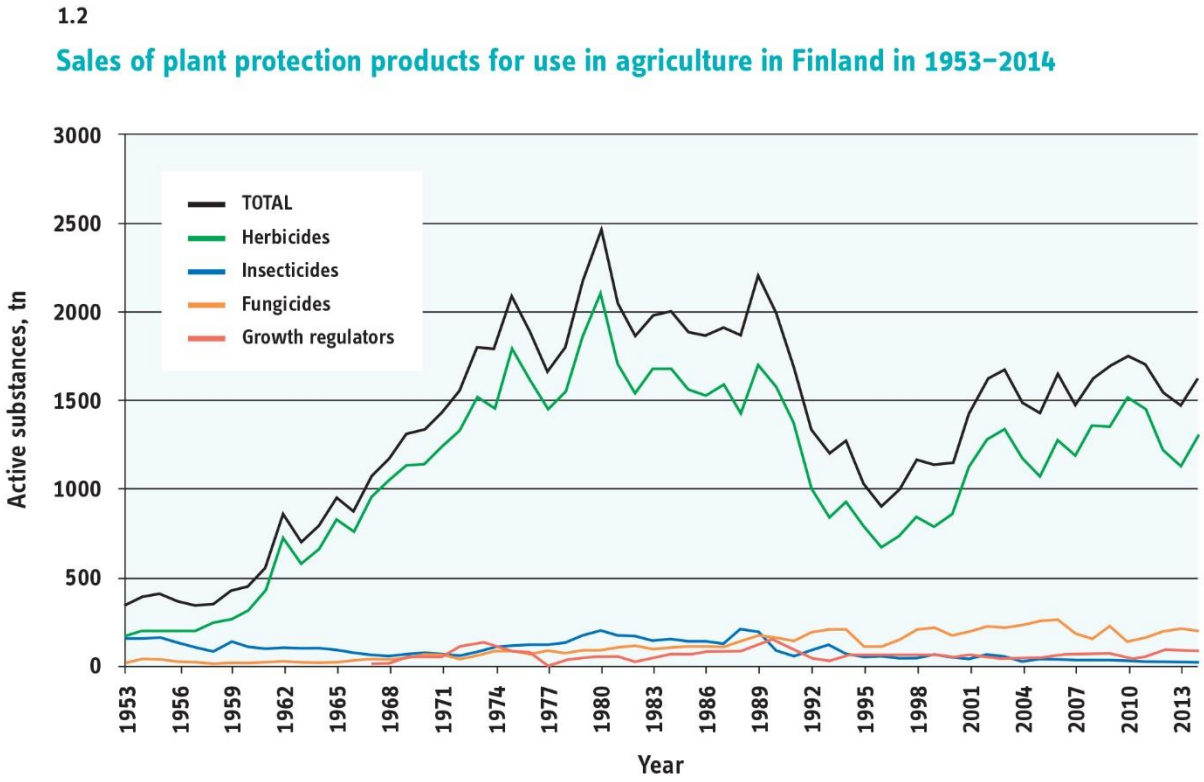

Figure 1.2. The sales amounts of plant protection products sold in Finland in 1953-2014 (Source: Tukes 2015g).

1.5. Legislative provisions on sustainable use of plant protection products in Finland

In Finland, the national Pesticides Act originates from the year 1952, when all pesticides had to be tested for their efficacy and chemical composition, and authorised before being placed on the market (Markkula 1954,

1957, 1962). Almost 200 products were on the market at that time (Markkula 1962). In 1969, the Pesticide and Poison Acts were revised to include the obligation to assess the impacts on the environment in addition to on the operators. Consequently, the Ministry of Agriculture and Forestry issued its first decisions on restricting or prohibiting the uses of some organochlorine pesticides (Markkula 1969, 1971, 1972, 1973). The control system was further developed in the 1970s (Rautapää 1976), and the Pesticides Act was again amended in 1984 to set up the decision-making Commission on Pesticide Matters under the Ministry of Agriculture and Forestry (Blomqvist 1984), with increasing attention given to assessing environmental impacts of pesticides (Luotola 1985; Kallio-Mannila 1988). A further amendment to Finnish Pesticides Act came in 1994, transposing Council Directive 91/414/EC, as Finland joined the European Community in 1995 (Hynninen 1994, 1995). As a result, since the 1990s, we have lived in an era of the common European risk assessment methodology for plant protection products (e.g. Hardy 2012). Over the years, a highly developed system has been established for evaluating the risks to human health and the environment from pesticide use. In the European Union, Directive 1991/414/EEC concerning the placing of plant protection products on the market (PPP Directive: EU 1991) laid down rules governing plant protection products and the active substances in them.

On 12 July 2006, the European Commission issued its Communication on a thematic strategy on the sustainable use of pesticides (EU 2006), based on the Sixth Environment Action Programme adopted by the European Parliament and the Council (EU 2001). According to the thematic strategy:

> "Despite all the efforts that have been made to limit the risks linked to the use of pesticides and to prevent any undesirable effects, unwanted amounts of certain pesticides can still be found in environmental media (in particular soil and water) and residues exceeding regulatory limits still occur in agricultural produce. It is, therefore, necessary to reduce the risks from pesticides to humans and the environment as far as possible by minimising or eliminating, where possible, exposure and by encouraging the research and development of less harmful, including non-chemical, alternatives."

The PPP Directive was replaced by Regulation (EC) No. 1107/2009 concerning the placing of plant protection products on the market (PPP Regulation: EU 2009a), in order to simplify application of the legislation and to ensure consistency throughout the Member States. As stated in Article 1.3, the purpose of the Regulation is to ensure a high level of protection of both human and animal health and the environment and to improve the functioning of the internal market through the harmonisation of the rules on the placing on the market of plant protection products, while improving agricultural production.

The possible risks from the use of plant protection products are accepted to a certain extent by society, given the related economic benefits they contribute to agriculture, ensuring reliable supplies of high-quality agricultural products. Based on PPP Regulation, the Commission issued an implementation regulation on *Uniform Principles* for evaluation and authorisation of plant protection products in the European Union Member States. This implementing regulation defines the criteria and level of acceptability for the risks to different organisms, where the authorisation is possible (EU 2011). It also sets out various principles that must be fulfilled, namely: general principles for evaluation, specific principles concerning efficacy, effects on plants and plant products, impacts on vertebrates to be controlled, impacts on human and animal health, influence on the environment, analytical methods and physical and chemical properties, and the decision-making principles laid down in the Annex. One way of reducing the risks is to consider appropriate risk mitigation measures, such as restrictions on use that are specific to single plant protection products according to their use patterns. Environmental risk mitigation measures are not harmonised within Member States, but are instead subject to national deliberation when the products are authorised, and binding for users (Autio 2009, 2010, 2012; Tukes 2013c, 2015d, f).

Maximum residue limits of plant protection products in food and feed commodities are laid down in a separate regulation (EU 2005).

It was found that it was necessary to regulate the entire life cycle of pesticides, from the placing on the market to their uses and disposal, and consequently the Framework Directive on Sustainable Use of Pesticides (SUD) was adopted in 21 October, 2009 (EU 2009b). The aims of the Directive are to reduce the risks and impacts of pesticide use on human health and the environment and to promote the use of integrated pest management and of alternative approaches or techniques such as non-chemical alternatives to pesticides in Member States. These targets will be achieved by adopting and implementing National Action Plans (NAPs) in Members States. In the first phase, the Directive only applies to plant protection products, but it is intended to apply in a later phase to biocides as well, thus finally covering all kinds of pesticides.

A few attempts to consider imminent NAP issues emerged in Finnish agricultural policy during the first half of 1990s, when a programme was implemented to *reduce the use* of plant protection products by half by 1995 (Pölkki 1993). In the early 2000s, one action towards *reducing the risks* from the use of plant protection products in Finland was to publish guides on balanced plant protection for 24 crops, to provide advice on principles of integrated crop management (Kasvinsuojeluseura 2014). The first national plant protection strategy was established in Finland in 2003 (MMM 2003), thus requiring strategic planning of the plant protection sector as a whole (Kurppa 2004).

In Finland, the Sustainable Use Directive (SUD) was transposed into the national legislation by the Act on Plant Protection Products 1563/2011 (MMM 2011b). In June 2009 the Ministry of Agriculture and Forestry appointed a working group tasked with bringing out a proposal regarding a National Action Plan (NAP) for sustainable use of plant protection products. As outlined in the European Commission's Thematic Strategy, early and effective opportunities were sought to involve stakeholders in the setting up, implementation and adaptation of the NAP. The working group consisted of 19 nominated participants and their substitutes, representing hugely varied stakeholder organisations and considering different aspects of plant protection. The working group convened regularly during the preparation of its proposal between June 2009 and December 2010. The draft proposal for the Finnish NAP was circulated for comments to 26 organisations, and the comments were taken into consideration as far as possible in the final version of the NAP.

Based on the Act on Plant Protection Products, Ministry of Agriculture and Forestry issued decrees to manage several technical details of the National Action Plan, namely the arrangement of training and certification system for professional users and retailers of plant protection products (MMM 2012a), the common principles of Integrated Pest Management (MMM 2012b), the prohibition of aerial spraying (MMM 2012c) and performing field trials and the official recognition of facilities testing the biological efficacy and usability of plant protection products (MMM 2012d).

The National Action Plan includes objectives, measures and timetables for reducing the health and environmental risks of plant protection products, as outlined in the thematic strategy (EU 2006):

> "The most important expected outcome of the implementation of this Thematic Strategy is a reduction of the overall risks and negative impacts on human health and the environment from the use of pesticides. Such a reduction can be achieved by reducing unwanted exposure (direct and indirect), and by reducing the intrinsic hazards of the substances used by replacing the more dangerous ones with less harmful ones (the so-called "substitution principle") or alternative protection measures. Currently, no universally accepted indicators are available to measure these risks."

The Finnish Safety and Chemicals Agency Tukes is the competent authority for Regulation 1107/2009 and Directive 128/2009, and is thus responsible for coordinating the implementation of the National Action Plan. Several authorities, institutes and organisations are involved in the execution of particular actions in different sectors. The specific actions included in the Finnish NAP are summarised in Appendix 1.

2. Literature review on the issues included in the NAP

Reflecting the requirements laid down in the Sustainable Use Directive, the Finnish NAP includes a range of concrete actions assigned to several stakeholder organisations. The NAP is thus inherently multidisciplinary by nature. Many issues included in the National Action Plans are subject to profuse research worldwide today, and the purpose of this chapter is to briefly review the literature published around various priority areas of the NAP. A comprehensive literature search was not carried out regarding the issues covered by the NAP activities during the preparation phase of the Finnish NAP, and therefore it was considered necessary to fill this gap in this work. Due to the abundance of active research published on the variety of NAP issues in recent years, it is not possible to provide full coverage here, rather, this review aims to highlight and illustrate some topical studies within each field. A more natural scientific perspective was chosen for most topics, as the problems and innovations proposed in the NAP as solutions to alleviate them are usually described as natural scientific; problem-orientated considerations from a social scientific perspective would also be possible, however. The order of the issues is not followed exactly as presented in the NAP; instead, the following sub-chapters are organised into larger entities, as presented in Table 2.1.

Table 2.1. Research themes addressing the main priority areas included in the NAP.

Chapter	Priority area
2.1.	Taking into account the environmental externalities and application of the substitution principle in plant protection
2.2.	Towards sustainable pest management practices
2.3.	Learning as the core of extension, training and certification of professional users and retailers
2.4.	General public and plant protection
2.5.	Reducing the risks to human health
2.6.	Reducing the risks to the environment
2.7.	Technical issues: spraying equipment, storage and disposal of plant protection products
2.8.	Monitoring progress using indicators

2.1. Taking into account the environmental externalities and application of the substitution principle in plant protection

Mäkinen et al. (2013) reviewed European agricultural, environmental and food policy instruments related to the use of plant protection products in Finland. The Common Agricultural Policy (EU 2013) covers about 90 % of Finnish farms. With a marginal share of global PPP use, food production in the Nordic countries has additional value from the clean environment (Kurppa et al. 2015). Hildén et al. (2012) observed that the concept of sustainable agriculture is valued positively in the Finnish public discourse, while stakeholders' views of it differ widely. It can be claimed that sustainable agriculture has become a rhetorical paradigm in the sense that it is presented as conflict free, whereas the main policy focus is set on the economic competitiveness of Finnish

agriculture through adaptation of high-tech innovation and the latest know-how that is considered to guarantee both ecological and socio-economic sustainability.

Current understanding about the implications of climate change in Northern Europe assume increased yields but also higher pest pressure, and thus also a growing need for pest control (Gustafson 2011; Liskola 2007), while surface water run-off and risk of exposure of aquatic biota will increase (Babut et al. 2013). The prevention of any unnecessary environmental load from the uses of plant protection products is therefore deemed important in current agricultural and environmental policies.

The need to account for environmental externalities in assessing the economic profitability and competitiveness of farming has been highlighted by Lefebvre et al. (2015). *Polluter Pays* is recognised as an essential principle in environmental protection (Morin & Orsini 2015), although it is not universally applied in agriculture according to Tobey & Smets (1996). *Ecosystem services* are the direct and indirect contributions of ecosystems to human well-being supporting our survival and quality of life directly or indirectly (Brouwer et al. 2013), and valuing ecosystem services has recently been subject to increasing research (Maes et al. 2016; Mononen et al. 2016). The ecosystem services perspective should be taken into account in assessing the achievement of the intended objectives of Agri-Environmental Support systems (Rega & Spaziante 2013). Examples of negative externalities in farming are the loss of biodiversity (see e.g. Scheper et al. 2013) or decline in surface water quality (van Eerdt et al. 2014), whereas positive externalities contributed by ecosystem services, such as pollinator services (see e.g. Korpela et al. 2013; Sepp et al. 2004) have also been considered. Skevas et al. (2012a-b, 2013, 2014) included environmental impacts as externalities in farm profitability calculations and revealed a significant overuse of pesticides in terms of the economic profitability of agriculture. They concluded that pesticide reduction quotas are more effective incentives in reducing pesticide use and environmental impacts than taxes, price penalties or subsidies (2012b, 2013). An optimal pesticide policy should include tax schemes that are based on standards for environmental and health quality, but may not necessarily rely on a specific measure. Risk-related pesticide use trends among different crops and countries seems to be variable, implying the need for further investigation at individual country level so as to enable differentiated fiscal measures (2013).

Applying the substitution principle and the comparative assessment of plant protection products is stated as an important target in the Finnish NAP. In chemicals regulation and risk management, the *substitution principle* means a policy principle that requires the replacement of hazardous chemical substances by less hazardous alternatives, interpreted as any chemical or nonchemical methods that reduce the potential for damage to health or the environment. Since the substitution principle is part of environmental policies, the substitutions aim to protect the environment and human health. Given that the reasons for substitution can sometimes conflict with one another, the substitution principle refers to all the properties of a chemical and the potential dangers to human health and the environment that may be associated with its use. While attempting to reduce the hazard, the functionality of the original substance should be retained and the increasing of the costs should be avoided. The priority between these three objectives is a matter for negotiation and adjustment in each particular case. Substitution should not be seen as a single decision, but a continuous development towards safer processes. Decisions to substitute can be taken at different organisational levels from the primary producer of a chemical, to the users of the products that may substitute a product or process. (Hansson et al. 2011).

In a few Scandinavian countries, *comparative assessment* based on the substitution principle has been a chemicals policy objective for many years (Kemikalieinspektionen 2007, 2008a), while most European countries are just about to apply it, and the experiences, results and expectations are variable. Løkke (2006) considered the voluntary substitution of hazardous substances with less hazardous ones as a possibility for integrating risk management with the precautionary principle. The constructive side of the precautionary principle is manifest

in the search for alternatives, and in the building of transparency and deliberative processes that enhance this search. However, to search for alternatives alone would be naïve. Chemicals are an area characterised by both innovative new thinking and strong economic interests bounded by specific production technologies, and it is therefore important to create incentives that motivate the phasing out of candidates for substitution. The preliminary assumptions of the substitution principle in chemical regulation have been criticized by Löfstedt (2014). Further debate on its philosophical grounds and societal application was addressed by Aven (2014) and Renn (2014), as well as on its political acceptance in America by Dudley (2014) and in Europe by Girling (2014).

As stated in the NAP, substituting dangerous plant protection products with less dangerous products or control methods is a primary means for reducing risks, whenever possible. The European Commission has prepared a list of active substances that are candidates for substitution (EU 2015), which Member States have to consider in their comparative assessments when granting authorisations for plant protection products for similar uses, according to Article 50 of the PPP Regulation (EU 2009a). Fabrizi (2013) described the development of the process and criteria on how the persistent, bioaccumulative and toxic (PBT) properties of active substances are evaluated to warrant a substance being placed on the list of candidates for substitution. In view of agronomic efficacy considerations, the European and Mediterranean Plant Protection Organisation (EPPO) provided guidance on performing a comparative assessment to determine whether the substitution of a plant protection product is appropriate. It covers comparison with chemical and non-chemical pest control alternatives (EPPO 2011). Faust et al. (2014) highlighted the heavy workload involved in assessing the risks from each use of a candidate plant protection product and its potential substitutes until a substitution decision can eventually be taken. Bahlai et al. (2010) recalled of the potential shortcomings of substitutes alleged to entail less risk in certain uses. Thus, the future practical impact of applying the comparative assessment and substitution principle is not yet clear as regards phasing out of dangerous plant protection products.

In France, *reducing the dependence* on pesticides is a matter of socio-technical transitions within the whole agri-food system at the levels of cropping systems, advisory systems and markets, and within society as a whole (Lamine et al. 2010). Based on a cost efficiency assessment of plant protection decisions of 600 farms in France over a 12 years period, Boussemart et al. (2011) concluded that in the long term, reduced use of plant protection products is a cost-effective option for farmers as well as for society as whole. An economic assessment of the feasibility of the policy goal of reducing plant protection product use was performed by Jacquet et al. (2011), who concluded that a reduction of up to 30% can be achieved without disrupting the prevailing production systems and farmers income. For the target of reducing PPP use by half, a loss of 12% in production and 5% in gross margin is anticipated, thus presuming economic incentives to compensate the losses. Combining taxation with direct subsidies for organic farming would be the most effective policy to reduce the PPP use, but the tax level would have to be remarkably high to be sufficient to finance the organic farming subsidy alone. Therefore, other funding within the framework of the Common Agricultural Policy (CAP) is also required to enable the policy goal of halving PPP use.

Germany relies on an approach to reduce pesticide use to the *necessary minimum*, and significant research efforts have been made to define the necessary extent of PPP use (e.g. Bürger et al. 2008; Sattler et al. 2007). According to their analysis, the smallest pesticide use intensity can be achieved by combining the economical savings and pesticide use and by altering the whole cultivation system to lower pest risks. However, this does not happen without policy-making, which suggests that clear political initiatives like reduction programmes are needed, and benefits from integrated pest management must be demonstrated to increase adoption.

However, fundamentally deviating views on the European PPP policy have been also published in the literature. In Ireland, Jess et al. (2014) find it challenging to sustain agricultural production and profitability within the obligatory implementation of integrated pest management, due to the limited availability of plant protection

products and potentially increasing pest resistance, principles of risk assessment modified to apply hazard rather than risk as the approval criterion in long term and presumed further restrictions on the basis of European water legislation.

2.2. Towards sustainable pest management practices

Crop protection researchers are seeking alternative approaches to conventional chemical plant protection practices worldwide. *Integrated Pest Management* (IPM) is a core concept in sustainable agriculture and a cornerstone of European PPP legislation, and thus also plays a key role in the implementation of NAPs. The legislative framework provided for in the SUD requires the general principles of IPM, as laid down in Annex III, to be followed in all farming in Europe as of 1 January 2014. However, what constitutes the IPM is not universally understood. Community level actions are therefore supported to create this understanding within the EU (C-IPM 2015a). Barzman et al. (2015) proposed a holistic systems approach to apply the eight *principles of integrated pest management*:

1. prevention and suppression of pests based on inherently robust cropping systems
2. local availability of monitoring, warning and forecasting systems
3. decisions based on long-term strategies with monitoring and control thresholds
4. combination of non-chemical methods
5. selection of products and methods with least impact on health and the environment
6. reduced pesticide use can be combined with other tactics
7. addressing the root causes of pesticide resistance
8. evaluation of multi-season effects and trade-offs of control decisions.

In line with the assertion of Peshin & Pimentel (2014, p. v), that in reality IPM is often perceived as "integrated pesticide management", merely training farmers in right use of pesticides to minimise selection for resistance, conserve beneficials and reduce health and pollution risks, Hillocks (2012) and Hillocks & Cooper (2012) worried about the reduced availability of plant protection products on the market as a consequence of implementing the SUD, leading to a challenge of farming with the consequent greater risk of pesticide resistance in target pests. They claim that insufficient availability of IPM technologies does not yet offer practical and economically viable alternatives to withdrawn plant protection products in the crop protection toolbox. Today research activities are busy focusing on technical devices to support IPM in Europe (e.g. Jalli 2016).

Dehne & Schönbeck (1994, p. 65-68) discussed the relationships between biological control, IPM and integrated crop management (ICM). *Biological pest control* is based on the targeted use of all biological measures that limit the development of pests and diseases. Besides the benefits of antagonistic organisms it also includes the cropping of resistant plants and the use of natural defense mechanisms of resistance, as well as pheromones and colour traps. Integrated pest management uses all economically, ecologically and toxicologically justifiable means to keep pest populations below the control threshold, with the emphasis on the deliberate use of natural forms of control and preventive measures, starting with cultural and biological measures and ending with chemical pesticides with a direct mode of action. Chemical plant protection should only be applied if the epidemiologically relevant infestation levels or economic thresholds are exceeded. Integrated Crop Management is a further developed stage of a cropping system that combines care and concern for natural resources and the environment with responsible and economic use of modern methods to produce safe and wholesome food, taking into account all known factors including location, crop rotation, tillage systems, soil fertility, irrigation practice, energy utilisation, seed selection, plant nutrition, as well as biological, physical and chemical plant

protection. Kogan (1998) traces the starting point of IPM back to the late 19th century, when ecology was identified as the foundation for scientific plant protection. He also distinguished progress levels in ecological, socio-economic and agricultural scales of implementing IPM today.

Brewer & Goodell (2012) claimed that the first 50 years of IPM generated an incentives dilemma for farmers due to selecting IPM activities for individual fields founded on market-based economics rather than regionally applied IPM activities that would have longer-term benefits that would accrue for wider society and the environment. Public support for transitions to broader landscape scales is promoted by coordinated community decision making and partnerships, which are needed to gain long-lasting regional and environmental benefits. Suckling et al. (2014) assessed the premises and promises of several larger regional-scale integrated insect pest eradication strategies, such as mating disruption, mass trapping, lure and kill and sterile insect techniques. Overall, there are still major gaps in surveillance and selective eradication techniques for most insects. Shaner & Beckie (2014) discussed the future for weed control and technology, particularly herbicide resistant weed management, in the current situation where a decreasing number of herbicides with different modes of action are available. Proposed solutions include integrated weed management with emphasis on reducing the dependence on chemical weed control, agroecoregion-specific practices of mixed technologies and a multidisciplinary approach with increased dialogue between stakeholders are. Rains et al. (2011) argued for redirecting agricultural production from the current therapeutic paradigm to a multitrophic approach emphasising the built-in inherent self-sustaining strengths of agroecosystems that maximise the genetic presence and phenotypic expression of inherent renewable mechanisms in fields. Nevertheless, the tools being delivered through the existing agricultural research, extension, and industrial infrastructure are predominantly pesticides, chemical fertilisers, and similar interventionist technologies, thus requiring the shift of mindset from input-driven to resource-driven technologies throughout the sector, assessing the entire field system in a holistic and dynamic manner.

Due to the *knowledge-intensive* nature of IPM, high requirements for farmer training and education are assumed as a prerequisite for its wider implementation. Orr (2003) explained the low implementation rate of IPM in the context of several IPM projects in Sub-Saharan countries, where the constraints observed may not be characteristic of developing countries only. According to his research, annual average crop losses from pests in Africa are less severe than originally thought. Resource-poor farmers may see low soil fertility and not pests the primary constraint on crop production, and tend to reject labour-intensive IPM strategies as much as farmers in developed countries do. Economic incentives to adopt IPM may be lacking. Farmers' ability to evaluate local pest management practices may be limited due to their lack of knowledge about pest biology and other scientific research data, thus impeding their participation in control decisions as equal peers.

A recent European collection of pesticide application data (Garthwaite et al. 2015) throughout the Northern, Central and Southern zones of the EU in 2013 (prior to when it became mandatory to apply the general principles of IPM in the EU) showed that in Lithuania, representing the Northern EU, farm size is a driver in utilisation of personal agronomist advice and IPM on potato, wheat and oilseed rape as representative arable crops. Smaller farms claimed to use significantly less advisory services and implement less IPM practices compared to middle-sized and large farms. For historical reasons, the farm size and other agricultural conditions in Lithuania may not be comparable with Finnish family farms, although a similar increasing level of professionalism in parallel with the increasing farm size is also characteristic here.

In Finland, a few major projects on gathering and disseminating IPM knowledge have been implemented in recent years, e.g. PesticideLife partly funded by the EU Life+ financial instrument and dealing with arable cereal crops (see PesticideLife 2013, and Alanko et al. 2013a-b, Mäkinen et al. 2013, Räsänen et al. 2013 a-b), and IPM-APU dealing with horticulture and greenery sector (Vänninen 2014; Vänninen et al. 2014). Current challenges in

the pipeline are to develop a strategic IPM research agenda for Finland (Nissinen et al. 2015a-c) as well as internationally (C-IPM 2015b-c).

Vogt (2007) did a historical review on the events that steered the development of *organic farming* in Europe and USA in the early 20th century. Agricultural science at that time was dominated by the discovery of mineral fertilisers, which led to inappropriate fertilising that disturbed plant metabolism and to declining soil fertility, so-called 'soil fatigue', before the biological orientation gradually increased the understanding of the key role of soil microbial activity that contributes to soil fertility. Simultaneously, there was increased interest in organic farming within the life reform movements in Germany (e.g. biodynamic farming) and food reform movements in the USA. More recent development of organic farming has highlighted the biologically-orientated science-based approaches that focus on biologically stabilised soil structure, rhizosphere dynamics and systems ecology. Klein (2014, pp. 134-135) considered promotion of organic farming and *agroecology* today as one of the necessary steps for human endeavours to seek solutions to the climate crisis.

In Finland, future scenarios have been drafted for a possible agricultural policy goal of 50% of Finnish cultivated area to be cultivated organically, and its environmental and economic consequences (Koikkalainen et al. 2011). A distinctive feature of Finnish organic farming is its strong association with animal husbandry based on cultivated grassland, whereas the area under organic horticulture is decreasing due to plant protection challenges, among other things. Nuutila & Kurppa (2016a) recently analysed the reasons why the Finnish organic food chain has not developed sufficiently to reach the goals for production volume and consumption, and outlined an alternative model for organic food chain (2016b). Schader et al. (2013) found that the cost-effectiveness of public expenditure on specific agri-environmental measures is higher when implemented on organic farms rather than on non-organic farms in Switzerland.

In the European Union, organic farming is regulated according to Council Regulation No (EC) 834/2007 (EU 2007a) and Commission Regulation (EC) No 889/2008 (EU 2008b). These regulations set the basis for the standards and detailed rules of organic production, labelling and control of organic products. All organic producers are inspected regularly by organic inspection bodies, which may be private or managed by the government. The use of plant protection products in organic production is restricted to the products specified in the Commission Regulation, provided that they are authorised in the Member State concerned and the control threshold for the pest is exceeded.

The idea of *biological pest control* is not very new. Biological control agents are also known as natural enemies or beneficial organisms with three major categories: parasites and parasitoids, predators, and pathogens. Biological pest control is a valuable ecosystem service, but farming intensification has distorted the relative abundance distributions of natural enemy communities in favour of a few dominant species. Plant protection in organic farming is primarily based on preventive measures, natural enemies, the choice of species and varieties, crop rotation, cultivation techniques and thermal processes. In addition to naturally occurring beneficial organisms, organic farming can utilise biological plant protection products. In the case of an established phytosanitary threat, plant protection products may only be used if they have been authorised for use in organic production, and these products and substances shall be of plant, animal, microbial or mineral origin (EU 2007a). The active ingredients in microbial plant protection products are microbial strains isolated from nature with the basic principle of allowing beneficial microbes to occupy living space in advance of the harmful organisms to be controlled. Additionally, several plant extracts have been developed for biological control. International cooperation intends to remove the obstacles of introducing biopesticides by harmonising their national requirements (OECD 2012a). In the Northern countries, research on biological pest control was already active in the 1960s-70s (Sylvén 1971), and there are also several commercial microbial plant protection products on the

market today, mainly for greenhouse uses. A few microbial plant protection products are Finnish innovations that have been developed over the recent decades and are increasingly available on the market (Winquist et al. 2000).

Helyer et al. (2014) distinguished several major strategies for the use of biocontrol. Conservation or preservation biological control is based on exploiting existing natural enemies by modifying the environment to encourage the establishment and survival of greater numbers of beneficials. Augmentation biological control involves the periodic release of beneficial organisms to control a pest population, frequently using commercially reared agents. Importation/classical biological control introduces beneficials to an area, country, or continent to control a pest that does not have effective, native, natural enemies. The aim of an inoculative control is to establish the biocontrol agent on a short-term basis. Such agents may be native or introduced under license or permit. The biocontrols may reproduce and persist while the pest is present, but not form a permanent relationship. This method is used more extensively in greenhouse and interior settings than in large-scale open field crops. With inundative control the pest is overwhelmed by mass applications of commercially reared beneficials but with no expectation of long-term control of the pest's progeny. This form of biological control is also referred to as biopesticide applications as the majority of these agents are applied using slightly modified conventional pesticide application equipment. The latest research on biological pest control highlights the complex three-dimensional ecological interactions that can gradually stabilise the unstable conditions and rescue biological control in organic farming by achieving a balance between pest, predator and pathogen to be robust to agroecosystem perturbations, instead of simpler, ineffective pest management systems (Ong & Vandermeer 2015). Early experience with biological pest control was hampered significantly by the difficulty of maintaining autonomous and stabile populations of the control agents. Crowder et al. (2010) showed that rejuvenation of ecosystem function requires restoration of species evenness, rather than just richness, and organic farming offers a means of increasing the functional evenness of agroecosystems.

The challenge of producing enough food for the world's increasing population is debated between advocates of conventional and organic farming. Several comparisons of farming practices between organic and conventional farming systems have been done, e.g. by Seufert et al. (2012) and Tuomisto et al. (2012), concluding that organic yields are lower than conventional, and organic farming practices generally have positive impacts on the environment per unit of area, but not necessarily per product unit. Organic yields thus depend more on knowledge and good management practices than conventional yields. While the key challenges in conventional farming are to improve soil quality, reduce the use of pesticides and mineral fertilisers and enhance and protect biodiversity, an optimal outcome may be achieved by combining the best farming technologies from both organic and conventional systems resulting in higher environmental performance than either of the systems alone. Soil quality management is a high priority in organic farming to maintain long-term productivity, including crop rotations. While the biodiversity has in most studies been higher in organic farming systems, Nuutinen & Haukka (1990) could not find any clear differences in the species composition of earthworm abundances between the conventional and organic systems in field experiments in Finland. Deike et al. (2008a) compared the energy efficiency of organic and integrated farming, where both rely on fossil fuels as energy supply, with specific emphasis on pesticide use intensity. The energy intensity was significantly lower and the output/input ratio higher in organic compared to integrated farming due to major contribution of mineral nitrogen fertilisers in energy inputs in integrated practice, while pesticide use was attributable to only 5% of the total energy input. Leifeld (2012) compared soil respiration and carbon sequestration in organic and conventional farming systems, and concluded that more stabilised oganic matter and higher substrate use efficiency do not seem to be typical features of organically managed soils only, but likewise occur in conventional systems, thus not supporting the assertion of the superiority of organic farming as a means of sequestering soil carbon.

Bahlai et al. (2010) compared the ecological impacts on beneficial arthropod communities of two conventional synthetic, two novel synthetic and two novel organic insecticides with different modes of action in controlling soybean aphids. Contrary to the assumption that organic pesticides are more environmentally benign than synthetic ones, they found that the environmental impact quotient ratings were highest among the old synthetic insecticide dimethoate and the two organic insecticides. The organic insecticides were less selective, had higher toxicity than the synthetic insecticides, and the mineral oil product additionally had an extremely high use rate. The two novel synthetic insecticides had relatively low impacts and presented higher selectivity. As a conclusion, the authors rejected the organic-conventional dichotomy and emphasised, that individual crop protection decisions must be evaluated based on their environmental impact in the context of an IPM approach instead of arbitrary either/or choices in order to optimise environmental sustainability.

2.3. Learning as the core purpose of extension, training and certification of professional users and retailers

Turnpenny et al. (2008) identified *learning as one of the main dimensions of policy assessment* systems. Lifelong learning has been set as a policy goal to foster the transition to greener skills and jobs within the OECD (OECD/Cedefop 2014), and the EU, where a Community-wide framework has been agreed to assess citizens' key competences of lifelong learning (EU 2007b, EU 2008a). Blackmore et al. (2012) explored the role of learning theories in changing agricultural practices associated with training, advice and dissemination of research findings. Social learning theory (Bandura 1977; Blackmore 2010a) explains social learning as a cognitive process, where the learner is not a passive recipient of information, but makes observations and decisions about the behavior of successful individuals in interpersonal contexts. Although applicable in group situations also, the social learning theory basically deals with individual cognition. Expansive learning theory in adults (Engeström 1995) explained the learning process of practitioners and organisations developing their own working practices. In the Finnish NAP contexts, for instance proposals to transfer the good practices to farmers with help of experimental and demonstration farms and accomplished farmers at the head, are implicitly founded on the social learning theory, implying the learning of the individual farmer.

Röling & Wagemakers (1998) highlighted the need for a *paradigm shift* in contemporary agricultural training and extension, as its prevailing realist-positivist epistemology can no longer be used to cope with the uncertainties related to the challenges of facilitating the three steps of sustainability in agriculture: improving its efficiency, integration of regenerative technologies, and re-design with communities. According to Klerkx et al. (2012), innovation emerges from the complex interactions among multiple actors and is about fostering combined technical, social and institutional change. Gibbon (2012) also supports moving from disciplinary to trans-disciplinary thinking and practice, as well as systemic thinking abilities to be taught to agricultural trainers and extension advisors to facilitate farmer experimentation and innovation. In Sweden, Kreuger & Nilsson (2012) demonstrated that the involvement of local farmers in surface water monitoring and regular positive feedback on their progress in skill development created a social learning atmosphere where the farmers were willing to change their cultivation practices, which materialised as reduced PPP residues when the local surface water catchment area was monitored.

Several authors (e.g. Blackmore (ed.) 2010; Hubert et al. 2012; Schön 2010: public learning) have challenged the prevailing individualist theory of adult learning and argue instead that a collective, systemic learning processes are prerequisites for bringing about societal and behavioural change in organisations and adult learning

interventions. The theory of collective learning highlights the influence of shared values and experiences of the learners in a collective learning situation where the participants, including both learners and educators, develop a group consciousness by constructing a collective identity and acting collectively (Kilgore 1999). Innovative, collaborative methods for learning have been developed to enhance the transformative agency of training participants. The emergence of a collective learning process among the Finnish greenhouse entrepreneurs in the context of plant protection problems in the greenhouse sector has been studied by Vänninen et al. (2015; Vänninen 2012). Charatsari et al. (2012) highlighted the special needs of organic farmers with regard to extension education services. Organic farmers are not satisfied with the advisory work provided by the public or cooperative sectors, but instead are more motivated to search for knowledge by participating in agricultural education programmes than conventional farmers. Barzman & Dachbrodt-Saaydeh (2011) considered collective learning as a key concept in the implementation of the NAP on different scales: when individual farmers apply the IPM principles in their farming practices, on a national scale when the stakeholder groups negotiate the policy options for implementing and evaluating the NAPs, and also on an international scale when countries share their implementation experiences.

The rapid development of IPM discourse in Finland over recent years (Nissinen et al. 2015b) is a challenge not only to the scientific community, but also to the training providers who should be able to respond to farmers' topical knowledge needs and disseminate the research findings into practice. Ward et al. (2009) discussed the theory of knowledge brokering to make research and practice more accessible to one another. They distinguish three *modes of knowledge brokering*: dissemination, linkage and exchange, and capability building models. Knowledge brokerage can reside in individuals, organisations and structures, and it can be further described by three frameworks: in the knowledge system framework as a way of facilitating the activities, in the transactional framework focusing on the interface between the providers and users of knowledge and in the social change framework to enhance access to knowledge by providing training to knowledge users to create positive social outcomes. The possibility of impartiality in relationships between consultants and clients has been questioned in the consultancy model of knowledge brokering. Reed et al. (2014) outlined principles for effective practice of knowledge exchange that suggest it needs to be designed as a part of a research process that engages the likely research users and other stakeholders, whose needs should be systematically represented. Long-term relationships built on trust and two-way dialogue between researchers and stakeholders are also necessary to facilitate and sustain collective learning to ensure effective co-generation of new knowledge.

According to a European survey, the minimum duration of plant protection training varies a great deal within the EU Member States: for advisors the training is typically 24-72 hours, while for agricultural users it is 12-74 hours and 6-60 hours for distributors (European Commission 2014). In terms of the themes to be included in user training interventions, several studies have surveyed the needs of stakeholders. Pesticide storage, preparation, loading and disposal of spray mixtures, cleaning of spray equipment, workplace safety requirements and risk attitudes were identified as most important areas where guidance and training of professional users would be improved according to a survey in Italy (Calliera et al. 2013b). Similarly, safe handling, hazards and risks of using plant protection products and the use and maintenance of spraying equipment emerged in the needs survey for user training in Central and Northern Ostrobothnia in Finland (Myllylä 2013), as well as in the background study for the Finnish NAP (Peltonen & Rajala 2009). In California, Goodhue et al. (2010) came to the conclusion that an educational programme to train farmers to reduce their use of pesticides with hazardous properties could substitute policy options to totally withdraw those products from the market.

Sacchettini et al. (2012) reported on the European-funded project BROWSE, which used stakeholder consultation methods to contribute to the development and dissemination of communication material to train of professional users of plant protection products and raise awareness for people living in rural areas. In other projects, digital devices have been developed to enhance learning by professional users, e.g. the computer-based e-learning and

decision supporting application software called Drift Evaluation Tool (DET) developed by Doruchowski et al. (2013), which instructs pesticide users in risk mitigation in specific weather and field situations, and the internet-based software by Calliera et al. (2013b), which facilitates farm-scale evaluation of current level of sustainable pesticide use in Italy.

The results of a European survey on how the *training of spray equipment inspectors* is organised show great differences in national approaches. As a conclusion, a common level or strategy to train and certify sprayer inspectors is proposed for the EU (Andersen & Nilsson 2012). Doruchowski et al. (2012) reported on Polish experiences on organising sprayer calibration training. They composed a ten-hour training programme with a practical calibration exercise for the operators in teams, including elements of competition between the teams. Incorporating the gamification methods stimulated participants' thinking and action, and also made their involvement enjoyable.

Gibbon (2012, p. 101) distinguished six modes of participation in farming systems research where the level of outsider control (e.g. by advisors and trainers) decreases and the potential for sustaining local action and ownership of farmers themselves increases gradually from co-opted, co-operating and consulted to collaborating, co-learning and collective action types of participation. The role of extension advisors in facilitating the *farmers' participation in knowledge production* is significant. The modes of participation gradually change from technology transfer to adaptive management (Berkley 2013; Klerkx et al. 2010; Pant et al. 2014; Voß & Bornemann 2011), and the transformation not only involves a change for the farm but also, and especially, for people, institutions and policies (Röling & Jiggins 1998, p. 290). Freier & Zornbach (2008) reported on the issues to be covered in training of the advisors in Germany. The need for continuous learning and training of food safety risk assessment professionals is recognised at international level as well (Bosman et al. 2016).

2.4. General public and plant protection

Disseminating information and *raising awareness* on the risks and proper use of plant protection products among the general public is one of the core tasks in the implementation of the NAP. The inventory of existing communication programmes on the impacts of plant protection products in the EU Member States (FCEC 2012) showed that very few communication and awareness raising schemes were initiated beyond the legal obligations (e.g. residues in food) and quite often communication is achieved via the official websites of the national authorities. This is also the case in Finland. The national communications plan for dangerous chemicals 2014-2020 (Tukes 2013a) lays down the objectives and describes the methods for communicating the risks from dangerous chemicals, including plant protection products. Communications targeted at citizens focus on the importance of personal choices in reducing the risks to the environment and human health. Citizens are also encouraged to trust the information issued by the authorities. The precautionary principle (Løkke 2006; Gupta 2015) is highlighted in communications. The training and certification system established provides information and advice for professional users of plant protection products, but amateur users and the general public is provided with information on voluntary basis, advising non-professionals to choose primarily non-chemical plant protection methods.

The challenges of chemical *risk communication* from experts to the general public has been subject to abundant research in last decades (e.g. Lash et al. (eds.) 1996; Luhmann 2004). Slovic (1991) highlighted the false assumption that the audience would share the experts' conceptual knowledge about the risks, which leads to unsuccessful risk communication. Renn (2008, p. 205-241) pointed out that risk communication should be

regarded as a mutual learning process, although it implies a stronger role for risk professionals providing information to the public than vice versa. Risk professionals are encouraged to take a much more prominent role in risk communication, because effective risk communication can make a strong contribution to the success of a comprehensive and responsible risk management programme (ibid. p. 203-204). Covello et al. (1991) advised accepting and involving the public with their concerns, perceptions and experiential knowledge as a legitimate partner in communication. The reflexive view of risk communication as a social learning process is also supported by Lyytimäki et al. (2009), who studied the experts' views on communicating chemical risks. In their other article (Lyytimäki et al. 2011), the authors underscored the paradox of providing adequate information about chemical risks: too much communication may increase rejection of the information and denial can provoke dramatised debates. A visualisation of the environmental and human health risk assessment of chemicals might enhance the general public's understanding of the complexity of risk concepts as presented for instance by Painter et al. (2014).

There is conflicting research on the *effectiveness of information* and awareness-campaigns in enhancing the general public's environmentally responsible behaviour. According to Kaivola (2000), information gathered from the public media alone appears to have rather limited interfaces with responsible environmental behaviour. Keene & Blumstein (2010) claimed that there is limited evidence of the ability of environmental education programmes to create behavioural change in longer term, while Jacobs et al. (2012) highlighted the role of adherence to social norms. More personal approaches are obviously needed that emphasise social capital and networking to create favourable conditions for behavioral change, as experienced by Husák (2012), for instance. Blackmore (2010a-b) seeks communication methods that lead to social learning and purposeful action based on the concept of an appreciative system.

Communication on plant protection is not only necessary between regulators and scientists and the general public, but also between the users (farmers) and their neighbours. As an example of local success in communicating sustainability issues between farmers and neighbours, Cardona (2012) presented an initiative in France to relink farming to local and environmental stakes of the general public. Centner et al. (2014) discussed pesticide labelling as a means of communication to address the liability conflicts from spray drift between farmers and their neighbours.

The general public may not necessarily perceive themselves as pesticide users, according to Ahmed et al. (2011), who compared the perceptions of pesticide use of farmers and neighbours in two periurban areas in Sweden. Pesticide use is common among both groups, not only among the farmers. Neighbours regarded pesticides more dangerous and less valuable than farmers did, although despite this, they used pesticides at their homes as often as their neighbouring farmers did. Almost half of the neighbours perceived themselves as non-users of pesticides even though they reported they had been using pesticides during the past year. This misperception, where their actual use of pesticides was higher than how they perceived it was more common among neighbours who saw themselves as non-pesticide users than among farmers. At the time of the study, 20% of the tonnage of active substances sold was reported as being for household purposes in Sweden, dominated by herbicides.

The Finnish NAP states that the use of plant protection products should be avoided in amenity areas where the general public and specifically vulnerable groups, such as pregnant and nursing women, infants and children and the elderly may stay, as obliged by the Article 12 of the SUD (EU 2009b). Such areas are e.g. parks and gardens, sports and recreation grounds, school grounds and children's playgrounds, and the vicinities of healthcare facilities. The purpose of plant protection in amenity areas is typically targeted at the control of certain invasive alien and particularly hazardous plant species, such as hogweed (Korhonen 2015; Nielsen et al. 2007). Guidance and advice in sustainable plant protection on amenity areas is provided e.g. by Rajala (2014). In the UK, an industry-led body, the Amenity Forum, has been established to bring together professional organisations that

are involved in the amenity horticulture sector. It publishes guidance notes and briefings to assist amenity managers, advisors, users and operators in fulfilling best practices of plant protection in amenity areas (Amenity Forum 2014).

Although it is stated that chemical plant protection in *urban and amenity areas* is minimal, no actual data on its intensity is available in Finland yet. In some countries specific programmes have been established to reduce the use of plant protection products in amenity areas. Kristoffersen et al. (2004) analysed the consequences of an agreement between the government and local authorities to create municipal action plans to reduce pesticide use in public areas. The existence of a municipal action plan was recognised as an effective tool that led to a reduction of 78% in pesticide use in public areas in Denmark between 1998 and 2002. Factors affecting the plant protection decisions in public areas were largely habitual, and after introducing a local phase-out policy, significant reductions were possible within a fairly short time period. Kristoffersen et al. (2008) compared the pesticide policies and regulations for urban amenity areas in seven European countries. Denmark, Sweden, the Netherlands and Germany had a strong public and political interest for reducing the use of herbicides to control weeds in urban amenity areas and also have very strict regulations. The UK was experiencing increasing awareness and strengthening regulation, while Latvia and Finland did not have specific regulations for weed control in urban amenity areas or on hard surfaces. Statistics on the use of plant protection products in urban amenity areas were only available in Denmark and the Netherlands. Wittmer et al. (2011) reported about a Swiss field study where the measured loss rates from urban uses of pesticides were found to be up to ten times higher than from agricultural uses in four Swiss catchment areas, despite the substantially lower amounts used.

The NAP also states that the use of plant protection products should be avoided within the buffer zones of drinking water abstraction sites and in Natura 2000 areas designated for the purposes of establishing conservation measures for natural habitats of wild fauna and flora. Egan et al. (2014) suggested that herbicide pollution may be a secondary factor structuring plant communities at landscape or regional scales, while other factors beyond herbicide exposure may be more important in shaping the distribution and abundance of plant diversity across an agricultural landscape. In conservation areas trade-offs between the livelihoods of inhabitants and conservation purposes may be unavoidable, as illustrated for instance by Frys & Nienaber (2011) in Germany, or Birge & Fred (2011) in Raasepori, my home landscape.

2.5. Reducing the risks to human health

Plant protection products are deliberately developed to kill organisms to be controlled, but because the effects focus on living cells, unintended effects are possible on humans as well (Luomahaara 2012). One of the core objectives of the NAP is to reduce the risks to human health from the use of plant protection products. As a means to this end, the NAP specifies pre-approval risk assessment for operators, bystanders and consumers, control of residues in food commodities as well as training and information on the safe handling and application of plant protection products, including appropriate risk mitigation and use of personal protective equipment (PPE).

The scientific risk assessment methods and data requirements on evaluating the potential of human health risks from the use of plant protection products are developing internationally (EFSA 2014a; Großkopf et al. 2013; Hardy 2012), but are less debated compared to environmental exposure models as presented in Chapter 2.6. Several authors have contributed to the research on operator exposure, safer working practices and sprayer techniques in field and greenhouse cultivations (e.g. Bjugstad & Torgrimsen 1996; García-Santos et al. 2011;

Godyń et al. 2012), uniformly concluding that hand-held knapsack sprayers undoubtedly cause the highest exposure to operators.

Santti (1988) highlighted the difficulty in proving the evidence on symptoms and illnesses resulting from environmental exposure to potentially harmful substances. Thundiyil et al. (2008) proposed a classification tool for diagnosing acute pesticide poisonings in primary health-care systems, and a harmonised reporting system for pesticide poisonings was proposed by Settimi et al. (2016). In a Finnish telephone survey on persons who contacted the Poisoning Information Centre in 2002 due to suspected pesticide poisonings, 79% of cases happened at home and 56% of the exposed persons were children (Mäkinen et al. 2004). Symptoms in household exposures were typically very slight, whereas the occupational cases, although fewer in number (14 cases), led to more severe symptoms. The majority of suspected exposures were caused by insecticides, and the work-related exposures were typically due to disregarding the appropriate personal protection, thus highlighting the importance of training in safe working methods. The survey was repeated in 2014 and the report is under preparation (Koponen 2015a-b).

Fantke et al. (2012) quantified the health impact and damage costs from 133 plant protection products applied in 24 European countries in 2003. Just 13 active substances applied to three crop classes (wine grapes, orchards and vegetables) contributed to 90% of overall health impacts of around 2000 disability-adjusted life years per year, corresponding to annual damage costs of 78 million €. Five of those active substances have been withdrawn from the European market on the basis of the PPP Regulation.

The experiences and attitudes of professional users of plant protection products are the core of *safe working practices* and success in risk reduction. In an American survey, Lichtenberg & Zimmerman (1999) found that farmers who reported adverse health experiences from pesticides tended to adopt alternative pest management practices that reduce reliance on pesticides more so than farmers who had not had such experiences. Interestingly, the highest-selling commercial farmers with the highest formal education level, who are certified to apply pesticides, showed lower concern for health or environmental problems, compared to farmers with lower sales, a lower education level or without certification.

Bystanders may be exposed to pesticides if staying in the vicinity of the fields to be treated. For instance, Butler Ellis et al. (2010) measured the spray drift exposure of bystanders through experiments carried out with mannequins, human volunteers and passive line collectors in UK. Their data showed that bystander exposures can be significantly higher than currently assumed in risk assessment, thus suggesting that the models should be refined. Exposure data with pet dogs can serve as a surrogate for human exposure to herbicides. Knapp et al. (2014) detected lawn herbicides in the urine of pet dogs following home lawn treatment. Herbicide-treated lawns have been associated with a significantly higher bladder cancer risk in dogs. Herbicides were found commonly in the urine of dogs both in treated and untreated areas, and the persistence of herbicides in treated lawns was longer than expected, thus suggesting that dogs' access to treated lawns should be restricted after treatments. Arbuckle et al. (2001) associated exposure to specific plant protection products (phenoxy acetic acid herbicides, glyphosate and triazines) with spontaneous abortions in an Ontario farm population.

Consumers are exposed to plant protection products primarily through residues in food and beverages. Roca et al. (2014) found that school children living in an agricultural area in Spain had significantly higher concentrations of organophosphate metabolites in their urine compared to those living in an urban area, indicating a higher consumption of vegetables treated with insecticides. The results of annual residue monitoring in food are published by Evira in Finland (latest by Kekki & Siivinen 2013). Cumulative risk assessments on dietary exposure to plant protection products were produced in Finland by Laakso et al. (2010), and internationally, for instance by Boobis et al. (2008). The Finnish studies indicate that the health risk to Finnish consumers from consuming

domestic vegetables is generally low. Recent results from Poland (Struciński et al. 2015) indicate that although consumers in Poland are adequately protected in general, some incidental cases have not been totally excluded, where residue levels may potentially have posed a threat to consumers' health due to acute exposure.

The approval of active substances and authorisation of plant protection produts is temporary. The detailed risk assessment procedure means that commonly used plant protection products that are on the market have been assessed as safe, but the growing data available on re-evaluation may change the conclusions and approval decisions. A topical example of this process is the recent case of *glyphosate,* which is probably the most heavily used herbicide in the world, with increasing sales since the 1970s (http://www.tukes.fi/en/Branches/Chemicals-biocides-plant-protection-products/Plant-protection-products/Sales-statisitics/). Toxicological research on glyphosate has also been abundant, resulting in an exhaustive package of studies. The re-evaluation of glyphosate under the European PPP legislation has taken several years, Germany being the Rapporteur Member State. Recently, the International Agency for Research on Cancer (IARC) under the World Health Organisation (WHO), conducted an evaluation on the carcinogenicity of glyphosate, concluding that there is limited evidence of carcinogenicity to humans and sufficient evidence of carcinogenicity in experimental animals (IARC 2015). Consequently, the toxicological evaluation of glyphosate was repealed and the European Food Safety Authority (EFSA) extended its peer review, finally reaching the opposite conclusion, that glyphosate is unlikely to pose a carcinogenic hazard to humans. Instead of the active substance itself, it was the adjuvant POEA in certain glyphosate products that likely contributed to the effects observed in specific studies (EFSA 2015). The scientific discussion continues (Portier et al. 2016). The Member States could not find the qualified majority for a renewal decision, and the Commission decided to extend the approval of glyphosate until the end of 2017, by which time the European Chemicals Agency (ECHA) is expected to issue its opinion on the classification and labelling of glyphosate. The Member States will withdraw the authorisations of plant protection products containing the adjuvant POEA and pay particular attention to the conditions of authorisations for plant protection products containing glyphosate (EU 2016).

2.6. Reducing the risks to the environment

A recent review of environmental fate research on plant protection products conducted within the Northern zone was compiled by Stenrød et al. (2016). The aquatic environment is in general very susceptible to the toxic effects of chemicals. Protecting the aquatic environment from exposure to hazardous chemicals, including plant protection products, is the core of the Water Framework Directive (WFD, Directive 2000/60/EC: EU 2000). The NAP, for its part, enforces the requirements of WFD. Therefore a good number of actions in the NAP are targeted at aquatic protection issues in the NAP. First, an overview on the aquatic exposure research is presented. I then focus on aquatic monitoring studies and the environmental quality standards for plant protection products. Next, possibilities for risk mitigation in aquatic environments are reviewed. In addition to surface waters, other compartments of the environment may also suffer from exposure to plant protection products. Exposure and risks in terrestrial compartments, specifically in agricultural soils in the Northern climate, is considered. Although specific groups of non-target organisms are not explicitly highlighted in the Finnish NAP, profuse research is dedicated to the ecotoxicology of non-target organisms today, and therefore an overview is given at the end of this chapter.

DO WE LISTEN TO EARTHWORMS? TOOLS FOR EVALUATING THE FINNISH NATIONAL ACTION PLAN ON THE SUSTAINABLE USE OF PLANT PROTECTION PRODUCTS

Exposure and effects of plant protection products in aquatic environment

Ecosystem services (Brouwer et al. 2013) provide an operable framework for a holistic view on aquatic ecosystems to guide the sustainable management of water resources. Although not explicitly mentioned in the Water Framework Directive (WFD; EU 2000), there are clear links between the aims and objectives of the Directive and the ecosystem services delivered by surface waters. Achieving the required environmental characteristics of water bodies leads to the achievement of good ecological and chemical status, which together lead to good surface water status, thus the aim is to keep exposure to chemicals at low levels. This is equivalent to the environmental quality whereby water bodies have the potential to deliver ecosystem services (Vlachopoulou et al. 2014).

Brock et al. (2006) contributed to the discussion about what constitutes a sustainable freshwater ecosystem by comparing the ecological risk assessment procedures of the WFD and PPP legislation. Ecological impacts on biodiversity and on ecosystem functioning under a range of environmental conditions, as well as socio-economic impacts on perceived aesthetic and functional values to humans alter the sustainability of freshwater ecosystems, while the multifunctionality of most surface waters in the agricultural landscape cannot be ignored. Contrary to point source pollution, the environmental load from the use of plant protection products is diffuse and temporarily variable. Spray drift from the application of plant protection products in the vicinity of water courses is an important route of acute exposure, although plant protection products may additionally end up in surface waters via drainage and runoff in the longer term (e.g. Autio 2012; Siimes et al. 2006). The bases for aquatic risk assessment are ecotoxicological laboratory studies with standard species from different trophic level while field studies are also occasionally available (Koivisto & Autio 2009). In addition to agricultural uses, urban uses of plant protection products may also be significant sources of exposure in surface waters (Ghanem et al. 2007; Kolpin et al. 2006; Wittmer et al. 2011).

The effects of mixtures of multiple plant protection products that are actually used are very difficult to verify in field. The effects of plant protection products on macroinvertebrate community structures may occur below levels where the risks are commonly thought to be negligible (Schäfer et al. 2007). This conclusion was confirmed by evidence derived from eight field studies worldwide, which showed that the European regulatory threshold for single pesticides is not protective for macroinvertebrate communities subject to multiple stressors, pesticide mixtures, and repeated exposures, although risk mitigation measures can alleviate the effects (Schäfer et al. 2012). Similarly, the results of Berenzen et al. (2005a) showed that pesticide runoff in small agricultural streams, resulting in concentrations well below the acute toxicity to macroinvertebrates, affects their community structure over the main application season. Obviously the most mobile species are able to actively escape following even a very low short-term contamination of the stream caused by runoff. In another paper, using a calculation model, the authors compared predicted and measured short-time levels of runoff-related pesticide concentrations in small lowland streams on a landscape level similar to the previous study, and propose the modelling method to be used for improved exposure assessment in streams where measurements are not possible due to high costs (Berenzen et al. 2005b).

Aquatic monitoring and the environmental quality standards (EQS) of plant protection products

Measuring the concentrations of plant protection products in the environment is interesting albeit a very expensive control measure, as a number of measurements need to be conducted in a defined area and at appropriate intervals. Therefore, measurements can usually only be conducted to a limited extent, and careful planning of the monitoring is required to produce an accurate and reliable picture of the exposure (Biber 2013; Cimorelli & Stahl 2014; Levine et al. 2014). Detailed calculation methods are used in the risk assessment to predict environmental concentrations from the intended uses of plant protection products prior to their release on the

market (FOCUS 2015). However, monitoring of the environmental concentrations is a valuable tool in assessing whether the assumptions made in the risk assessment and risk management have been correct, while different countries have chosen different approaches to implement monitoring of plant protection products in the environment (FCEC 2012). Guidance in exposure assessment based on environmental monitoring is provided by the OECD (OECD 2013b). There is a great deal of literature on planning monitoring programmes in variable environmental conditions.

Different approaches for the planning and design of monitoring systems for diffuse source pollution of hazardous chemicals, including plant protection products, have been studied in Finland (Mannio 2001; Mannio et al. 2014; Siimes 2014) and in other countries. Mathematical modelling linked with spatial data such as topographical, soil and climate parameters (Schriever et al. 2007) and modelling linked with probabilistic methods (Stehle et al. 2013) have been used to compare measurement data in order to predict the potential runoff hot spots and most appropriate sampling strategies in agricultural streams. Remote sensing data was used by Macary et al. (2014) to develop vulnerability indicators for the surface water environment to score the risk of contamination of watersheds, in order to support public policy decision making on looking for monitoring hotspots. Bundschuh et al. (2014) focused on the most appropriate sampling strategies to capture the diffuse source load from pesticide use.

In Scandinavia, Sweden has organised long-term monitoring to measure plant protection products in surface waters associated with local farmer involvement activities including increased advising and training to reduce the environmental load (Kreuger 1998; Kreuger & Nilsson 2012), whereas Denmark has put special emphasis on groundwater monitoring (Thorling 2015). In Norway, long-term surface water monitoring has been conducted in six agricultural catchments since the mid-1990s (Stenrød 2015). Results on Finnish surface water monitoring have been published by Heinonen et al. (2007), Siimes (2012) and Karjalainen et al. (2014), and the publication of groundwater monitoring results is currently under preparation (Juvonen 2014).

Environmental quality standards (EQS) are a policy tool for environmentally rational governance, as defined by Emmelin & Lerman (2008, p. 464-465). For the purposes of monitoring the aquatic pollution of hazardous chemicals, including plant protection products, the measured concentrations can be compared to EQSs, indicating whether the releases are within the limits set by regulations, projects or plans intending to manage them, in line with the general societal ambitions for environmental quality. Environmental quality standards for plant protection products are thus not binding norms, but instead soft standards, goal or target values to indicate the good chemical status of aquatic environment, to be used in the monitoring of chemicals in the environment. Different approaches have been proposed for the scientific process of prioritising chemicals and for setting the EQSs for them, as exemplified by von der Ohe et al. (2011) or Guillén et al. (2012). The French approach was published by Babut et al. (2003). In Sweden, the Swedish Chemicals Agency has given environmental quality standards for plant protection products in surface waters (Kemikalieinspektionen 2008b). The Finnish proposal for EQSs for all plant protection products on the market was prepared by Kontiokari & Mattsoff (2011) as one of the first outputs of the Finnish NAP. Considering groundwater protection, Balderacchi et al. (2014) have been required the setting of European-wide environmental quality standards for emerging pollutants from new sources, including higher emphasis on urban releases.

Risk mitigation to protect the aquatic environment from the use of plant protection products

When using plant protection products properly, risk mitigation may be necessary to avoid pollution and hence reduce the risks to the environment to an acceptable level. Planning risk mitigation measures implies a trade-off between acceptable efforts for farmers and effective pollution prevention. Risks may be managed with

appropriate risk mitigation measures, like use instructions, buffer zones and restrictions in certain vulnerable areas (Autio 2012; Tukes 2015d). The risk mitigation measures available in different countries are not harmonised within the European Union (Stenrød et al. 2016; Tukes 2015a), and our national practices have been questioned by the producers, as will be presented in Chapter 6.4. Various practices are in use and their applicability and effectiveness is contested by different stakeholders from time to time. Consequently, environmental risk mitigation measures are subject to substantial research worldwide, and there is much debate on the adequate width of buffer strips along the water courses.

A few reviews of literature are available to evaluate the effectiveness of risk mitigation strategies and measures for reducing pesticide inputs into water bodies through several pathways (e.g. Bereswill et al. 2014; Reichenberger et al. 2007; Zhang et al. 2010). As a conclusion, vegetated buffer strips located at the lower edges of the fields are effective in reducing pesticide runoff and erosion in general, but the necessary width of the buffer strip is highly variable. Riparian buffer strips appeared less effective than edge-of-field buffer strips in controlling runoff, but are important in spray drift control. Based on the studies reviewed, it did not appear to be possible to defend the assumption that no-tillage practice would contribute to lower pesticide runoff. As regards drainage and leaching, the only feasible mitigation measures for these pathways are product substitution, application rate reduction and shift of application date. Crop-free no-spray buffer zones combined with drift reducing sprayer technologies and windbreaks can be effective risk mitigation measures to reduce spray drift, while stewardship initiatives, training and awareness-raising and application of best practices are the most effective mitigation measures to reduce point source pollution.

Several authors have taken a stand on the adequate width of buffer strips as an applicable risk mitigation measure for protecting aquatic communities. Mathematical simulation models provide a promising tool for studying risk mitigation strategies for aquatic protection, and this branch of research is very productive. Contrary to the better established models for operator and bystander exposure assessment as discussed in Chapter 2.5, the simulation models for environmental exposure are still subject to debate and abundant research and development. Although the European regulatory risk assessment is harmonised using the surface water models and scenarios of the Forum for the coordination of pesticide fate models and their use (FOCUS 2015), the research community warns against overreliance of them (Knäbel et al. 2012) and there is ongoing discussion of their implications for the adequacy of risk mitigation measures (Bach & Hollis 2013; Knäbel et al. 2013a-b; Stehle et al. 2013; Knäbel et al. 2014; Reichenberger 2014; Knäbel & Schulz 2014).

In addition to the regulatory uses of FOCUS models with standard scenarios, also other models with landscape-specific input parameters have been applied in research on surface water risk mitigation measures, as for instance the landscape-level simulation presented by Probst et al. (2005), who produced site-specific risk maps for different risk mitigation options with decreased and increased buffer zone widths. They also considered a likely climate change scenario to illustrate how the increased precipitation increased the proportion of high risk sites dramatically, suggesting that risk mitigation adequate for protecting the aquatic environment within the current practices may not be adequate for future climate change situation.

Bunzel et al. (2014) concluded that riparian buffer strips of at least 5 metres in width had a positive effect on macroinvertebrate communities, with the highest abundances at sites with a buffer strip width of more than 20 metres. The minimum buffer strips were considered necessary not only at the exposure zone but along the whole stream system to provide adequate upstream recovery areas. A field experiment by Maltby & Hills (2008) studied the effect of aquatic buffer zones on reducing the effects of pesticide spray drift to benthic macroinvertebrate communities. The non-application area had a higher taxon richness, a greater abundance of snails and worms and a lower abundance of blackfly larvae, but there was no evidence to suggest that these differences were related to pesticide applications or the width of the buffer zone. Rasmussen et al. (2011) surveyed the occurrence

of 31 pesticides and their potential toxicity for benthic macroinvertebrates in 14 Danish streams, finding that vegetated buffer strips wider than 6.6 m would be necessary to obtain good ecological status and sufficient protection of stream ecosystems from pesticide runoff. This is not the case in Denmark, however, where only about 40% of the total stream network is required to have uncultivated buffer strips of 2 m in width.

In another field experiment in Italy, a 6-m wide buffer was sufficient for controlling nutrient release by almost 100%, whereas for herbicide abatement this buffer strip reached only a 60 to 90% reduction (Borin et al. 2004). Syversen & Bechmann (2004) showed that 5-m vegetated buffer zones were able to filter 39% of glyphosate, 71% of fenpropimorph, 63% of propiconazole and 62% of soil particles in a field experiment with simulated short-term runoff events of 5000 litres of runoff water with known added concentrations of three pesticides and suspended soil particles. The lower removal efficiency of glyphosate was probably due to adsorption of glyphosate into the smallest particle size fractions, which have a lower trapping efficiency in buffer zones. Erosion rills can easily offset the efficacy of vegetated buffer strips (Ohliger & Schulz 2010; Stehle et al. 2016).

The cost-effectiveness of measures to reduce aquatic risks in the Netherlands was assessed by van Eerdt et al. (2014). Of the evaluated 105 farm-scale risk mitigation measures available for IPM practices, the most effective means were emission reduction and replacement of high-risk products with lower risk products, contributing to up to an 80% reduction of aquatic risks, while 40% of the measures also reduced the overall cost of pest management. Around 60% of the measures were voluntarily implemented by Dutch growers. There are also industry initiatives to reduce water pollution with plant protection products from spray drift, runoff and erosion, by informing professional users about proper application practices (TOPPS Prowadis 2014). Chemical plant protection has sometimes been justified due to its positive influence on reduced nutrient leaching.

As regards ground water protection, some studies have assessed the applicability of European risk assessment methods and their implications on national conditions. For instance, Labite et al. (2013) compared the European FOCUS ground water scenarios (FOCUS 2014) to Irish local site specific simulations, finding that the FOCUS scenarios overestimate pesticide leaching by 42-99% compared to Irish data, and ensure the desired level of protection against pesticide contamination of Irish water resources. Gimsing et al. (2013) seek to harmonise the national practices of groundwater risk assessment within the Northern zone. Birch (*Betula spp*.) wood biochar was recently proposed as a soil amendment to reduce the leaching of glyphosate and its degradation product AMPA in agricultural soils (Hagner et al. 2015).

Risk mitigation to protect the terrestrial environment from the use of plant protection products

The specific characteristics of Finnish soils are not completely understood yet (Greve et al. 2000; Yli-Halla & Peltovuori 2016), thus requiring considerable research on the environmental fate and behaviour of plant protection products in Northern conditions. Several projects have produced data for instance on the processes of adsorption (Autio et al. 2004; Rämö 2008), leaching (Laitinen et al. 2009; Siimes & Alakukku 2008; Stenrød et al. 2008), freezing and thawing (Andersson & Hartikainen 2008; Chen et al. 2013; Stenrød et al. 2005) and soil microbial activity (Niemi et al. 2008) in cold climate. The degradation of plant protection products in cold Northern climate conditions has been studied for instance by Braunschweiler (1992), Helander et al. (2012), Ruuttunen et al. (2008) and Siimes et al. (2006). Laitinen contributed greatly to our understanding about the fate and behaviour of glyphosate, the herbicide with highest sales amounts in Finland (Laitinen 2009; Laitinen et al. 2006, 2007, 2008, 2009). Her work has subsequently been continued within the GlyFos project, with several publications in progress (Petruneva et al. 2016; Siimes et al. 2016; Uusi-Kämppä et al. 2015).

Increasing knowledge has implications for the setting of possible risk mitigation measures for plant protection products. The Finnish practice of mitigating risks to soil dwelling organisms by applying restrictions on use in

consecutive years is defined by Mattsoff (2005). The purpose of the restriction on use in the same field plot in consecutive years is to hinder the accumulation of slowly degrading pesticides in soil to the extent that effects to soil dwelling organisms would occur. The assessment takes into account the effects of temperature and moisture on the degradation rate of active substances in the Finnish climate as well as their toxicity to soil organisms. Application can be restricted to every second or third year if necessary. Arguments have been presented in favour of accepting terrestrial field dissipation studies performed in different regions in authorisation of plant protection products (OECD 2012b). Groundwater can be protected by restricting the use of mobile plant protection products on defined groundwater areas (Tukes 2015f). Stakeholder have criticized the determination of this restriction for complicating farming, as exemplified by a project on taking these use restrictions into account when setting boundaries for groundwater areas (Hanski et al. 2010).

Although the enforced drive to rationalise intensive crop production has led to a significant reduction in *crop rotation* in recent decades, its benefits are well understood and emphasised in agricultural science worldwide (e.g. González-Díaz et al. 2012; Hwang et al. 2009; McDaniel et al. 2014; Westerman et al. 2005). Statistical analysis of crop rotation history in Finnish field plots was presented by Jauhiainen & Keskitalo (2012). Adequate crop rotation helps prevent the accumulation and formation of resistant pest populations and mitigates the adverse effects of continuously using persistent and leaching plant protection products in fields (Junnila et al. 2012; Alanko et al. 2013a-b). A Finnish field study on plant protection products used consecutively in continuous potato cultivation demonstrated that consecutive uses of metribuzin, linuron and fluazinam increased the risk of accumulation in soil and of adverse effects to field ecosystems (Ruuttunen & Laitinen 2008), thus warranting the restriction of use in consecutive years for the plant protection products studied (Autio & Mecke 2008). While not being able to confirm the interaction between crop rotation practices and the intensity of pesticide use, Deike et al. (2008b) found that the ecotoxicological risk potential from plant protection was higher in direct drilled fields compared to ploughed fields, and the risk potential was consistently lower in plots with lower treatment rates.

Protection of non-target organisms

The NAP does not highlight any specific groups of terrestrial non-target organisms, taking a general approach to minimise the uses of plant protection products in areas that contribute to maintaining biodiversity, such as Natura 2000 sites (e.g. Muller 2002; Müller & Maes 2015). However, because the effects of plant protection products on non-target organisms are under intense scientific debate today, a short review is given here with its implications for potential risk mitigation measures.

A topical research question worldwide recently has been the *declining populations of pollinators* (Scheper et al. 2013). The total economic value of the ecosystem services provided by honey bees and other pollinating insects via pollination amounted to 153 billion euros, representing 9.5% of the value of the world agricultural production used for human food in 2005 (Gallai et al. 2009), and demand for honeybee pollination service supply in agriculture is increasing (Breeze et al. 2014). Several studies have brought out the alleged impact of plant protection products on pollinator decline, especially the effects of neonicotinoid insecticides observed in many countries (e.g. EFSA 2013a - c, EFSA 2014b; Henry et al. 2012; Koistinen 2015; Rundlöf et al. 2015; Seppälä 2013; Whitehorn et al. 2012), although other pesticides (Baron et al. 2014) and combined exposure to several pesticides have also been blaimed (Gill et al. 2012; Thompson 2012). Kessler et al. (2015) found that bees cannot control their exposure to neonicotinoids, as they prefer foraging neonicotinoid-containing nectar, if available. The research findings are ambiguous, as several authors have either found no effects or assert other explanations as being more important than insecticides (e.g. Genersch et al. 2010; Pohorecka et al. 2012; Ketola et al. 2015). The scientific debate is therefore ongoing and evidence is to be gathered to further assess the reasons for pollinator decline worldwide. The consequences of these research findings for risk mitigation strategies are

considerable to assess whether risk mitigation that relies on alternative, more attractive sources of nectar and pollen in the vicinity of treated fields adequately decreases the exposure of pollinators.

In addition to pollinators, Goulson (2013) argued that current use of neonicotinoids is likely to impact a broad range of non-target taxa and threaten a range of ecosystem services. He reminds that neonicotinoids are neurotoxins with high toxicity to most arthropods, with reported levels in the environment that may exceed the concentrations regarded as safe for beneficial organisms, because they can persist and accumulate in soils and leach to groundwater and waterways. Although vertebrates are less susceptible to neonicotinoids than arthropods, consumption of dressed seeds offer a route to direct mortality in birds and mammals, and recent declines in insectivorous birds have also been associated with high neonicotinoid concentrations in the environment (Goulson 2014; Hallmann et al. 2014).

Amphibians are a less researched taxonomic group of organisms with regard to pesticide exposure. Dwelling between the aquatic and terrestrial environments, they can suffer from sublethal exposure both in cultivated fields and adjacent water courses. Piha (2006) discovered that pesticide exposure may increase the costs of fitness of tadpoles in response to natural environmental stressors in an intensive agricultural environment. However, tadpoles may compensate these impacts if the heterogeneous landscape patterns can adequately maintain tadpole populations even under extreme conditions. *Unsprayed field margins* significantly maintain the biodiversity of Northern agricultural environments (Helenius & Bäckman (eds.) 2004). A Finnish background study for defining necessary risk mitigation measures to protect terrestrial non-target plants in field edges was performed in Tukes (Tukes 2013b), but the project to establish terrestrial buffer strips was delayed at request from the Ministry of Agriculture and Forestry. Recently Jalli & Junnila (2016) demonstrated that drift-reducing nozzles as a risk mitigation measure do not compromise the efficacy of herbicide applications.

2.7. Technical issues: spraying equipment, storage and disposal of plant protection products

The proper functioning and *conditions of spraying equipment* for plant protection products is key in reducing the unnecessary exposure of the operator and the environment (Autio 2012; Manni 2014). Inspections of tractor-mounted and self-propelled spray equipment have been compulsory in Finland since 1995 as connected to the agri-environmental support system, but the SUD requires a testing system to be established for other types of spray equipment in professional use as well. Testing is carried out by inspectors authorised by Tukes, and spray equipment must fulfil the environmental criteria laid down in the revised Machinery Directive (2009/127/EC, EU 2009c). Manni (2014) looked into different types of spray equipment in use in Finland. Health risks to operators may occur during maintaining, filling, using and cleaning the sprayer. Risks to the environment were identified during leakage and spray drift situations. He recommended updating the guidelines on testing the spray equipment for plant protection products (Tukes 2011), and the work is currently ongoing (Tukes 2015e). The legislation was recently amended (MMM 2016), and the aim is for all equipment to be tested for the first time by 26 November 2016.

Wehmann (2012) presented the results of a survey on spray equipment inspections throughout Europe. Around 1.2 million field sprayers and nearly 1 million air-assisted sprayers exist in Europe, with around 300 000 inspected every year. The average inspection interval has increased from 2.7 years in 2006 to 4.0 years in 2011. Establishing inspection procedures for different types of equipment should be based on a risk assessment. Ganzelmeier

(2012) proposed a European system for assessing the risks of pesticide application equipment that takes into account the extent of damage and its probability of occurrence.

In addition to tractor-mounted and self-propelled sprayers, other types of professional spray equipment also have to be tested, which may cause challenges in establishing effective testing systems in all Member States. Wahlander (2015) highlighted the uneven regional density of sprayers that makes equal distribution of inspection services difficult in the North: in the Netherlands, Denmark and southern Sweden, there is one sprayer per 2 km^2, while in the middle of Sweden this is per almost 1300 km^2 and in northern Sweden up to 2400 km^2. The Finnish density most likely reflects the northern Swedish estimate. Polvêche (2012) noted that in France only approximately 40% of farmers had submitted their sprayers to inspection by 2012, despite having around 250000 field- and air-assisted sprayers in use (Wehmann 2012). Polvêche (2012) described the new French inspection system of teaching centres and certified workshops to conduct the mandatory inspections, and the national database for collecting the information from the inspections. A similar national database exists in Italy, and it is proposed that an EU-wide online database for spray equipment investigations should link the national databases on order to get regular updates on lists of authorised workshops, licensed inspectors, types, identification and condition of sprayers inspected, sprayer owners, etc. (Oggero et al. 2012).

In Norway, a technical function test is compulsory every five years for handheld equipment in greenhouse uses (Bjugstad & Skuterud 2010). In the testing situation, the inspector carries out the test together with the owner of the spraying equipment. In this way, the grower receives increased knowledge and motivation for calibrating the device and performing the application correctly. The authors support the practice of spray equipment owner getting to meet the inspector individually instead of attending a compulsory authorisation course in group, thus getting individually adapted knowledge of the spraying technique and more precise and safer application skills.

Also Bondesan et al. (2012) argued for integrating the testing of spraying equipment and user training during the inspection event. Providing training during the inspection makes the operator aware of the most appropriate drift reduction techniques. Drift reducing equipment are increasingly recommended to reduce the unnecessary environmental load from spraying. Herbst et al. (2012) developed a test procedure for drift reducing equipment in relation to 50%, 75% and 90% drift reduction classes recommended by the German authorities. Their trials show that drift reduction of 99% is even possible in orchards using appropriate and well-calibrated equipment. In Europe, there are also chemicals-industry initiatives to provide professional users with information and training to implement drift and run-off reducing spraying techniques in plant protection (TOPPS Prowadis 2014). Spray drift reducing technologies are in use as a risk mitigation option in Finland as a result of an NAP action, to be presented later in more detail in Chapters 5.4.2 and 6.4 (Tukes 2015d).

Safe storage and disposal of plant protection products is essential to reduce health and environmental risks. The storage and disposal of plant protection products are subject to specific requirements laid down in the Finnish legislation on plant protection products (Hynninen 2012, p. 34-35). Instructions on constructing appropriate pesticide storages on farms have been published for instance by Slocombe et al. (1987). In addition to professional users and retailers, private households may also store plant protection products. In Western societies, Adgate et al. (2001), Grey et al. (2006) and Ahmed et al. (2011) identified storage and usage patterns of pesticides in households. According to Adgate et al. (2001), pesticide products were found in 97% and reported used in 88% of households in Minnesota, with three products per year on average. They did not find any significant differences in residential storage and use patterns between households located in urban versus non-urban locations. In the UK, Grey et al. (2006) reported that over 85 different pesticide products were stored in 76% of homes, with 76 different types of active ingredients. Insecticides were the most commonly used and stored pesticides. Most households reported using one to five different products over the past year, with a mean of 3.5. Therefore, the proper storage of dangerous chemicals is not insignificant in homes either. However, in

these studies it was not stated if the pesticides stored in households were intended for plant protection or for other biocidal uses.

In Asian developing societies, Vijayakumar et al. (2013) and Weerasinghe et al. (2008) highlight that self-poisoning with pesticides is the cause of an estimated 300 000 deaths annually in rural Asia. Weerasinghe et al. (2008) studied rural community acceptance of a variety of different domestic lockable storage devices in Sri Lanka, while in southern India, Vijayakumar et al. (2013) suggested centralised community storage facilities, similar to bank lockers and maintained by the local government in each village, to reduce the likelihood of improper and impulsive use of pesticides for self-poisoning or suicides. As a result, during the study period, storage of pesticides in homes dropped from 44% to 7%, indicating greater awareness of the risks of storing pesticides at home. An inventory of storages of obsolete pesticides in the Russian Federation was conducted and safe disposal was organised in 2001-2012 as a project of the Arctic Contaminants Action Programme (ACAP) under the Arctic Council (Arctic Council 2013).

Since only authorised plant protection products may be used, the products for which the authorisation has expired, are obsolete, and thus subject to *appropriate disposal*. In order to decrease the storage of obsolete plant protection products on farms and by retailers, Tukes provides stakeholders with guidance on the disposal of obsolete plant protection products through an information brochure that is available on the Tukes website (Tukes 2015h). However, no legislative requirement to collect statistics with regard to actual amounts of disposed obsolete pesticides is currently in effect in Finland. Instructions on how to collect information on obsolete pesticides are published by the United Nations Food and Agriculture Organisation (FAO 2010).

2.8. Monitoring progress using indicators

The achievement of quantitative policy targets may be monitored using appropriate indicators. The NAP states that the progress of risk reduction efforts will be monitored using risk indicators, once the EU has agreed on the most appropriate approaches. Sustainability indicators are a field of profound research, with the development and implementation of indicators for governance purposes (e.g. Lehtonen 2008; Rosenström 2009; Herva et al. 2011; Lyytimäki 2012b; Lyytimäki et al. 2014) and, more specifically, indicators for chemical risk reduction (e.g. Jenseit et al. 2005; Sala & Goralczyk 2013). In Finland, a collection of national ecosystem service indicators (Mononen et al. 2016) is available at: http://www.biodiversity.fi/en/home. The website includes more than 110 indicators reflecting the state and development of various components of biological diversity as well as factors driving changes in Finnish nature. Data on the sales and risk indices of plant protection products are also included to illustrate the pressures of farmland biodiversity. The development of indicators for plant protection products has been particularly active for some decades in Europe (e.g. Claeys et al. 2005; Lindahl & Bockstaller 2012; Trevisan et al. 2009; Vercruysse & Steurbaut 2002; Vernier et al. 2013) and worldwide (e.g. Feola et al. 2011; Narita et al. 2014; Nowell et al. 2014; Zhan & Zhang 2013).

Several papers illustrate the difficulties in harmonising the risk indicators. In their review of the NAPs of 28 EU Member States, the Food and Veterinary Office (FVO 2014b, Annex III) invented a broad variety of indicators to measure the achievements of the NAPs. These were classified into categories of activity indicators, indices, outcome indicators for equipment, training and practices, enforcement and monitoring indicators, indicators for IPM and organic farming, indicators concerning the registration of plant protection products, Member State-specific indicators, and positive indicators. Two general types of national PPP risk and impact indicators were distinguished: mathematical models predicting the risk or impact for each active substance, and descriptive

indicators, which are categorical indices of impacts (FCEC 2012 pp. 65-79). *Model indicators* identify the relative importance of various dissipation pathways, and allow for flux densities, concentrations, residence times and exposure, while *descriptive indicators* are quantitative or qualitative indicators that use biologically or ecologically significant threshold levels to define categories of impact, hazard or risk from all actions in place. The advantages and disadvantages of the indicator types are compared in Table 2.2.

Table 2.2. Comparison of the types of PPP risk indicators in use in Europe, based on FCEC (2012).

Type	Model indicators	Descriptive indicators
Advantages	+ Predict a risk (anticipation). + May consider diverse compartments of the environment and human health. + May assess the impact of a single application of PPP. + Rank alternative application options. + Allow for developing several scenarios and sensitivity analysis. + Most indicators consider active substances.	+ Easy to implement. + Easy for general public to understand and communicate. + Easy to understand for actors: good appropriation.
Dis-advantages	- Require significant efforts for implementation (expertise and resources). - Require large data input sets. - Statistics on PPP use only available every 5 years. - Perceived as being a "black box". - Difficult for policy makers and the general public to understand the rationale of the approach. - Limitations of modelling in general. - Easy possibility of misunderstandings, particularly in case of dissimilar models used. - List of pesticide uses differ across MS leading to difficulties in comparing risk perceptions from one MS to another.	- Most descriptive indicators do not take into consideration that PPP may differ considerably in their toxicity to non-target organisms, their rate of degradation and their mobility in the environment. - Considered more as impact/hazard indicators than risk indicators. - May be costly to measure via sampling and monitoring.

Although research and development on environmental risk indicators for plant protection products has been conducted since the 1990s (cf. the review provided by Reus et al. 1999), the deployment of harmonised risk indicators within the EU has been delayed since the adoption of the SUD, and national practices are variable (Autio 2009). Levitan (2000) categorized pesticide risk indicators into three categories by their uses: decision support for farmers, ecolabelling to influence consumers and research and policy analysis tools, differentiated by separate user groups on the basis of their objectives and intended applicability. According to the uses of research in policy-making (Amara et al. 2004), several authors have paid attention to the obstacles of the instrumental use of sustainable development indicators in supporting decision-making for directing environmental policies (Rosenström 2009; Rapport & Hildén 2013; Rinne et al. 2013; Lyytimäki et al. 2013, 2014). Conceptual uses of risk indicators in the training and education of farmers and other professional users towards safer and more sustainable pest management practices have been highlighted for instance by Wustenberghs et

al. (2012), Bürger et al. (2012), Calliera et al. (2013a) and Claeys et al. (2005). Appropriate indicators for the level of IPM uptake are disputed and currently under development in Europe (C-IPM 2015b-c). In assessing the IPM achievements, Germany relies on treatment frequency indices calculated for a set of reference farms (Freier et al. 2015). A Life Cycle Analysis approach was used by Räsänen et al. (2015) to assess the ecotoxicological pressure from plant protection products on surface waters in Finland.

The processes and criteria for selecting the most applicable indicators were discussed by Niemeijer & de Groot (2008a-b), who proposed an explicit, clearly defined framework as an analytical and scientific basis for indicator selection rather than the individual characteristics of specific indicators. More specifically for plant protection products, Capri & Marchis (2011) suggested guidance on selecting risk indicators and quantitative target setting for EU Member States to meet the objectives of the SUD, and Calliera et al. (2013a) described the participatory process of selecting the proposed indicators within the same European research project in more detail. The review of Labite et al. (2011) on 19 ranking tools for plant protection products commonly used in Europe, America and Australia revealed the differences of the indicator models in terms of methods used, purpose, scale of intervention, environmental and toxicity endpoints, functionality and stage of development. Due to the poor correlation between risk ranking systems, it is very difficult to recommend one single risk ranking tool as a reference model. All tools reviewed in this article fulfilled their own objectives. Therefore, the choice of a pesticide risk indicator depends on the specific criteria set by the users.

The OECD has launched an expert group to share experiences with the development, implementation and use of pesticide risk indicators and a common database has been created, and the work continues with the development of IPM indicators (OECD 2015). The European Union is preparing to implement the harmonised risk indicators based on the work of the OECD expert group. Appointed by the Commission, the Dutch research institute Alterra has developed user-friendly software on the harmonised indicators (HAIR2010/2014) for reporting the achievements of National Action Plans and fulfilment of the SUD to the Commission and other Member States (Kruijne et al. 2010; 2014). Before taking decisions about the implementation of potential indicators, their applicability and functioning needs to be tested and users need to be introduced to the software, while Member States also have to plan their procedures for collecting the national usage data to run the models. Finland has recently contributed to the testing of HAIR2010/2014 indicators by Räsänen et al. (2013a) and Kruijne et al. (2014).

3. Philosophical, theoretical and methodological framework of this study

In order to help the reader understand the choices I made for conducting this study, in this chapter I will give an overview of evaluation research as an interdisciplinary practice. I hope it is also useful to enhance the collective learning and capacity building of our NAP community in terms of programme evaluation in general, as it is necessary to sum up and assess various strains of evaluation practice, systems thinking, participative methodologies and philosophical standpoints about the nature of our research object and evaluand, the NAP, before we can take decisions on what kind of evaluations are needed for specific purposes in different situations. Therefore, a somewhat broader approach was chosen for this presentation rather than only expressing my own choices for performing this particular study.

In terms of systems thinking, I consider my study a system of knowledge production distinguishing its boundaries in relation to its scientific environment. In this chapter, my purpose is to position this study in a broader context of interdisciplinary environmental science, research on sustainability, evaluation and systems thinking. Due to the intricate nature of the NAP, I felt it necessary to make my theoretical prerequisites very explicit in order to justify my theoretical and methodological approach into producing my study results as intended outcomes of this purposeful research system, while I appreciate that someone else might choose quite different approaches for his/her evaluation. I hope this monograph can serve as a handbook for such considerations in future.

Niiniluoto (1986) distinguished three categories of research: basic research, applied research and development. Instead of the epistemic utilities of basic research, this study belongs to the domain of development on the basis of its practical utilities, aiming to develop procedures for evaluating the goals of the NAP. Organising the NAP and evaluating its achievements requires collaborative work from several independent institutions, experts and actors to produce and share knowledge collectively, aiming to solve the shared problems. It therefore embodies the Mode 2 type of knowledge production of Gibbons et al. (1994), characterised by knowledge produced in the context of its application, heterogeneity of skills and experience and organisational diversity prevailing between participants, transdisciplinarity, and social accountability and reflexivity in focus. Many of my data sources and references are thus not solely scientific in nature, rather, administrative and lay data have also been used.

A study on a complex policy instrument like the NAP could be performed from perspectives of many different disciplines. My background as an environmental scientist led me to choose the NAP goal of reducing the risks and impacts for the environment as my major standpoint in this work, although some other angles are also examined. My study positions are in the field of environmental science and sustainability research, where my ontological and epistemological view builds on the critical theory, as presented in more detail in Chapter 3.5. Evaluation theory is applied for preparing the evaluation tools for the Finnish National Action Plan, and the data collection and analysis methodologies follow those of participatory action research, critical systems thinking and qualitative methods of social science. Different actions under the NAP follow a range of different disciplines such as agronomy, agricultural technology, education, communication theory, toxicology, ecotoxicology, environmental chemistry etc., and therefore systems thinking is applied as a means for creating an overview and synthesis of the efforts as a whole.

My philosophical preliminary assumptions and the theoretical and methodological framings of this study are included in a multifaceted framework, as illustrated in Figure 3.1. below. The onion-like layered framework illustrates the multiple perspectives included in the theory of evaluating a complex policy programme like the NAP, where the expectations and perceptions of various stakeholders and participants are variable and even contradictory, and substantially shape knowledge production at all levels.

Chapter 3 is organised as follows: environmental science and sustainability research as the interdisciplinary framework for studying complex systems is discussed in Chapter 3.1; programme evaluation theory is presented in Chapter 3.2, which is further divided into three sub-chapters to explain evaluation research as a discipline, procedures and methodologies of programme evaluation, and uses of the evaluations; Chapter 3.3 deals with systems thinking in programme and policy evaluation; in Chapter 3.4, the implications of stakeholder participation and action research in evaluation are discussed, and finally, Chapter 3.5 focuses on the philosophical preliminary assumptions on the interest of knowledge that delineate the ontological and epistemological views on the NAP as my research objective and my paradigmatic and methodological choices of this study. My study approach is an integrating mix of different methods used in several disciplines, as discussed in detail in Chapter 4. As a conclusion, the results to be presented in Chapters 5-9 are organised to follow the research questions along the evaluation cycle, as illustrated in Figure 1.1.

3.1

The philosophical, theoretical and methodological framework

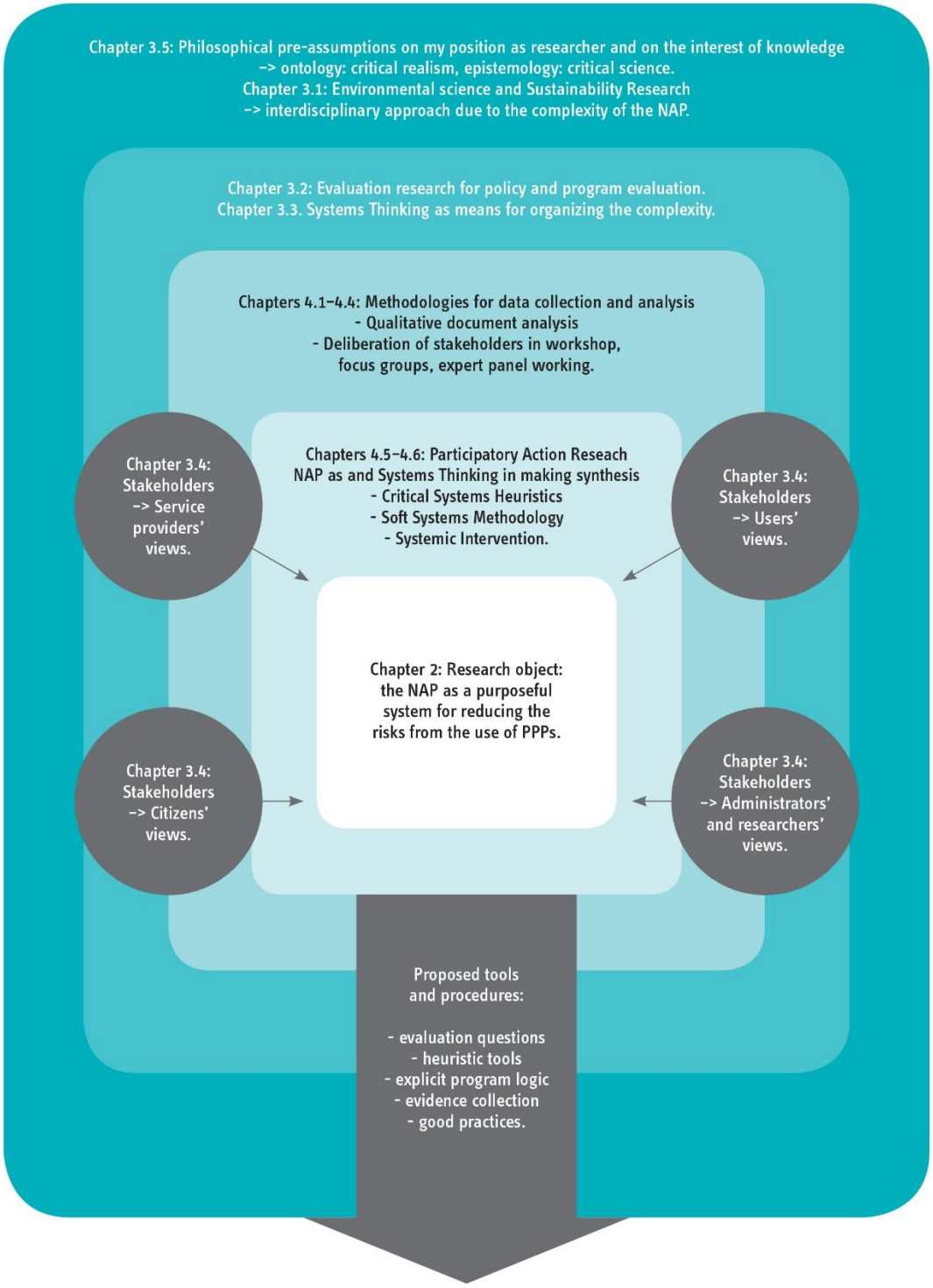

Figure 3.1. The philosophical, theoretical and methodological framework of this study. The chapter numbers refer to respective chapters of this thesis where the issues have been discussed in detail.

3.1. Environmental science and sustainability research as the interdisciplinary framework for studying the NAP as a complex system

The NAP as an environmental policy instrument is a *complex system* constructed in human minds, with the need to reconcile the diverse assumptions and expectations of the stakeholders involved. Waldenfels (1996) offered a view on the ontology of complexity. After Prigogine & Stengers (1984) established the concept of emerging complexity in natural systems, Funtowicz & Ravetz (1994) further developed the idea of complex systems in societal relations, asserting that full analysis of emergent complexity requires dialectical thinking, with contradiction as a key concept. Hardin (1968) highlighted complex, common worldwide problems where no technical solutions are available. While Rittel & Webber (1973) created the concept of "wicked problem" to denote complex policy problems difficult to resolve, Levin et al. (2012) highlighted the even higher complexity of many modern environmental problems as "super wicked".

Sustainability is a normative concept that aims to make explicit the values towards which we hope to move and that advocates for stakeholder participation and empowerment in policy-making (Lee & Stech 2011, p. 182). Since the concept of sustainability was established and developed within the work of United Nations (UN 1987, 1992, 2002a), it has become mainstream in policy discourse worldwide. It has led to the development of criteria and principles for considering sustainability in governmental planning and policy programmes, for which guidance is available internationally (e.g. OECD 2001; UN 2002b). Unfortunately, social and cultural norms vary from one culture to another, thus making it difficult to agree on a common definition of sustainability (Little et al. 2016). Sustainability research is a multidisciplinary environmental science that connects, combines and amalgamates theories and methodologies of research traditions originating from both natural and social sciences (e.g. Bond & Morrison-Saunders 2011; Kates et al. 2001; O'Riordan 1988; Princen 2003; Rockström et al. 2009; Turner 1988). Franklin & Blyton (2011) denoted sustainability research as a normative science that studies the possibilities of maintaining the conditions of life over generations, based on ecological, societal and economical perspectives and that aims to preserve natural resources that are adequate for meeting the needs of future generations.

Complexity calls for interdisciplinarity to integrate diverse knowledge, skills and tools from natural and social sciences in order to the research sustainability (e.g. Klein 1990; Kline 1995; Miller 2004; Osborne 2013; Pohl 2008). Interdisciplinary environmental research tends to have a problem-solving orientation and logic of accountability, while the practice of interdisciplinary environmental research still appears fragmented as a field today (Barry & Born 2013, p. 24-26). Despite the rapid expansion of sustainability science, as illustrated e.g. by Bettencourt & Kaur (2011), Salas-Zapata et al. (2016) revealed that the research programme of sustainability science is still not mature enough to have shared theoretical and paradigmatic assumptions and methodological prescriptions.

There are varying views on how societies could cope with sustainability challenges (Massa 2012). Permanent solutions to environmental problems are rare due to the dynamic complexity of the problems, numerous interacting variables, multiple parties with differing values and inadequate information available, all of which make environmental policy and programme evaluation complicated (Birnbaum & Mickwitz 2009). Turnpenny et al. (2008) highlighted the constraints of integrating policy assessment, while Bruyninckx (2009) requested that programme evaluators engage in interdisciplinary teams to blend social science expertise of the with natural sciences in order to assess innovative governance arrangements and the outcomes of environmental problems as the two are interconnected. Ison (2010) introduced systems thinking as an organised way to deal with and learn from complex situations, and knowledge exchange has been highlighted as important in this sense in many studies. For instance, the increasing use of digital technologies is seen as promising means of sustainable

governance (Larsson & Grönlund 2014). Parr (2009) considered popular culture as the predominant arena of public's enthusiasm for sustainable ways of life, environmental stewardship and social equality, with film and sports stars contributing to a rising interest in the ethics of business practice and shareholder activism.

The NAP consists of several actions belonging to a range of separate disciplines, such as agronomy, education, communication, policy analysis, toxicology, ecotoxicology, environmental chemistry, agricultural technology etc. One actor alone cannot master so many fields. However, they all must be covered in some way when evaluating the outcomes of the NAP as whole. Interpretive policy analysis is applied to explain the interactions and cooperation between the different civil society actors who participate in decision making, recognising the contextual shift from government to governance, where independent stakeholders are involved in policy making (Häikiö & Leino 2014). There is growing acknowledgement that complexity is a crucial issue for understanding the limits and possibilities of concerted human action and that complexity theory has important implications for policy research. The *adaptivity* of a policy system like the NAP refers to steering the policy towards the intended goals during its implementation (Wagenaar 2011, p. 280-282).

Systems theory frameworks, e.g. by Holland (1998), Jackson (2006), Gotts (2007) and Gibbon (2012), are recommended as solutions for increasing understanding and coping with complex systems in different contexts. A systems approach to agricultural sustainability covers economic sustainability as one of its keystones, intertwined with ecological and social aspects (e.g. Dogliotti et al. 2014). The concept of Ecosystem Services has been developed as an attempt to make explicit and value the benefits of ecological sustainability and the cost of disregarding it (e.g. Hauck et al. 2013; Maes et al. 2013; Mauerhofer et al. 2013). Research is currently emerging, for instance within the IPM research, that is concerned with connecting the economic and ecological aspects in the overall sustainability of using plant protection products, as unnecessary applications of plant protection products simultaneously reduce economic profit and increase the environmental load from farming (e.g. Alanko et al. 2013b). Economic obstacles may also limit the fulfilment of sustainability programmes like the NAP. Kajihawa et al. (2014) make a distinction between science *for* sustainability and (inter- and transdisciplinary) science *of* sustainability. This study entails both elements, as furthering the goals of the NAP is the driver of my interest of knowledge, and I simultaneously focus on the success of the policy process included in the NAP.

Giddens (2011) predicted that the huge environmental problems such as the global change will gradually force societies to return to more centralised planning, because the numerous private actors lack power to carry out integrative policies to adapt societies to climate change and more sustainable ways of living. This certainly also concerns the sustainable use of pesticides, where stakeholders' views on sustainability are varied. Therefore, a Community-wide framework directive was considered to be the most appropriate means for obliging all Member States to aim for sustainability in plant protection while allowing the local application of NAPs to consider the varied agricultural, environmental and societal conditions (EU 2009b). Consequently, the policies on sustainability in this field of environmental discourse led the framing of my study more specifically towards the research of environmental policy evaluation.

3.2. Evaluation research

The purpose of this chapter is to illustrate the possibilities evaluation research can offer in terms of assessing the merits of a policy programme like the NAP. Evaluation research is typically utilised for producing knowledge to develop processes and organisations (Seppänen-Järvelä 1999). Raivio (2011) pointed out that decision-makers have to be educated to retrieve and critically evaluate the controversial information about human-induced

environmental change. Therefore, I will first briefly present evaluation research as a discipline in general in Chapter 3.2.1, then I will give a review about the procedures and methodologies of evaluation in Chapter 3.2.2 and lastly, I will discuss the uses of environmental policy evaluations in Chapter 3.2.3.

3.2.1. Evaluation research as a discipline

A great deal has been published on the evaluation of policies, programmes and practices worldwide, with a range of different approaches (e.g. Donaldson & Scriven 2003; Scriven 1991; Shaw et al. (ed.) 2006; Warpenius 2006). Along with the abundant literature, there are a host of definitions for evaluation. A common feature of the definitions is to highlight the judgement of the *merit or worth* of the evaluand, and to position evaluation research within the realm of applied social research by utilising its scientific methods in the process. Clarke & Dawson (1999) explained the primary purpose of programme evaluation as not discovering new knowledge, but studying how effectively existing knowledge is used to inform and guide practical action, thus establishing the value of the programme. Worthen et al. (1997, p. 5) summarised evaluation as an assessment of the extent to which specific objectives have been attained. To some, evaluation encompasses professional judgement, while others equate it with auditing or quality control. Evaluation can be defined as collecting and providing information to enable decision makers to function more intelligently, leading to recommendations intended to optimise the evaluation object in relation to its intended purpose(s).

Mäntysaari (1999) and Scriven (2003) defined evaluation research as transdisciplinary research that produces tools for knowledge users, such as political decision-making or other sciences, and it is therefore comparable to statistics or mathematics, for instance. The requirements of specific cases to be evaluated then influence the forms and methodologies to be used in each specific evaluation. Programme-theory-driven evaluation science is the systematic use of substantive knowledge about the phenomena under investigation and scientific methods to improve, to produce knowledge and feedback about, and to determine the merit, worth and significance of programmes, where the performance of an evaluation proceeds along the steps of evaluation practice, as presented earlier in Figure 1.1 (Donaldson & Lipsey (2006).

Chelimsky (2006) gave an overview of the development of the fields of programme evaluation. A first strand of evaluative development in the USA can be traced back to the early 1900s, when *evaluation of agricultural practices* was expected to increase crop yields, and experimental design and statistical analysis were applied for the evaluation. In 1950s-60s, demonstration programmes in *education and public health* were set up and carefully evaluated responding to government efforts to examine the effectiveness of social programmes in moving people out of poverty or reducing crime. This path of evaluation drew on learning from a wide array of fields, including psychology, sociology, economics, political science and anthropology. Another strand of evaluation was directed at rationalising resource allocation and the management of *defense* programmes, with methods including cost-effectiveness and cost-benefit analysis, political science and systems analysis.

Evaluations have traditionally been conducted within the fields of *educational and social practices* (e.g. Biggs & Tang 2011; Johnson et al. 2004; Kirkpatrick & Kirkpatrick 2006), but the domains of evaluation needs are expanding rapidly, also including *environmental and sustainability policies* (Crohn & Birnbaum 2010; Mark et al. 2006). The demand for evaluation has increased enormously after the management by results was put into operation in public administration (Vedung 2004). Recently, policy plans and programmes have spread to all fields of society, and the needs to evaluate their legislative, executive and judicial accountability are increasing, thus supporting the building of knowledge bases and oversights for the decision-makers and the public. Hatry (2013) emphasised that programme evaluation and performance measurement have different but basically complementary purposes.

The purpose and utilisation of an evaluation defines its type (Rajavaara 1999). Two basic distinctions can be made in programme evaluation: formative and summative roles of evaluation. *Formative* evaluations are conducted to provide programme staff with evaluative information that is useful in improving the programme. *Summative* evaluations are conducted and made public to provide programme decision makers, funders and potential consumers with judgements about the programme's worth or merit in relation to important criteria, for instance to determine whether the programme should continue or be terminated. The characteristics of formative and summative evaluation can be summarised as presented in the Table 3.1, as compiled based on Clarke & Dawson (1999, p. 8) Chen (1996, p.47-48) and Worthen et al. (1997, pp. 14-20).

Table 3.1. The characteristics of formative and summative types of programme evaluation.

	Formative evaluation	**Summative evaluation**
Target audience	Programme managers, service providers, programme staff	Policy-makers, funders, public
Role of evaluator	Interactive; often internal programme staff	Independent, external
Timing	Typically in early stages of a programme's development	Typically in later stages of a programme's development
Aims	Ascertain whether changes are needed in the programme design	Determine the overall effectiveness of the programme
Orientation	Action-orientated, provides information during the process, improvement	Conclusion-orientated, success indicators, summarises outcomes
Focus on data collection	Clarification of goals, nature of implementation, identifying outcomes	Implementation issues, outcome measures
Methodology	Quantitative and qualitative (emphasis on qualitative)	Emphasis on quantitative
Frequency of data collection	Continuous monitoring	Limited
Reporting procedures	Informal via discussion groups and meetings	Formal reports
Frequency of reporting	Throughout period of observation / study	Upon completion of evaluation
Strategy	Supports process improvement	Determines effectiveness, assesses outcomes

3.2.2. Procedures and methodologies of programme evaluation

Evaluation research is a purposeful action and requires its own procedures. Shadish et al. (1991) reviewed the historical development of programme evaluation methodologies. In the 1960s, programme evaluation theorists were more interested in summarising the achievements of existing programmes for public sector policymakers than in collecting data to help practitioners at local level. Their greatest interest was in evaluating demonstrations of new ideas that might be incorporated into existing or new programmes. Over time, evaluation theories diversified to reflect accumulating practical experience. Exclusive reliance on studying *outcomes* yielded to inclusive concern with examining the *quality* of programme implementation and the *causal processes* that

mediated any programme impacts, and qualitative methods were put into operation with quantitative methods in 1970s. Using policymakers as both the source of evaluation questions and the audience for the results yielded considering multiple stakeholder groups in the 1980s. Concern over methodology gave way to concern over the context of evaluation practice and to fitting evaluation results into highly politicised and decentralised systems. By the 1990s, modern evaluation theories covered more topics, had a better sense of complexity, and better integrated the diverse concepts, methods and practices. Later, Dahler-Larsen (2006, p. 152) continued that *theory-driven evaluation* (e.g. by Chen 2005) had attracted a considerable amount of interest because it has helped revitalise the scientific element in evaluation via critical thinking and reality-testing of assumptions. It offers a demarcation for evaluation based on scientific work from other processes found in the context of evaluands, such as discussions, negotiations, and development processes. One of the specific strengths of theory-based evaluation is that it combines a conceptual interest in social processes and programme mechanisms with an understanding of outcome measures. One of its practical implications is therefore to suggest how the selection of performance indicators can be improved based on relevant programme theory. Theory-based evaluation has also demonstrated the mutual benefits between evaluation and social science in evaluating programme theories across sites, contexts and policy areas.

Chen (2005, p. 16) defined *programme theory* as a configuration of the prescriptive and descriptive assumptions held by stakeholders on how a programme is supposed to work. It can be understood as a logic model of a causal chain of plausible and sensible assumptions concerning the resources, activities and intended outcomes linked with the ultimate goals of a programme. The terms programme theory and logic model (programme logic) are often used interchangeably, but the two serve separate purposes. A logic model is a graphical presentation of the relationship between the activities and the expected outcomes to highlight the programme components such as inputs, activities, outputs and outcomes in order to make the assumptions of a programme theory visible. Mickwitz (2006, Table 3 on page 34) summarises the key elements of an intervention (policy or programme) theory: target groups, whose actions the policy is intended to influence; outputs as assumptions about what should be produced and that the target groups are faced with; inputs supposed to produce the outputs; and outcomes as actions expected and consequences believed to follow from implementing the intervention. These vital elements are at the core of my work as well. Pawson's (2002) realist synthesis approach to evidence-based policy evaluation includes a review methodology on how programmes achieve their effects (causation), a list of vital ingredients of programmes that are actually working (ontology) and knowledge transfer about lessons learned in a programme to inform future policies and practices (generalisation).

Systemic evaluation blends three different approaches to evaluation within a methodological framework drawn from a branch of systems theory known as Critical Systems Thinking (CST, see e.g. Ulrich 2000). Emphasis is placed on the need for stakeholder participation, dialogue on the boundaries of evaluations considering multiple values and ensuring that marginalised people and issues are properly accounted for. Systemic evaluation intends to broaden the scope of an evaluation beyond a narrow view based around monitoring the achievement of pre-set goals towards a more *participative*, flexible and responsive practice, where multiple values of stakeholders and organisational processes would be considered to support *capacity building* in the evaluation (Boyd et al. 2007). Wasserman (2010) created a systems orientation to enhance theory-driven programme evaluations and logic models, and van Ongevalle et al. (2014) demonstrated how actor-focused evaluation approaches can help manage complex processes of social change by stimulating processes of results-based learning. Jacobs et al. (2012) asserted that without enforceable behavioural consequences for norm adherence (e.g. understood sanctions like legislative or monetary penalties, social rejection of peer community), little change occurs in instrumental action and governance in translating the awareness to actual change in the behaviour of the participants in environmental information/education programmes.

Simons (2006) highlighted the ethics in evaluation: the choice of methodologies has political implications, and thus an evaluation cannot be free from values, but instead must strike a balance between various stakeholders' mutually conflicting principles. A stakeholder evaluation can lead to setting community-sensitive goals, the achievement of which can be measured through goal-based evaluation, and the pursuit of the goals can be enhanced by organisational evaluation. *Empowerment evaluation* (Fetterman et al. (eds.) 1996; Fetterman 2003; W.K. Kellogg Foundation 2004) aims to help participants evaluate their own performance. Compton & Baizerman (2012) and VeLure Roholt & Baizerman (2012) suggested how a shared understanding can be gained by using Evaluation Advisory Groups or Committees in project evaluation, as well as the skills and knowledge participants and their facilitator should have to successfully create and manage the evaluation process.

Practical methodological decisions on conducting evaluations depend on who and how the findings will be used, what kinds of information is needed, when the information is needed and what resources are available for conducting the evaluation (Royse et al. 2010). Evaluators encounter the problem of choosing between *quantitative* and *qualitative* methods of programme evaluation (e.g. Hockings et al. 2009; Margoluis et al. 2009; Worthen et al. 1997, pp. 341-370). Quantitative methods use standardised measures that fit into predetermined response categories, measure the reactions of a large number of people to a limited set of questions and facilitate comparison and aggregation of data. Qualitative methods typically produce a wealth of detailed data about a much smaller number of people and cases, provide depth and detail through direct quotation and careful description of situations, events, people, interactions and observed behaviours without attempting to fit them into predetermined, standardised categories (Patton 1987). Quantitative measurement means designating for an object a quantitative value, index number, and then metrising it using different measurement functions. The index numbers are then subsumed to an unambiguous scale for measuring the term (Niiniluoto 1980). However, Latour (2005, p. 228) asserted that even measurements and metrology are social conventions presenting themselves as metrological networks.

Although Chelimsky (2006, p. 35) considered determining accountability as one of the main purposes of programme evaluation by performing studies that measure effectiveness or efficiency, evaluation literature constantly highlights the difficulty of reliably evaluating the cost and benefits or effectiveness of policy programmes, as evaluators are very seldom experts on econometrics (e.g. Clarke & Dawson 1999, p. 142-145; Royse et al. 2010, p. 255-270; Worthen et al. 1997, p. 361-364). In theory-driven evaluation, Chen (2005) highlighted the importance of making explicit the resources available for carrying out the intended interventions of a programme. Cost-effectiveness or cost-benefit might be of interest to recover the accountability of measures in a programme like the NAP. Cost-effectiveness or cost-benefit analysis can quantify the costs and benefits of a programme into a single ratio, and may therefore be attractive for evaluative purposes. However, cost-effectiveness methodology is not uniform, making it difficult to make generalisations across studies that examine similar interventions (Rizzo & Fortune 2006). In social and environmental programmes, the outcomes can be rather abstract and not necessarily easy to measure. When examining costs and programme outcomes, the analysis should be called "cost-effectiveness" if the outcome variables are not measured monetarily (Royse & al 2010, p. 264).

3.2.3. Using the evaluations of environmental policy instruments

The challenge in evaluation is getting the best possible information to the people who need it, and then getting those people to actually use the information in their decision making. Worthen et al. (1997, p. 78-79) characterised alternative approaches for programme evaluation from the point of view of different users, whether objective-, management-, consumer-, expertise-, adversary- or participant-orientated. Different types

of uses for evaluation results may also be distinguished: instrumental uses are associated with direct decision making on policy change based on the evaluation. Persuasive uses aim at some kind of personal gain, for instance to persuade the funders of the programme achievements. Conceptual uses affect the thinking of the policy-shaping community indirectly and cumulatively, for instance by drawing attention to critical issues. Symbolic uses of an evaluation are other than those originally intended, for instance drawing from an existing programme evaluation to prepare a new proposal. (Amara et al. 2004; Worthen et al. 1997, p. 431-432).

Many studies agree with the claim that interactive knowledge making in environmental policy evaluation increases the likelihood of evaluations actually being used and improves the accountability and credibility of assessments. Interactive approaches are also consistent with changes in the modes of knowledge production, which have made science more socially implanted and more closely tied to contexts of application (Jasanoff 2003). Environmental policy evaluations produced or commissioned by the actors and innovation champions within the policy arena are most likely actually used, whereas detached policy evaluations often show that the information produced has not been used (Hildén 2014).

Mickwitz (2003, 2006) argued that environmental problems and policies have several specific characteristics that have to be considered in evaluating environmental policy instruments. In the jurisprudential literature, for instance, effectiveness, cost efficiency, dynamic efficacy, equity, democratic decision making, significance, foreseeability and flexibility are criteria that are often considered important for the functionality and efficacy of environmental legislation (Similä 2002), thus framing the prospective uses of evaluations. Versatile criteria most likely reflect real needs better than using only a few criteria in the evaluation. Mickwitz & Birnbaum (2009) identified the following four issues that need to be addressed when improving the quality of environmental programme and policy evaluation: first, framing the evaluation requires consideration in choosing the focus, identifying the purpose of evaluation and the stakeholders involved; second, the limits of establishing causality should be recognised while maintaining counterfactual thinking; third, more effort is needed to increase the usefulness of evaluations for various stakeholders; and, fourth, continued deliberation and community building is required. Frondel & Schmidt (2005) proposed experimental studies with randomised assignment to be considered for evaluating the efficiency of environmental policy programmes, and recommended that regulators and users should work more closely with researchers even at the stage of designing the interventions. The time horizons for environmental policy evaluations must be based on an understanding of the dynamics of the processes that the policy is intended to affect (Hildén 2009).

Jabbour et al. (2012) evaluated the progress of internationally agreed sustainable development strategies and policies, and found patchy achievements rather than sustained progress. The most encouraging evidence of progress was identified in areas where measurable targets were established for problems with relatively straightforward causes and courses of action. In terms of the internationally agreed goals related to chemicals and waste, only one of the 23 goals evidenced significant progress. The lack of information is of paramount concern to achieve better management of hazardous chemicals. Although there is a growing body of scientific knowledge on the impacts of chemicals and wastes on human health and the environment, this knowledge still remains incomplete due to limited data on uses and exposure pathways. The results suggest that long-term monitoring programmes should be maintained and expanded to fill this data gap.

Recent examples of environmental policy evaluations in Finland are for instance the Finnish National Biodiversity Action Plan 1997-2005, evaluated by Auvinen et al. (2007), and the Finnish National Programme for Sustainable Consumption and Production (SCP), with comparison to its Swedish and British counterparts by Berg (2011). Berg & Hukkinen (2011) distinguished different categories of uses of the Finnish SCP programme, as scripted, deliberative, political, ritual and unprompted uses. Scripted uses refer to the actual implementation of action proposals as planned. Deliberative uses cover for example discussion, participation, learning and commitment

to the programme. Political uses promote certain agendas to prepare the ground for future changes. Ritual uses highlight the symbolic value of the actions, and unprompted uses include unanticipated side effects that the process has catalysed, but that are not directly linked to the programme. Unfortunately, there is little evidence of the actual political impact of citizen participation in science and technology governance processes so far (Rask 2013).

Furthermore, Finnish experts have recently participated as co-evaluators in a few projects to evaluate the chemicals policies of other countries, attempting to enhance the good practices and transparency of governance that enable citizen participation in the public discussion on chemicals management. The OECD has recently carried out evaluations of the environmental performance of the Austrian and Colombian governments, highlighting their chemicals management (OECD 2013a and OECD 2014). Koëter et al. (2013) evaluated the scientific process, the scientific output and the decision-making process of the Netherlands Board for the Authorisation of Plant Protection Products and Biocides (CTGB) at the request of the Parliament of the Netherlands. As an example of the reflexivity from the audience, the Dutch evaluation was disputed by Pesticide Action Network Europe, a non-governmental organisation campaigning against chemical pesticides (PAN 2013).

3.3. Systems thinking in programme and policy evaluation

This chapter discusses the possibilities of systems thinking in performing practical evaluations of environmental policy programmes like the NAP. "System" is defined by Flood & Carson (1988, p. 7) as a situation where an assembly of elements is related in an organised whole, capable of behaviour such that they have some significant properties that may change. Relationships between elements may be flows of materials, information or energy, and can help us to distinguish a system from its environment, thus defining the boundaries of the system. The authors reviewed the origin and evolution of Systems Science as a *means for dealing with complexity*, with the dichotomy of Hard and Soft Systems Thinking. While hard systems are denoted as concrete "real-world applications" and rely on mathematical modelling (e.g. in engineering), soft systems are constructions in the human mind and thus less visible (e.g. organisations or plans). Both strands of systems science have developed a range of specific methodologies and practices to reflect on the specific characteristics of the systems to be examined.

The NAP, being a mental structure, typically falls under the category of soft systems. The soft systems methodologies are therefore appropriate for exploring the NAP. Systems thinking researchers argue that purposeful social systems are inevitably value-*full* instead of being value-*free*, striving for pre-defined goals and improvement, and thus have ethical dimensions (Ulrich 1994; Midgley 2000). For instance, Bawden (2012) highlighted the importance of making explicit the values of sustainability in any action in agriculture, farming, agricultural research and extension that aims to be right, good and proper. Pohl (2014) considered systems thinking methodologies in transdisciplinary sustainability research as promising *heuristic tools* that link scientific knowledge production and societal problem solving in a process of co-producing knowledge that lead from complexity to solvability. Systems thinking has been influenced by interdisciplinary science studies and has produced practical solutions in planning and management. Practical applications of systems thinking in programme and policy evaluation have been used for instance by Chen (2005) and Wasserman (2010). Originally based on the ideas of Critical Systems Thinking, Boyd et al. (2007) developed a participative multi-method model for evaluation practice, called Systemic Evaluation.

Jackson (2003) provided a typology of systems methodologies. According to his classification, some core features of four types of soft systems thinking are briefly described below as promising tools for programme evaluation. Although the theoretical approaches of these methodologies are somewhat different, they share the idea of examining a problem situation of a complex societal system in a holistical way. The first of the methodologies used in this study, *Soft Systems Methodology* (SSM) originally developed by Checkland (1981, 1988, 2010), belongs to Jackson's Type B, encompassing systems approaches specifically aimed for exploring purposes and highlighting effectiveness. The philosophical foundations of SSM rely on hermeneutic, interpretative paradigm. SSM manages a richly unfolding set of relationships instead of taking straightforward rational decisions to achieve the goals, contrary to the "hard" systems approaches such as operational research, systems analysis or systems engineering, which belong to Jackson's Type A systems approaches. SSM is widely used today in a variety of managerial and organisational settings (Checkland & Scholes 1991; Checkland & Poulter 2010; Reynolds & Holwell 2010a-b).

The second systems thinking approach used in this study, *Critical Systems Heuristics* (CSH) developed by Ulrich (1994, 2000; Ulrich & Reynolds 2010), belongs to Jackson's Type C, aiming to ensure fairness, with empowerment and emancipation as its measure of success. The philosophical foundations of CSH build on a purposeful systems paradigm arising from the Habermasian view of rationality that emerges from dialogue. CSH polemically redraws the boundaries of the system so that it comes to serve all its customers, including those affected but not involved, thus extending the interpretative to emancipatory paradigm and demanding that attention be given to disadvantaged stakeholders. It is applicable in multiagency situations where it is important to secure the commitment of all parties.

The third and fourth systems thinking approaches from which I drew methodological ideas for this study both belong to Type D, promoting diversity as their philosophical foundations. *Systemic Intervention* developed by Midgley (1997, 2000, 2003, 2010) has concerns about paradigm incommensurability and calls for creativity, methodological pluralism and multiple perspectives in order to tackle complex problems. *Critical Systems Practice* by Jackson (2000, 2003, 2006) is committed to critical awareness, improvement and methodological pluralism. It holds that paradigms critically confront one another in reflective conversation, and views the problem situation from the perspectives of different paradigms. Ison (2010) outlined the Critical Systems Practice as a tool for guidance on how to build practices of thinking and acting that move from systemic understanding to action in complex situations.

Chisholm & Elden (1993) discussed the links between systems theory and the action research performed in organisations at increasing levels of complexity, from groups of individuals to organisations and societies. Because emergent features of groups develop as the systemic level increases, the complexity of the research and change process tends to grow as the system level rises above the single group. Systems at lower levels will have a shorter, more defined time perspective on research and change than those towards higher levels. The level of the focal system thus makes a substantial difference in conceptualising, designing, implementing and evaluating specific action research efforts. Different authors have applied systems thinking methodologies as means of *organisational and collective learning* in different contexts, e.g. Blackmore (2010a-b) in agriculture, Schön (2010) in government administration and Senge (2006) in business management. Bawden (2010) explained the experiences from the use of systems methodologies and its implications for learning in agricultural education at Hawkesbury Agricultural College in Australia since the 1970s. Farming systems research is an approach for examining sustainable agriculture that takes the agroecosystems into account holistically (Darnhofer et al. 2012).

While some criticism has emerged on the effectiveness of environmental education programmes as a conclusion of their evidence-based evaluations (Flowers 2010; Monroe 2010), Sieber (2011) considered systems theory and constructivism as promising background theories for systemic thinking in an interdisciplinary model of

communicating sustainability. The concept of feeling-thinking appeared to be promising for environmental education programmes to promote sustainable behaviour by connecting cognition and emotion with the construction of reality through language in the sustainability discussion, where systemic ecological thinking finds a touchpoint with systemic therapy and systemic pedagogy.

3.4. Stakeholder participation and action research in evaluation

Geurts & Joldersma (2001) explain a policy network as independent relationships between actors that are involved in policy making regarding a policy problem. They assert that policy networks are hard to govern because the actors involved show self-governing characteristics driven by their internal laws, as policy programmes result from complex interaction between different stakeholders each seeking to influence the collectively binding decisions that have consequences for their interests. Independent actors develop and shape their mental models by learning-by-doing as reflective practitioners, as described by Schön (2010). Hukkinen (2008) emphasised the empowerment of stakeholders to be considered as experts of sustainability within their own disciplines as a means for composing a holistic view of sustainability in an interdisciplinary collaboration. Collective learning also engages the participants in striving for jointly defined goals like evaluation of their practice (Newton & Parfitt 2011).

Divergent forms of practical applications of *action research* have been developed since Kurt Lewin (1946) first coined the term, and ample literature has been published on it, for instance by Heikkinen et al. (1999, 2010c), Reason & Bradbury (2008), Smith et al. (2010) and Toulmin & Gustavsen (1996). Costello (2003, p. 7-9) and Townsend (2013, p. 12-13) characterised action research as a flexible, spiral process of enquiry, which has a practical, problem-solving emphasis and is carried out with participation from individuals, professionals and educators in a variety of settings, in order to improve existing practices. It involves research, systematic gathering and interpretation of data and action aimed at improvement. Action is undertaken to understand, evaluate and change the practices that are intended to be improved. Critical self-reflection involves reviewing the actions undertaken and planning future actions. The approach of action research is thus cyclical and continuous (van Beinum et al. 1996). Action research has been used in a range of different settings, from single school classes (e.g. Costello 2003) to industrial working places (Ledford & Mohrman 1993; Greenwood et al. 1993), and from local greenhouse enterprises (Vänninen 2012) to national (Engelstad & Gustavsen 1993) and international policy organisations (Brown 1993). The application of action research could be useful in organisational change and development (OD) towards sustainable practices. From its original focus on discrete teams inside one organisation, action research applied to work is moving to engage large numbers of participants, involving gatherings of people from all over the world and engaging them virtually through the web or teleconferencing (Bradbury et al. 2008).

Participative approaches to evaluation are more likely to ensure the actual use of evaluation outcomes by those involved in the programme implementation. Different approaches to stakeholder participation in knowledge production and its implications for research methodologies are therefore considered here. Participative processes of enquiry have intrigued many researchers in social sciences in general (e.g. Elden & Chisholm 1993; Toulmin 1996), and more specifically in sustainability research (e.g. Bell & Morse 2005, 2007; Lehtinen 2014; Paavola & Hubacek 2013; Ramos et al. 2014). Participative methods are increasingly applied (e.g. Charnley & Engelbert 2005; Geist 2010; Kaufman et al. 2014) in environmental planning (e.g. Kopperoinen et al. 2014; Malinga et al. 2013; Sager 2009) and in policy and programme evaluation. Lee & Stech (2011) argued that

sustainability itself implies involvement and bottom-up rather than top-down processes of policy development, where changes towards pro-environmental behaviour are more likely if internal and external influences work in combination. As changing behaviour is the most stubborn obstacle to progress towards sustainability, policy-makers need the attitudinal, behavioural and qualitative research expertise of social scientists to gain an understanding of the complex determinants of behaviour and explanations of why specific policy interventions do and do not work as intended (Roberts 2011). Reid & Frisby (2008) recommended collaborative processes to be considered in all enquiries into action plans, to build intersectional relations across genders and other markers of difference. Cheney (1989) appreciated the role of feelings, values, attitudes and emotion in researching multiple and plural knowledge of environmental ethics. Gaventa & Cornwall (2008) pointed out that consensus can all too easily masquerade as common vision and purpose, blotting out difference and with it the possibility of more pluralist and equitable solutions. Attention should be given to the position of those who participate, and what this might mean in terms of the versions they present. Great care must be taken not to replace one set of dominant voices with another, all in the name of participation. Gergen & Gergen (2008) recognised advocacy as the conflict of goods of different stakeholders, and supported significant efforts to generating a context of mutual trust.

Elliott (2006, p. 173) described the major components of participatory learning and action as a triangle consisting of the behaviour and attitudes of the participants, the methods and tools to be used and of the process of analysis and sharing. The epistemological grounds of participatory action research (PAR) are different from those of positivistic (natural) sciences, as their assumed objectivity and distancing of the researcher from the researched object is not appropriate in participatory action research, where the researcher and participants are producing the knowledge collaboratively (Toulmin 1996). Kuula (1999) highlighted the binding force of change in action research, but also identified obstacles that make the eligible change sometimes difficult to achieve and thus may cause confusion for the participants.

In his review, Dick (2010) explains the link between action research and soft systems methodology, calling for action researchers to have capacity for systemic thinking. The concept of collective learning by action research is presented by Ison (2010), who calls the process Systems Practice, and by Ulrich (2000) as Critical Systems Thinking (CST). Soft Systems Methodology (SSM) was developed by Checkland following a range of action research projects for tackling complex problem situations that were based on and embodied new thinking (Checkland 2010). In the action research approach, the researcher takes part in the problem-solving situation as an accountable participant. In these situations, people have different ways of seeing and interpreting the situation (worldviews), and they nevertheless contain attempts to take deliberate, intended, well-thought-out purposeful actions. Despite the deviating worldviews of the participants, it is possible to explore a system of organised process of learning as a complex flux of interacting events and ideas which unfolds over time to bring about improvement (Checkland & Scholes 1991).

Programme evaluation can be performed in a participatory way (Cousins 2003). Rogers & Williams (2006) discussed action research as an approach of evaluation and a technique for practice improvement that share a parallel and often interconnected history with organisational learning ideas. Participatory evaluation (PE) assumes that the beneficiaries are the best judges to evaluate the effects of programmes in which they participate (Swantz 2008). Dahler-Larsen (2006), however, finds it problematic, that the representative democratic dimension among stakeholders is neutralised in some participatory, constructivist and utilisation-focused forms of evaluation practices, where politicians are considered either too remote to be involved or are only one stakeholder among many within the context of a given set of involved stakeholders, because the mere sum of stakeholders does not constitute a society in general.

The empowerment evaluation practice fosters improvement and self-determination of programme participants by self-evaluation and reflection. Contrary to external programme evaluation where programmes have been given grandiose long-term goals that participants could only contribute to in some indirect manner, programme participants are empowered to determine their own strategies to accomplish programme goals and objectives that are directly linked to their daily activities through brainstorming, refining, critically reviewing and consensual agreement processes (Fetterman 2003, p. 71).

3.5. Philosophical assumptions on the interest of knowledge

Philosophical assumptions are used to justify what can be considered valid or legitimate practice (Midgley 2000, p. 22). This chapter deals with the preliminary assumptions that guided me as a researcher in planning this study. Again, unfolding the different worldviews of stakeholders may contribute to the interests of knowledge and the methodological choices of future NAP evaluations, and therefore a general presentation is given first instead of simply stating my own choices for this study. I first give a short overview about different ontological and epistemological views on which to base my own standpoint in Chapter 3.5.1, and then make my own paradigmatic and methodological approach explicit in Chapter 3.5.2.

3.5.1. Ontological and epistemological views on the NAP as research object

Ontology is a branch of philosophy that deals with conceptions about the nature of reality. Methodologically, human action as a research subject dissociates significantly from natural science research subjects, because causal explanation is not appropriate for analysing intentional behaviour; rather, humanistic and social sciences aim at a teleological understanding of human actions and historical events from their goals (von Wright 1984). In natural sciences, the research objects are typically concrete things that can be physically grasped and thus support ontological realism, whereas in social sciences such as policy analysis or soft systems thinking, the reality is largely perceived as socially constructed, merely embedded in our language to define our understanding on key concepts of 'risk', 'knowledge', 'research', 'system' or 'National Action Plan', thus making space for multiple worldviews (Forester 1989). Therefore, it is assumed that there are as many conceptions for this kind of research object as there are human beings, who construct their realities in terms of activities (Szerszynski et al. 1996). With a functional, intentionally goal-orientated view of science, the philosophy behind sustainability research and action research can be seen as *teleology*, because of their explicit commitment to improvement (Hawthorne & Nolan 2006). Teleology tends to analyse and explain the final causes and goals of processes and happenings, as well as ways to achieve those goals. Intentional behaviour can only be understood if we are aware of the actor's own conscious aims and beliefs (Niiniluoto 1983, pp. 253-263).

The ontological view of reality in turn dictates the *epistemological* perception of the nature of the knowledge to be produced, thus giving rise to methodological choices (Midgley 2000). Paradigm is the philosophical view or basic belief system that grounds the theories and methodologies chosen by the researcher (Guba 1990). Although not always expressed explicitly, the paradigm directs the researcher and the enquiry deliberately or unconsciously (Molander 1998, p. 103-104). Depending on the purpose and design of the enquiry, the researcher needs to take decisions on the paradigm that best accommodates his or her research aims and own worldviews in particular (Lincoln 1990, p. 78). While natural scientists are usually confined to the positivist paradigm as originally presented by Thomas Kuhn (1970), within social sciences there are divergent views and thus a state of

multiple paradigms that move beyond the considerations of a single research methodology, contributing to a dialogical, reflective discourse about the variety of available research logics and paradigmatic perspectives (Skrtic 1990). Some authors have argued that paradigms are in dialectical interaction in research practice and can be accommodated by practical needs (Firestone 1990; Inayatullah 1990). In the epistemological framing of complex dynamic systems, Contini (2013) argued for the recognition of contradictions and uncertainty as the building material of a new paradigm that will necessarily be open and complex. Galtung's trilateral science (1977, pp. 62-63) sought means for obtaining consonance between the preferred, foreseen and observed realities. Applications of these three levels of epistemology have been introduced into interdisciplinary research by Kuitunen (1988), Tapio (2002), Tapio & Hietanen (2002) and Willamo (2005), for instance. Mikkeli & Pakkasvirta (2007) highlight that interdisciplinarity is not necessarily a separate method or discipline, but rather a viewpoint on the research object, and therefore it is not appropriate to depend on the reasoning of only one single paradigm in interdisciplinary research.

Isaac & Michael (1990, p. 3) made a theoretical distinction between an experimental research study and an evaluation study, stipulating the consideration of study design accordingly. While the purpose of a research study is to gain new knowledge based on the impetus of curiosity, an evaluation study focuses on mission achievements based on specific needs and goals. The value of a research study is its explanatory and predictive power, whereas worth and social utility determine the value of an evaluation study. The paradigms of a research study and an evaluation study are therefore essentially different, where a research study features experimental or correlational methods, while an evaluation study has either a systems approach or objectives approach. Evaluation research has been based on different epistemological views by different authors. For instance, Scriven (1998) called for a practical approach with a minimalist theory dealing with the core concepts of evaluation, while Trochim (1998) defended a theory-driven evaluation.

Shadish et al. (1991, p. 42-44) summarised three knowledge components of an evaluation theory: *1) Key priorities of the issues to be evaluated*: is there anything special about the knowledge the evaluators are constructing, and how do they construct such knowledge? 2) *Knowledge bases* describing the ontology, meaning the ultimate nature of reality; the epistemology that explains the nature, origins and limits of knowledge, its characteristics and standards for its internal validity; and the methodology that describes the techniques for constructing such knowledge. 3) A better *theory of knowledge component* addresses the ontological, epistemological and methodological elements. It recognises that no paradigm of knowledge construction is best because significant difficulties plague all epistemological and ontological approaches. It also recognises that in methodology, all methods are not equally good for all tasks, so the strengths and weaknesses of methods must be defined according to specific purposes, and because no method is routinely feasible and unbiased, no study is free from flaws. Finally, the theory helps evaluators prioritise the kinds of knowledge to construct, how much uncertainty reduction is needed and what methods to use given the available tasks and resources.

Worthen et al. (1997, p. 68-74) highlighted the methodological differences caused by different philosophical assumptions about knowledge and value in qualitative and quantitative evaluations. Building on the ontological belief about the nature of reality and existence, a positivist evaluator tends to prefer quantitative methods, whereas a constructivist evaluator relies on qualitative methods. However, this dichotomy is rather artificial and not so clear in practice, and today mixed-method designs are common in programme evaluations. Evaluation questions are set by clients' needs and might be framed so as to require tools from several disciplines to answer them, thus requiring a certain degree of flexibility in methodologies.

Critical theory was originally developed by the Frankfurt school, especially by Jürgen Habermas (1987; Huttunen 2010), and later applied to action research (e.g. Heikkinen et al. 2010a, p. 40-48; Huttunen & Heikkinen 1999; Popkewitz 1990). The goal of critical theory is to produce liberative, emansipatory knowledge for a

communicative discourse, where participants aim to improve the problem in question. The emancipatory interest of knowledge has a derivative status. It guarantees the connection between theoretical knowledge and an 'object domain' of practical life (Habermas 1987 p. 371). Kemmis (2008) drew a connection between action research and the critical theory as having practical and emancipatory aims to achieve effective historical consciousness in and of practice as praxis, critical self-reflection, opening communicative space and transforming the social construction of their practice. The Habermasian epistemology of the emancipatory knowledge-constitutive interest and communicative action constitute a foundation for action research as connective factor between science and practice (Raunio 1988, p. 15). In programme evaluation, Ahonen (1999) advocated the "critical", "empowering" and "participatory" qualifiers as democratic practices of society, improving the accountability of the programmes and projects for the public and the promoting deliberative democracy.

Some authors assert that the participants and not only the researchers may influence the methodological choices of research. Post-Normal Science (Funtowicz & Ravetz 2003) links epistemology and governance of complex science-related issues, focusing on aspects of problem solving that tend to be neglected in traditional accounts of scientific practice: uncertainty, value loading and a plurality of legitimate perspectives. It provides a coherent framework for extended participation of peers in decision-making, based on the new tasks of quality assurance of science and policy. Depending on the particular context, the task of extended peer review may be more like policy-related research, or science-related decision making, or creative technical-social innovation. When risks cannot be quantified, or when possible damage is irreversible, we are then out of the range of competence of traditional sorts of expertise and traditional problem-solving methodologies. Andrews (2002, pp. 3-16) emphasised that a successful analysis that leads to actual resolving of the complex problems of contemporary society, for instance in decisions based on the evaluation of various programmes, requires joint fact-finding by specialised experts, decision-makers and interested lay people. Joint fact-finding brings together stakeholders to seek agreement on the nature of the problem, on the knowledge we have and do not have, on what we need to know and on how to collect, analyse and present the information.

3.5.2. The paradigmatic and methodological approach of this study

Following the introduction to the philosophy behind the paradigmatic choices given in the previous sub-chapter, it is now time to make my own paradigm and methodological approach explicit. Teleological aspects are clear in my study, because the Thematic Strategy, Sustainable Use Directive and National Action Plan are all aimed at the same predetermined goal of reducing the risks from pesticides by using them in a sustainable way. Therefore, this assumption puts my study into a philosophical approach framework as well. My intention is to analyse the purposeful system of the Finnish NAP, and propose means for evaluating the achievement of its processes working towards the goal of reducing risks. As a conclusion of the theoretical discussion presented above in Chapter 3.5.1, the interest of knowledge in my study can be driven from the critical theory. Following the model given by Guba (1990, pp. 23-25), the philosophical assumptions of this study can be postulated as follows:

Ontological premises: intermediate approach between constructivist and realist paradigms in the sense that generalisation of concepts from other evaluations and learning from other contexts is applied with caution (Mickwitz 2006, p. 67-68). Critical realism, which appreciates that reality exists apart from the perceptions of the observer, but can never be fully comprehended or explained. Reality is driven by natural laws that can be only understood incompletely. The NAP only exists as a convention between stakeholders, a construction of human minds with various worldviews, while the impacts from the use of plant protection products can be empirically observed in the environment, for instance by monitoring. The aim of the NAP to reduce risks presumes a shared effort and stakeholder participation in a collective transformation process, and likewise its evaluation is a

collective challenge that presumes joint commitment. This study therefore requires the endorsement of a variety of ontological viewpoints of the stakeholders involved.

Epistemological premises: subjectivist, in the sense that values mediate inquiry. Sustainability research is a teleological discipline, which intentionally aims to improve the ecological, socio-economic and cultural status of society so as to maintain its viability for future generations. The practical framework for my study is determined by the European Thematic Strategy on Sustainable Use of Pesticides (EU 2006) and all legislation under the provisions of it, which presume the concept of sustainability as the basis for the development of National Action Plans. Consequently, the evaluation and assessment of those plans must also be performed through the lens of sustainability research. My profession as an ecotoxicologist and my insider role as an expert and peer participant in the implementation of the Finnish NAP predetermine that the values of sustainability, and specifically the ecological sustainability, are driving my research. The implementation of the NAP and evaluation of its achievements also means a personal and collective learning process for the whole plant protection community, myself included (Couix & Hazard 2013).

Methodological premises: dialogical, transformative, emancipatory. According to the classification provided by Heikkinen et al. (2010a, p. 47), this study can be classed under the label of critical-emancipatory action research, due to the transformational aims of the study and my role as both researcher and activator, coordinator and co-operator with the peer participants who are jointly accountable for the results, while I am fully responsible for the report. The intervention is aimed at transformation and thus requires systems thinking methodologies to grasp the variety stakeholders' worldviews. The methodological pluralism of systemic intervention (Midgley 2000) was applied in the collection, analysis and synthesis of the research material. Classical qualitative analysis methods were applied to the purposeful data collection (Corbin & Strauss 2008) and analysis, and systems thinking and theory-based evaluation methods (Chen 2005; Wasserman 2010) were used to synthetise an overall picture and organise the outcome. Dialogue and reflection with the stakeholders during the study process facilitated collective learning, shared understanding and practical commitment to evaluate and improve the practice aimed at the goals set in the NAP, and the focus group and expert panel participants were perceived as co-researchers (Newton & Parfitt 2011).

Given the current scarcity of public resources in Finland, it does not seem likely that independent external evaluators can be utilised in the evaluation of the NAP. Empowerment evaluation (Fetterman 1996, 2003; Greene 2006) thus fits the Finnish culture of governance, where the stakeholders implementing the NAP actions will also become equally empowered and responsible for its evaluation, contrary to those forms where evaluations are ordered from outsider evaluators. Therefore it is appropriate to build capacity within the entire plant protection community to empower itself using self-evaluation and reflection.

In terms of the typologies given by Owen & Rogers (1999) and Worthen et al. (1997), this study can be classed as internal formative evaluation, because I am personally involved with the content and objectives of the Finnish NAP, and because my intention is to plan and improve the ways of assessing its outcome during the course of the programme. A summative evaluation will also be conducted at the end of the programme period, which this study attempts to equip with applicable tools. Thus, taking into account these limiting definitions, the theoretical framework of this study can be presented as the onion-like layered picture in Figure 3.1 at the beginning of Chapter 3. Next, my research process, material and methods used in this study are discussed in more detail in Chapter 4 below.

4. Research process, material and methods

During the preparation of the Finnish NAP, the working group did not take a stand on how its outcomes should be evaluated. Because no exact goals were set, it can mainly be evaluated using qualitative methods. My purpose was to consider a variety of alternatives for conducting future evaluations and not to exclude too many perspectives while the first programme period is still running. My concurrent role as implementer of the NAP and researcher certainly created an insider view, which clearly had an impact on the approach and the methodologies of this study (Alasuutari 2014, p. 142).

Plenty of literature on qualitative methods was available, and I combined models from several authors, e.g. Bernard & Ryan (2010), Grönfors (1985) and Tesch (1990). Kiviniemi (2001) described the process orientation of qualitative research, where the researcher is the vehicle for collecting material and the research is a series of problem-solving decision-making methods. This idea illustrates my path of methodological choices very well, where the theory and purposeful data collection were interwoven and the empirical material was gathered simultaneously interlocked into the deepening of the analysis, as a practical solution arising from the model of grounded theory (Corbin & Strauss 2008). However, this work cannot be associated with the original tradition of grounded theory as advocated by its founders (Glaser & Strauss 1967; Glaser 2001), in the sense that the theories of theory-driven evaluation (e.g. Chen 2005, Mickwitz 2003) and participative evaluation (Fetterman 1996, Greene 2006) were used as the background for building the conceptual framework and this starting point was kept in mind throughout the process of the purposeful data collection and analysis, and also because the empirical data itself did not alone dictate the constructing of the NAP programme theory. Flick (2007, p. 29) sees that some kind of theory always drives the sampling, however open the process remains for diversity.

During the material collection it appeared that the data was scattered, and therefore it was necessary to approach multiple sources in order to ensure adequate plurality of voices at the expense of a tight framing. None of the materials alone would have been adequate to answer all the research questions. Midgley (2010, p. 288) advocated methodological pluralism in systemic intervention, where being able to draw upon multiple methods from different paradigmatic sources in his opinion enhances the systems thinking resource available for an intervention. Because my aim was not to perform the evaluation myself, but rather to produce tools and measures to enable future evaluations of the NAP, I tested the suitability of different methods instead of being absorbed in some of them deeply. This approach was considered to serve the capacity building of the entire NAP community.

Mickwitz (2006, p. 72) highlights the role of triangulation between several data sources, methods, theories and perspectives in discovering unanticipated effects and assessing complicated causal relationships in evaluating policy programmes. Methodological triangulation (Saini & Shlonsky 2012, p. 126-127; Royse et al. 2010, p. 95-96; Isaac & Michael 1990, p. 92) was used in this study to gather more than one type of data for qualitative analysis: discursive and argumentative content analysis of the NAP documents, focus group memos, correspondence with citizens and experts, stakeholder analysis and questionnaires for collecting the views of different actors in a process of participative action research for mutual analysis and synthesis of the views of the stakeholders. Each method used in this purposeful data collection is discussed in more detail through Chapters 4.1.-4.5.

My study process could be illustrated as a reflective spiral of action research as presented by several authors (see for instance Costello 2003, p. 8; Heikkinen 2001, p. 177; Heikkinen et al. 2010b, p. 81), where every loop consisted of four phases: theoretical reasoning to plan the material collection, applying appropriate methods to

collect it, analysing the collected material and consideration against the theory, based on the material collected so far, towards the eventual need to collect further material, thus leading to the next circle of the perpetual spiral. My entire study process proceeded in methodological cycles and stages as presented by Checkland & Scholes (1990). Simultaneously, my process offered possibilities for collective learning to the colleagues involved with the focus group and expert panel work by sharing memos and preliminary findings during the process.

Figure 4.1 illustrates the spiral of my study process with the phases of desk top research and stakeholder participation, materials gathered and methods for analysing them.

4.1

The reflective spiral of my study process

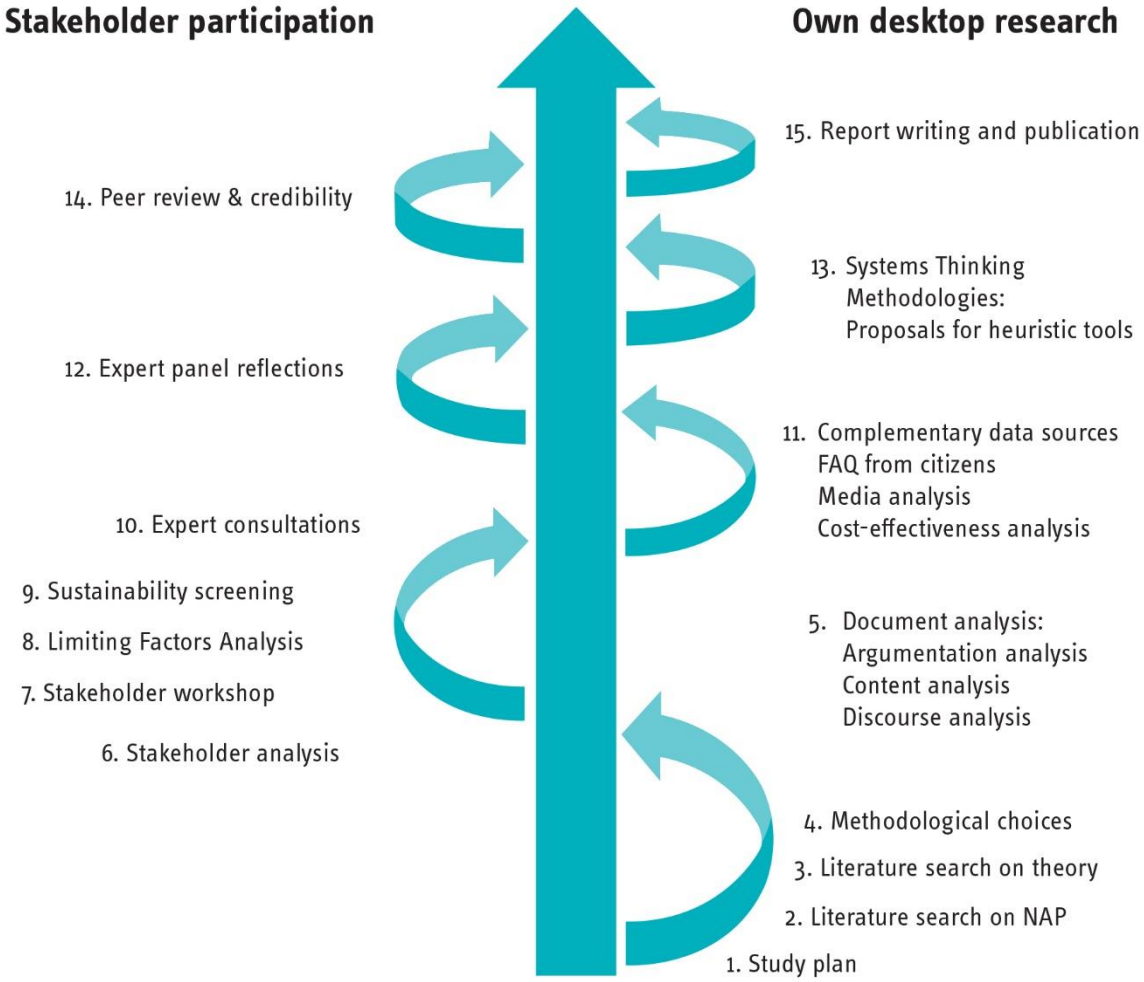

Figure 4.1. The reflective spiral of my research process.

This chapter proceeds as follows: first, Chapter 4.1 gives an overview of the methods for collecting and analysing the literature published about the scientific basis of the NAP issues (as previously presented in Chapter 2), for constructing the philosophical, theoretical and methodological framework for this study (as presented in Chapter 3) as well as for guiding me in the methods to be used (Chapter 4). Entering into the theoretical literature led to my paradigmatic choices, as presented in Chapter 3.5.2. Next, Chapter 4.2, divided into three sub-chapters,

presents the steps of document analysis with the classic qualitative analysis methods. Participative methods to involve stakeholders in producing research material is presented in Chapter 4.3, again divided into four sub-chapters. Four kinds of complementary data sources are presented in Chapter 4.4 with four sub-chapters. Chapter 4.5 explains the systems thinking methods for making the synthesis, divided into six sub-chapters, and finally, the empirical materials and the way the results are presented are summarised in Chapter 4.6. I will describe the actual study process chronologically in detail such that the reader can follow what was done at each step of the study.

As a result of this process, the outcomes were organised into five chapters covering the research questions, following the steps of the evaluation cycle in Figure 1.1. In terms of the subsequent chapters, the NAP will be characterised as a purposeful system in Chapter 5; the expectations of the stakeholders for the goals and implementation of the NAP are characterised and the programme logic for conceptualising their implicit assumptions will be explained and visualised in Chapter 6; heuristic tools and procedures for evaluating the achievements will be presented in Chapter 7; proposals for gathering evidence for the evaluation will be made in Chapter 8; and the engagement of the stakeholders in the risk reduction will be discussed in Chapter 9. In order to promote the instrumental use of my main research findings within the agencies involved (Amara et al. 2004), I organised the heuristic tools and guidance as a separate Appendix 4, thus enabling busy authorities to find the practical outcome of this research more easily.

4.1. Literature review to explore the scientific basis of the NAP and its evaluation

Published literature was gathered on themes included in the NAP, as presented in Chapter 2, on the theoretical background for the methodology chosen for this study, as discussed in Chapter 3, and on the research methods presented here in Chapter 4. The literature was found using electronic library databases such as Helka (the joint database of the University of Helsinki libraries and the National Library of Finland) and ScienceDirect, available at Tukes, the internet, professional networks and organisations, as well as by handsearching in the libraries of Tukes, the University of Helsinki, the Finnish Environment Institute, bibliographies and from several personal sources as a result of recommendations and consultations with subject experts. Guidelines were used from Pullin & Stewart (2006) and Saini & Shlonsky (2012) to plan searching for and selecting relevant data. Although a complete meta-synthesis (Saini & Shlonsky 2012, p. 30-31) on the literature published was not performed for this study, the search strategy covered the main issues of plant protection as addressed in the Finnish NAP and in the Sustainable Use Directive (EU 2009b).

Because it appeared that enormous amounts of literature have recently been published on different aspects of the sustainable use of plant protection products, as well as on programme evaluation, it was not possible to review all of this literature in detail. Instead, only the most relevant references are presented in Chapters 2 and 3. To frame the literature search, I mainly focused on natural scientific research for most of the issues, since the problems and innovations proposed as solutions to increase the sustainability of plant protection in the NAP are usually described as natural scientific. A social scientific perspective would have also been possible, however, although combining both disciplines would have increased the material and workload markedly. The material was organised with the help of content analysis as proposed by Tuomi & Sarajärvi (2009, p. 123-124). A preliminary screening of the articles was made using the thematic framework for the content analysis, and the most integral studies were investigated and discussed in more detail in this monograph. The result of this exercise enabled the structure of this study to be constructed and the titles of the chapters to be defined.

4.2. Written NAP documents and their qualitative analysis methods

Several data sources and references used in this study are not scientific by nature, as administrative and lay data were also used. Written documents that were produced during the preparation and implementation of the Finnish NAP were gathered from various administrative sources, such as the files from ministries, Tukes, EU organisations, research institutes, etc. The documents collected comprised the preparation documents and statements from the stakeholders on the draft NAP proposal, the final Finnish NAP document (MMM 2011a), comparisons to several other Member States' NAPs and EU documents concerning the implementation of the SUD and the NAPs, minutes from NAP Steering Committee meetings, communications from the public filed as frequently asked questions at Tukes, professional articles in media, targeted enquiries with selected experts as key informants and minutes from the stakeholder focus groups organised during this study. The documents were analysed using classical qualitative analysis methods of argumentation analysis, content analysis and discourse analysis, as described in detail below.

4.2.1. Argumentation analysis of the NAP document

Analysis started with argumentation analysis (Govier 2010; Kakkuri-Knuuttila & Halonen 1999) of the final NAP document (MMM 2011a). According to van Eemeren et al. (1997), one of the practical applications of argumentation analysis is critical: to develop a framework for the evaluation and improvement of actual argumentative practices, treating the practices both as phenomena to be explained and as opportunities for intervention, that is, for attempts to bring about social change (Willard 1989). Thus, this approach can be connected to the critical theory.

The purpose of argumentation analysis is to study whether the recipient will be motivated by the message as desired (Kakkuri-Knuuttila & Ylikoski 1999, p. 26). As one of the originally appointed participants of the NAP working group, I interpreted the content of the NAP document as 'benevolent reader', which means that I applied charity as a principle of interpretation of the text (Govier 2010, p. 55), thus specifying the missing premises where necessary in order to make the argument plausible. My aim was not to evaluate the quality of the arguments as such or reveal any loose reasoning, but to discern and extract the main claims with their supporting premises to seek the answers to my research questions.

The argumentation analysis of the NAP document led me to the theory of Message Design Logic (MDL, Willard 1989, p. 253-255), the questions of which I considered central for the analysis on the Finnish NAP:

> Who said what to whom through what medium for what purpose despite what distractions with what results?

Seeking answers to these questions made explicit a lot of the strategic positions of the actors within the plant protection community, thus increasing the mutual understanding of each other's values, views, goals and framing and improving our commitment and readiness to carry out and evaluate the tasks set in the NAP. Analysing the NAP document in the light of seeking answers to these MDL questions guided me in turn with the choice of themes and classifications for the thematic framework used in the content analysis, as presented in the next sub-chapter.

4.2.2. Thematic framework of the content analysis of documents for preparing and implementing the NAP

Qualitative content analysis (e.g. Elo & Kyngäs 2008; Hsieh & Shannon 2005; Luostarinen & Väliverronen 1991) was performed to study how the themes that are important from the programme evaluation perspective were manifested in the documents used to prepare and implement the NAP, as well as the final NAP document itself, bearing in mind the Willardian Message Design Logic questions (Willard 1989, p. 253-255) presented above in Chapter 4.2.1. Programme evaluation literature was used to define themes relevant to formative and summative evaluation, based on the themes that emerged from the argumentation analysis. A thematic framework for the concept-driven coding was consequently created for a deductive analysis. It was made up of five main themes pre-defined as specific areas encompassed by the NAP (themes A-E in Table 4.1). Under each of these themes, eight categories were searched (categories 1-8 in Table 4.1) that are vital in the process evaluation literature (Chen 2005; Mayer 1996; Royse et al. 2010; W.K. Kellogg Foundation 2004). The explicit mentioning and omission of these categories in the text was observed in the analysis.

Because the categories were established prior to the analysis, the procedure can be considered as theory-driven analysis (Tuomi & Sarajärvi 2009, p. 97; Stemler 2001; Seuring & Müller 2008), where the coding is concept-driven (Gibbs 2007, p. 44-45). The text of the NAP was coded manually, as opposed to using any of the numerous software packages for content analysis available on the market. This decision followed the observations made during the argumentation analysis, that the question of measuring and evaluating the achievements of the targets and goals was not explicitly elaborated in the Finnish NAP or in other documents, thus requiring an approach of expert judgement with interpretation by a benevolent reader in coding (Kakkuri-Knuuttila & Ylikoski 1999, p. 31-32), to analyse whether the NAP actions were aligned with the overall objectives. Jolanki & Karhunen (2010, p. 408) consider texts where part of the message has been left implicit as not suitable for analysis with computerised analysis software. Therefore, it was deemed inappropriate to trust any commercially available software packages, and instead human judgement with appropriate insights of the aims of the NAP was used as the leading theory guiding *a priori* coding (Krippendorff 2013, p. 208-266). To ensure the reliability of the qualitative content analysis, Krippendorff (2013) recommends that more than one person should independently code the text for data making. However, multiple coding was not possible, and therefore triangulation between other data sources and analysis methods, such as discourse analysis and focus group discussions with participative approaches, was used instead. For comparison, the same matrix was used to analyse other data sources, such as the NAPs of other EU Member States, professional articles published, frequently asked questions from the public and expert enquiries.

Table 4.1. Thematic framework for the content analysis of the Finnish NAP. (Y/N) = Explicit mentions and non-mentions in the text were separated.

Categories	Objectives of the NAP				
	A. Reducing health risks	B. Reducing environmental risks	C. Raising awareness	D. Agricultural practices and promotion of Integrated Pest Management	E. Diverse
1. Goals (Y/N)					
2. Reasoning (Y/N)					
3. Action (Y/N)					
4. Responsible actor(s) (Y/N)					
5. Measure (Y/N)					
6. Evaluation and reporting (Y/N)					
7. Link between the action and the goal (Y/N)					
8. Timetable (Y/N)					

4.2.3. Discourse analysis to explore stakeholders' discoursive strategies regarding the NAP

Discourse is defined as text above sentence level, and discourse analysis is used to study how particular phenomena are represented between the participants of the discussion (Blommaert & Bulcaen 2000; Hammersley 1997; Krippendorff 2013, p. 22; Törrönen 2010; van Dijk 1993, 1997, 1998). Vocabulary level is clearly important in discourse analysis, but words in discourse may only be interpreted precisely in the context in which they occur (Wilson 1993). Discourse semantics (Tomlin et al. 1997) or rhetoric (Gill & Whedbee 1997) was not scrutinised here; rather, the focus was on the positioning of the stakeholders in the discourse concerning the sustainable use of plant protection products (Jokinen 1999), as presented in Figure 6.5. Critical discourse analysis includes an element of self-reflexivity in that it may be applied to its own text (Krippendorff 2013, p. 68), as is the largely case for the main stakeholders as participants in the discussion on the sustainable use of plant protection products and in expert panel work.

In this study, I did not use any verbatim transcripts of the personal discussions, although I identified (implicit) meanings from documented texts produced by various stakeholders in different situations dealing with the sustainable use of plant protection products and the NAP, delivered through diverse media (Rapley 2007, p. 111-124). My intention was not to analyse the semantics of the texts, but rather the discoursive strategies of different actors representing various interests in the use of plant protection products. Therefore, my discourse analysis was aimed at seeking answers to the message design logic questions (Willard 1989), as presented earlier in Chapter 4.2.1. The documents were analysed with regard to how the construct of risk and impact on human health and the environment is dealt with in the discourse between the experts and the citizens, and with regard to how these issues are expected to be dealt with in the evaluation of the NAP. The thematic framework used in the content analysis, as presented above in Chapter 4.2.2, was used also to frame the discourse analysis.

Critical discourse analysis shows how social structures determine properties such as dominance in the discourse, and discourse in turn determines social structures (Fairclough 1985). Alvesson & Karreman (2000) introduced discourse analysis into the organizational research. Jones (2007), however, criticised critical discourse analysis for leading to a distorted view of the role of communication in society and of the workings of social processes. It is noteworthy that non-governmental organisations (NGOs) are largely absent in the discourse around sustainable use of plant protection products in Finland, although elsewhere in Europe NGOs constitute a significant lobby towards reducing the risks from pesticide use (e.g. PAN 2013). Despite my efforts to invite NGO representatives to participate in the focus group and expert panel work, not one person from any environmental, consumer or hobby gardener organisation attended and I did not even a receive a response to the invitations. However, the summary of stakeholder opinions on the draft NAP document contained comments from the Finnish Association for Nature Conservation (FANC), and the minutes from the focus group discussion with layperson neighbours provided some insights from those affected. Thus, the perspectives of those affected but not involved could be understood to some extent in this study.

4.3. Participative methods for gathering stakeholders' insights

This chapter describes the participative approaches for data collection that I used in this study. Stakeholder analysis was performed in focus groups as explained in Chapter 4.3.1. The stakeholder workshop and expert panel work are presented in Chapter 4.3.2. The procedures for conducting the limiting factors analysis will be described in Chapter 4.3.3, and sustainability screening in Chapter 4.3.4.

4.3.1. Conducting stakeholder analysis

Several programme evaluation scholars (e.g. Bryson 2004; Greene 2006; Preskill 2009) have argued that the implementation of a programme and the design of its evaluation suffers without adequate input and commitment from stakeholders. Stakeholders are also important users who utilise the results of an evaluation (Clarke & Dawson 1999). Stakeholder analysis can be used to generate knowledge about the relevant actors so as to understand their behaviour, intentions, interrelations, agendas, interests, and the influence or resources they have leveraged - or could leverage - on decision-making processes (Brugha & Varvasovszky 2000).

When the Finnish NAP was first being prepared, a background report (Peltonen & Rajala 2009) was drawn up by the ProAgria Association of Rural Advisory Centres and the Finnish Plant Protection Society on behalf of the Ministry of Agriculture and Forestry. The aim of the study was to survey the opportunities for reducing the risks from the use of plant protection products. The background report served as the basis for preparing the Finnish NAP. A questionnaire was sent to 135 professionals involved in plant protection, including representatives from farmer associations, advisory bodies, education, research, business, administration, the food and feed industry as well as PPP industry. Intentionally or not, apparently there were no attempts to more broadly gather the possibly deviating views of other interest groups such as consumers, environmentalists, neighbours or other bystanders, and therefore the outcome of the background study can be considered to be biased. An inclusive stakeholder analysis was not performed either when the interest groups were invited to nominate their representatives to the ministerial NAP working group, where the survey served as background document.

However, many authors (e.g. Hermans & Thissen 2009; Latour 2005; Starik 1995) support an inclusive view on who should be regarded as stakeholders. They also emphasise that if stakeholders are identified and selected on an *ad hoc* basis, important groups may be marginalised or excluded, thus resulting in bias and jeopardising the long-term viability of and support for the process. Therefore, for instance, Bryson (2004) and Reed et al. (2009) recommended stakeholder analysis to identify the individuals, groups and organisations that either can affect or will be affected by the process. Prell et al. (2008) recognised that focus groups comprising participants from more diverse stakeholder categories are more likely to broker across different insights and hence support social learning in environmental conservation projects than groups where participants have similar backgrounds.

Therefore, a stakeholder analysis was performed in my study to gather insights about the interests and influence of different stakeholder groups. Due to time and workload demand constraints, it appeared unrealistic to perform a complete survey with a statistically adequate sample of respondents for quantitative data collection. Instead, it was decided to turn to focus group discussions between invited participants using a nominal group technique as the method of data collection (Barbour 2007; Sulkunen 1990). Hirsjärvi & Hurme (2001, p. 61-63) considered focus group interviews particularly applicable for producing evaluative data. Geurts & Joldersma (2001) regarded this kind of conversation as important in policy dialogue, since it takes place between multiple actors, simultaneously in a process of sense making, which could not have been possible by speaking to each individual actor separately.

The stakeholder analysis was performed in the form of a power versus interest grid (Bryson 2004), following the concept of Reed et al. (2009). The first step was to identify the stakeholders and their stake involved in the implementation of the Finnish NAP. Focus groups of selected experts on five expertise areas (human health, environment, plant production, education and information, as well as neighbours to agriculture) were invited to gather information on their perceptions about the stakeholders that either affect or are affected by the sustainable use of PPPs.

A questionnaire was developed to ask participants about their views on different stakeholders that affect, should affect or are affected by the implementation of the NAP. Pre-testing of the questionnaire with three individuals led to substantial modifications of it. Before the focus group meetings, the questionnaire was sent by e-mail to selected experts with broad networks at Tukes (the competent authority implementing the NAP in Finland), to a total of 20 persons. Participants were asked to fill in the questionnaire and take it to the focus group meeting as their discussion aid.

Additionally, a focus group was invited comprising private laypersons who live in the countryside next to agricultural fields but who are not farmers themselves. Six persons enrolled to volunteer, although only four persons actually participated. After a general introduction to the NAP and PPP use issues, this group deliberated a shared view on the stakeholders with their interests and influence. Given that individual insights may be divergent regardless of the joint understanding discussed by the focus group, participants were also allowed to return their personal responses. After obtaining informed consent, the anonymous responses were able to be used to gather the insights of laypersons living in the vicinity of agriculture.

Due to the unavailability of experts, it was further necessary to modify the expert focus group formation in practice. In the end, only one focus group with mixed experts materialised, with eight participants in total. The overall expertise of the participants covered all the originally intended areas, however, and therefore can be considered representative. Barbour (2007, p. 59-60) does not see the reduced number of parallel similar focus groups as a problem, but suggests instead aiming to maximise the diversity in composition of different focus groups so as to provide more potential for comparison. Therefore, an additional group was proposed, consisting of farmers. However, the negotiations with two farmers' organisations did not lead to establishing a third focus

group with farmers within the timeframe of the sampling period. Following the comments received from the layperson group, the questionnaire was further modified before the expert group meeting. Those experts who were not available were given the opportunity to return the questionnaire without participating in the group discussion.

In the focus group discussions I served as facilitator, not actively participating in the discussion but moderating, observing, making notes, keeping a record and giving the floor (Mackewn 2008). The aim of the focus group discussion was to put together a shared view about the different stakeholders, their interests and instruments of power involved in the NAP. Finally, in addition to the shared views resulting from the focus group discussions, eight individual responses with comments and further remarks were received from individual participants and were used in further analysis anonymously.

In the questionnaire, four sub-categories of interests were proposed (regulatory, production, protection and information interests), as well as a free column to add further types of interests, if recognised. For influence, three sub-categories of influence were proposed (coercive, material and cultural), plus a free column. The format of the questionnaire is presented in Table 4.2. below. The categories were modified to fit the PPP use context from those presented by Reed et al. (2009). The additional types of interests or influence were only occasionally mentioned by focus group participants, and in the discussions it emerged that those types actually belonged to the explicit sub-categories. Therefore, the free column was excluded from the further analysis. No distinction was made if the interests and influence were perceived as positive (supportive) or negative (unsupportive).

Table 4.2. The format of the stakeholder analysis questionnaire for the focus groups. Each row represents the stakeholder groups the focus groups identified, and rows could be added as needed.

NAP stake-holder	**Interests in the sustainble use of plant protection products**					**Means of influence**			
	Regu-latory	Produc-tion	Protec-tion	Infor-mation	Other, what (specify)?	Coercive	Material	Cultural	Other, what (specify)?
…									
…									
…									

For each stakeholder group identified, the strength of interest and influence was estimated as negligible, weak, moderate or strong, using a scale of 0, +, ++ and +++. Even though it is an ordinal scale, it was considered appropriate to code the scale with numerical values of 0, 1, 2 and 3 for the analysis, since my purpose was not statistical testing but arranging the data (Ranta et al. 1989, p. 18-20).

Table 4.3. Order of the scores for total interests (4-digit codes) and total influence (3-digit codes) in the interest-influence analysis of stakeholders.

	Interest coding	Influence coding		Interest coding	Influence coding
1.	3333	333	16.	3110	110
2.	3332	332	17.	3100 and 2221	100
3.	3331	331	18.	3000 and 2210	000
4.	3330 and 3322	330 and 322	19.	2211	
5.	3321	321	20.	2210	
6.	3320	320	21.	2200	
7.	3311	311	22.	2111	
8.	3310 and 3222	310 and 222	23.	2110	
9.	3300 and 3221	300 and 221	24.	2100	
10.	3220	200	25.	2000	
11.	3211	211	26.	1111	
12.	3210	210	27.	1110	
13.	3200 and 2222	200	28.	1100	
14.	3111	111	29.	1000	
15.	3110	110			

All categories of interests and influence were considered as equal, so the order of the sub-categories did not make a difference in the analysis, and the total interest was considered as equal regardless of the order of the sub-categories. For instance, if four sub-categories of interest for one stakeholder received values of 3, 1, 0 and 3, the total interest was considered as equal to another stakeholder who received values of 1, 3, 3 and 0. Consequently, both stakeholders were coded with 3310. The three sub-categories of influence were likewise coded similarly with three figures. The strength of total interests or total influence was defined as a combination of two factors: the top value of any sub-category (perceived as a strong interest or influence in a particular category) and the sum of all sub-categories (perceived as variety of interests or influence). Any single top value was judged as being stronger than the variety of the sub-categories. For instance, if one stakeholder group received a strong interest (3) in one sub-category, its total interest was considered as stronger compared to another group with a slightly higher sum but lower top values in several sub-categories. Logical rules were developed to judge precisely between the top value and variety in each case. Following these rules, the scores for total interests and total influence were distributed as illustrated in Table 4.3 above.

4.3.2. Stakeholder workshop and creating the expert panel

On 11 November 2014, a three-hour afternoon workshop for the stakeholders was organised at Tukes, to discuss the measures and constraints of the success of implementing the NAP and to gather views on the aspects the participants feel are important to consider in the evaluation of the NAP. The organisational planning of the workshop followed the principles of participatory action research (Townsend 2013), the deliberative participation model (Renn 2008, p. 297) and the participatory and process-orientated procedure supported by Becker et al. (1999, p. 10), within the framework of soft systems methodology (Checkland 2010). The ideas for constructing focus groups were amalgamated from Barbour (2007), Hirsjärvi & Hurme (2001, pp. 61-63), Oreszczyn & Carr (2008) and Pietilä (2010). Participants were invited as representatives of key organisations nominated to the NAP Steering Committee or of otherwise recognised stakeholder organisations, thus representing a range of stakes and the highest level of knowledge and expertise within the field of plant

protection in Finland. The invitation was sent to 58 persons in 24 organisations, with 14 persons accepting the invitation. In the end, 11 persons attended the workshop, representing nine different organisations ranging from advisory services, authorities, research and industry, to farmers, thus covering all other stakeholder groups invited except for NGOs, which can be considered as a bias. Additionally, a few persons who could not attend the workshop notified of their interest in participating in the expert panel work, and they were included in the expert panel e-mailing list.

On the workshop agenda were two main goals for the discussion: using a nominal group technique (Barbour 2007) to rank the limiting factors constraining the success of the NAP (as presented in more detail in Chapter 4.3.3), and free brainstorming on the perceived priorities of the targets, measures and evidence of success of the NAP. The systemic discussion on the targets and measures was framed by presenting a first sketch for the logic model of the NAP, as presented in detail in its final stage in Tables 3.1.-3.6. of Appendix 4. The list of indicators in place in the NAPs of the EU Member States, as devised by the FVO (2014, Annex III), was used to initiate deliberation, and possibilities for gathering the Finnish data necessary for the FVO indicators were discussed. Following the structure of the content analysis framework (as presented in Chapter 4.2.2 above), the workshop discussion was structured according to the main themes pre-defined as specific areas encompassed by the NAP: reducing health risks, reducing environmental risks, raising awareness and promoting integrated pest management. Participants were asked to use sticky notes for their individual proposals for desired outcomes and measures in evaluating the NAP achievements under all these categories. I served as moderator or facilitator of the discussion (Mackewn 2008). The interaction of the group discussion was analysed using Stevens' (1996) elementary questions.

After the workshop, the draft minutes were circulated to participants for comments by e-mail, to seek a deliberated consensus on the conclusion established for the workshop, considered as one result of this study. The stakeholder participation thus provided my desk research with material, methods and co-produced results, and simultaneously led the participants to a collective learning process and preparation for the coming evaluation of the NAP. Following the workshop, participants were invited to take part in continuous expert panel work (Varho & Huutoniemi 2014) via e-mail correspondence, which offered the experts a forum for self-reflection in order to enhance collective learning and mutual understanding about the long-term goals of the NAP. Those persons who were not able to participate in the workshop but had indicated an interest in participating the expert panel work, were also included in the e-mailing list. Continuous dialogue with voluntary participants after the workshop as well was essential for the study process, thus facilitating the mutual transformation towards a practical commitment to achieving the goals set in the NAP. The correspondence served as data for the discourse analysis as presented in Chapter 4.2.3 and enabled the testing of the heuristic tools, as described below in Chapter 4.5. This exercise could therefore be considered as an attempt to apply a 'Giddensian structural theoretical model' of action research, as outlined by Jyrkämä (1999). According to Kuula (1999, p. 215) some action researchers present their analysis methods as their focal method, and consequently the practical process of action research can mainly be considered as their process of collecting data from the scientific point of view. The purposeful sampling and the focus group composition can be considered as adequately representative for this kind of study (Barbour 2007, pp. 57-73).

4.3.3. Exploring obstacles to goal-achievement using Limiting Factors Analysis

Gullison & Hardner (2009) developed a method for finding the likely obstacles related to preventing the achievement of the long-term goals of sustainability programmes and projects. The method was called Limiting Factors Analysis (LFA) after the Law of the Minimum originally published by Carl Sprengel and later popularised by Justus von Liebig in the 19th century, which is well known in agriculture and ecology and refers to the factor (scarcest resource) that has the greatest influence in limiting the growth of an organism (van der Ploeg et al. 1999; Gröger 2010). In the context of programme or project evaluation, the metaphor of limiting factors refers to obstacles that can prevent a programme from achieving its long-term objectives. The limiting factors may be policy-related, financial, scientific or social, and may extend well beyond the boundaries of the programme itself, thus requiring the evaluators to consider a broad context in assessing whether everything necessary is being done to reduce the risks of failing to achieve the targets. LFA has been developed as a quick tool to measure the progress before, during and after a programme or project period, and is therefore recommended to be repeated from time to time to monitor development (Gullison & Hardner 2009).

To prepare the evaluation of the Finnish NAP, an LFA was carried out during the stakeholder workshop on 11 November 2014. The organisation of the workshop was discussed earlier in Chapter 4.3.2. Participants were given a questionnaire with a gradual score (five-step Likert score) of the perceived severity, with empty lines to be filled as a result of the group discussion. The questionnaire was pre-tested with two individuals prior to the workshop, which led to a few modifications. Because the intention of this study is to develop and test evaluative tools and approaches, it was decided not to include an 'I don't know' option on the questionnaire for the individual experts. It was considered non-constructive if the respondents could have chosen the option to not take a stand on the severity of the likely obstacles they had first identified themselves. Therefore, the scoring of the severity was set from 0 (= does not limit in any way), 1 (= the problem is manageable), 2 (= limits to some extent), 3 (= serious impediment to work) to 4 (= prevents the work completely).

To gather views on the limiting factors for achieving the NAP goals, participants were asked to suggest and discuss factors perceived as those most severely threatening the implementation of the NAP in Finland. The deliberation between the participants yielded 16 limiting factors specific to the Finnish NAP. Next, after the limiting factors were mutually agreed upon, participants were asked to individually rank the status of each limiting factor according to the score on the response sheet and, finally, the group discussed and deliberated a joint view on the severity of the limiting factors. It was appreciated that individual persons representing a range of different stakes had different perspectives and opinions on the severity of the obstacles, and therefore individual rankings were also collected to add this data to the analysis. I served as a moderator for the group discussion, not actively participating in the discussion but rather observing, making notes, keeping a record and giving the floor. The questionnaire with the jointly agreed view on the limiting factors of the Finnish NAP is presented in Appendix 4, Chapter 2.3, Table 2.3.

In the analysis, the limiting factors established jointly were categorised according to the issues they represented. Five main issues were recognised. In addition to the jointly deliberated scoring, the means for individual responses (n=10) for each factor were also calculated, and the scores of each factor were plotted, as presented in Figure 5.3 in Chapter 5.4.3. Based on the comments and reflections from participants, the LFA framework is proposed as one of the heuristic tools for evaluating the achievements of the NAP.

4.3.4. Sustainability screening of the NAP

A range of sustainability screening frameworks have been developed to gain quick overall pictures of the state of national sustainability programmes and strategies (Niestroy 2005). Screening methods can also be used to demonstrate progress over time. Several existing, promising sustainability assessment frameworks published in the literature (Anderies & al 2004; Binder et al. 2013; Cherp et al. 2004; Fischer 2007; Fitzgerald et al. 2012; Gerdessen & Pascucci 2013; Hermans et al. 2012; Ijäs et al. 2010; Kuitunen et al. 2008; Mog 2004; Naddeo et al. 2013; Steyaert & Jiggins 2007) were scrutinised for the purpose of testing their applicability in screening the state of the Finnish NAP. The screening method developed by Cherp et al. (2004) was chosen for further elaboration with the expert panel participants. The other frameworks were assessed as not ideal for our purpose, since their procedures were not applicable to a specific programme like the Finnish NAP due to the different scope of their indicators, and therefore these frameworks were ruled out from further consideration.

The principles for assessing the state of national sustainable development strategies (NSDS) developed by Cherp et al. (2004) were applied to the Finnish NAP. Their method focuses on assessing how national sustainability strategies follow international principles and criteria for strategic planning and sustainable development. They proposed five principles, each covering four criteria that could be qualitatively scored from A to D, indicating to what extent each criterion has been perceived as met. Although originally developed for assessing socio-economic development strategies in the Eastern European transitional economies, this procedure appears to also be applicable to the practical assessment of more specialised programmes and plans as well, because its approach can easily be adapted to various situations and needs. The authors emphasised that each country should use the NSDS framework in the most suitable way under their conditions. Their criteria are essentially similar to the process-orientated and outcome-orientated criteria presented by Mog (2004) for evaluating sustainability development programmes.

In order to assess a programme from a specific policy area, the NSDS criteria were slightly modified to better fit the context of the sustainable use of plant protection products. The NSDS assessment principles and criteria were circulated to the expert panel for testing, and the responses received from the experts were compiled and analysed from the perspective of the method's applicability for the sustainability screening of the Finnish NAP. The responses from individual experts were also used as data for further analysis. The modified NSDS framework with the principles and criteria and the range of expert panel rankings is presented in Chapter 2.2 of Appendix 4, and the results are illustrated in Figure 6.4 under Chapter 6.6. Because the rankings are subjective and depend on the perceptions of the respondents, the range of variation was presented in the figure. Based on the comments and reflections received from the expert panel participants, the NSDS framework is proposed as one of the heuristic tools for evaluating the achievements of the NAP. Sustainability screening is intended to be repeated from time to time to monitor the development achieved.

4.4. Complementary data sources to add stakeholders' perspectives

During the collection of documentary and participative data, the sources appeared somewhat biased as presented above, and it was necessary to consider further data sources to establish adequate multiplicity of stakeholder views. The complementary data sources are presented here. Individual citizen communications are presented in Chapter 4.4.1, media analysis in Chapter 4.4.2, focused enquiries of selected experts in Chapter 4.4.3 and cost-effectiveness analysis in Chapter 4.4.4.

4.4.1. Frequently asked questions from individual citizens

Because the representation of individual citizens and NGOs was limited in the stakeholder analysis and workshop participation, it was necessary to find other ways to give floor to the voices of those potentially affected by the use of plant protection products and the implementation of the NAP (e.g. Reed et al. 2014; Koskinen 2010; Starik 1995). To highlight the opportune questions and problems of individual citizens concerned about plant protection products, a sample of citizen references was analysed that had been recorded by the officials at Tukes in internal working files (22 issues in total). The communications represented a range of issues concerning the authorisation and use of plant protection products. These communications are recorded at Tukes for internal training purposes as frequently asked questions and thus cover a range of different themes. The messages were sanitised to make it impossible to identify any personal details, locations, time of communication, active substance or product information or company details. It should be noted that these communications do not represent the average perceptions of the Finnish population as people usually contact the authorities first when they have been strongly harbouring a grievance, and therefore these examples can be considered as just the tip of the iceberg. However, they are a good illustration of the variety of discussion themes and citizen concerns about the sustainable use of plant protection products. These citizen references were used as part of the material for the discourse analysis as outlined in more detail in Chapter 4.2.3; the analysis is presented in Chapter 6.3.

4.4.2. Media analysis of the use of plant protection products in agricultural trade papers

Lyytimäki (2012a) highlighted the importance of taking media coverage into account as a key factor in the formulation and implementation of environmental policies aimed at broad-based actions. Similarly, media coverage can be analysed to reveal the perceptions about the achievements of those policies. In my study, a complete media coverage evaluation on all the issues included in the NAP was not possible, so I instead analysed the discourse on implementing particular NAP actions, as published in selected agricultural trade papers read widely by farmers in Finland between 2012 and 2014. A sample of 21 clippings including 34 separate professional articles published in six agricultural trade papers over the period 2012-2014 were analysed for the discourse on the sustainable use of plant protection products. The clippings were collected through the regular media monitoring by Tukes and filed by the experts. In some cases, the clippings were extracted from a special issue of the paper concerning a particular theme. The papers were *Maaseudun Tulevaisuus* (national newspaper on agriculture; circulation 80 000 copies three times a week in 2013), *Landsbygdens Folk* (national Swedish language newspaper on agriculture; 9 000 copies once a week) and *Juvan Lehti* (local newspaper; 4 000 copies once a week), *Käytännön Maamies* (professional journal on agriculture; 17 000 copies once a month), *Koneviesti* (professional journal on machinery; 32 000 copies 18 times a year) and *Puutarha ja Kauppa* (professional journal on horticulture; 3 000 copies 20 times a year).

The sampling did not extensively cover all the articles published during that period, but rather assorted articles on the basis that they had been considered significant enough to be saved in the shared files of the Plant Protection Product Unit at Tukes. The total sample included 34 separate articles in 21 clippings, with text types including 16 news items, six interviews, four guidance articles, three opinions or columns, three popularised study reports and one editorial. The thematic framework about the NAP issues as presented in Table 4.1 was used in the media analysis. Because the majority of the articles were about the amendment of the restriction of use of plant protection products along the water courses, these articles were looked at in more detail, as presented in Figure 6.3 in Chapter 6.4.

4.4.3. Focused enquiries of selected experts

Analysis of the data collected in the focus group discussions led me to consider whether targeted discussions with selected experts as key informants would still be necessary to add insights on specific aspects within the different areas covered by the NAP, and more specifically to discuss the proposed ways of gathering evidence for the evaluation in their expertise areas. This kind of phased data collection and analysis was inspired by the grounded theory, although it did not exactly comply with the model of its masters (Glaser & Strauss 1967; Glaser 2001; Corbin & Strauss 2008). The issues discussed varied from field to field, and were specific to each person's particular area of expertise. The aim of these enquiries was to define and focus the analysis on questions specific to those experts (Vaughan 2011).

In order to maintain the anonymity of the respondents, individual communications are not reported here, but all together 18 persons were consulted in several face-to-face discussions, video conferencing, by e-mail exchange and by means of documents and literature they provided during the years 2014-2015. The areas of expertise covered by the consultations were:

- PPP authorisation system, risk mitigation and implementation of the NAP;
- cost of human resources allocated to NAP actions;
- IPM research and extension;
- monitoring of plant protection products in the environment;
- occupational health;
- organic farming;
- sales and use statistics of plant protection products;
- training of professional users.

These expert consultations provided material for the discourse analysis (see Chapter 4.2.3). Because of the targeted nature of the consultations, they covered only a few of the specific themes in the thematic framework for content analysis (as presented in Table 4.1 in Chapter 4.2.2), although they provided valuable insights for the NAP theory building from their particular perspectives, while simultaneously offering possibilities for collective learning and knowledge-brokering (Ison 2010). In the following chapters, the chosen quotations represent the most succinctly expressed views of the respondents collected during the course of this study. To safeguard the anonymity of the respondents in a situation where the actors are mostly well known to one other, I decided not to report their identification details, and in a few cases the quotations have been slightly rephrased into a more general form, for instance leaving out references to their employers or not specifying their areas of expertise. The codes given after each quotation locate them in the archiving system of my research material. All translations are mine.

4.4.4. Cost-effectiveness analysis

Due to the multi-actor nature of the NAP, in this study it was not possible to gather comprehensive economy data on projects and actions from all responsible actors beyond the preliminary calculations during the preparation of the NAP. Many NAP objectives are also carried out as official duty, and therefore not calculated separately from other tasks at public agencies. However, to illustrate the order of magnitude of the inputs, a tentative cost-effectiveness analysis (Royse et al. 2010, p. 258-262; Worthen et al. 1997, p. 361-364) was performed as a case study for two projects at Tukes, as separately mentioned NAP objectives: under NAP measure 4.3.2 (MMM 2011a, p. 13), development of risk assessment-based use restrictions on plant protection products along surface water courses (project code 111KSM008), and under measure 4.6 (MMM 2011a, p. 19), development and implementation of the training and examination system for professional users of plant protection products (project code 132KE013).

Restrictions of use are set as buffer zones to prevent risks as a precondition of authorisation for plant protection products (Tukes 2013 c, 2015a, d). During the preparation of the NAP, the aquatic buffer zones were based on the inherent toxicity to aquatic organisms, without taking into account the risk from exposure as a result of the actual use rate. The interpretation of water courses only included rowable channels, thus excluding smaller water courses where exposure to unintended spray drift was assumed to lead to higher exposure due to dilution in a smaller volume of water and proximity to adjacent fields. In addition, the farmers complained about the fairly wide buffer zones making their crop protection practices more complicated on the fields next to the water courses. Therefore, a project was launched to redefine the aquatic restrictions taking into account the actual risks to aquatic organisms and the aim of simplifying farming practices (Tukes 2015d). The project was intensively reported in the professional newspapers analysed (see Chapter 6.4).

Similarly, prior to the NAP, the existing special qualification system for PPP users covered only a few active substances on the market classified as highly toxic substances, and no official training and approval system for trainers and examination organisers was in use. To fulfil these requirements of the Sustainable Use Directive, it was necessary to develop and implement an extended training and examination system for professional users, distributors and advisors. Tukes being the competent authority, and thus the responsible actor, started a project to develop and implement the training and examination system and material for the trainers (Tukes 2014b).

In this exercise, personnel costs were calculated on the basis of the total of working hours of the Tukes staff dedicated to each project. Personnel costs were calculated either on the basis of the mean salary at Tukes in 2011-13 for the aquatic restriction project or in 2013 for the training system project (Tukes 2014a), and respectively on the basis of the hourly absorption cost as calculated for Tukes' fees under public law, where the indirect costs were incorporated (TEM 2013). The outcomes of the projects were calculated for yearly reports for management by results at Tukes (Kallio-Mannila 2014, 2015). The cost-effectiveness analysis of these two projects is presented in Chapter 5.4.2 and the detailed calculations in Appendix 2.

4.5. Synthesising on various data sources using systems thinking methodologies

Following the analyses of data sources as described above, systems thinking methodologies were used to synthesise the outcomes of this study, as explained in this chapter in detail. Chapter 4.5.1 describes how systemic intervention was used as the synthesis tool. The formulation of the root definitions for specific interventions will be explained in Chapter 4.5.2. Critical systems heuristics and the evaluation influence pathways will be discussed in Chapter 4.5.3. The construction of the logic model and the systemic programme logic for the NAP will then be

presented in Chapter 4.5.4. The formulation of evaluation questions, procedures and expected measures of success will be explained in Chapter 4.5.5, and the process of selecting the heuristic tools in Chapter 4.5.6.

4.5.1. Systemic intervention as synthesis tool

Based on my overlapping role as an implementer of the NAP and simultaneously as a researcher and evaluator of its implementation, this entire study can be seen as a practical solution of systemic intervention as per Midgley (1997, 2000, 2003, 2010), who asserted scientific observation as intervention. The practice of systemic intervention benefits from the situational application of multiple methodologies.

The systems methodologies used aimed to construct conceptual models for different interventions, looking at the NAP from the angles of the different actors involved, in order to build and make explicit the programme theory behind the Finnish NAP as the synthesis of the whole. All the data gathered was used as material for analysis and synthesis via the reflective circle of action research between the volunteering participants. Rounds of expert panel discussion on the drafts involved the volunteer experts with the reflective practice of collective learning (Ison 2010), and provided me with reflections from the stakeholders about the evaluation tools to be constructed. The problem situation of my study could be understood in terms of a series of systemically interrelated research questions, each of which might need to be addressed using a different method (Midgley 1997). The results of my purposeful sampling and analysis of the empirical data, as presented in Chapter 4, are incorporated into the synthesis. The views of different participants and stakeholder groups from varying sources were amalgamated, and the different methods of analysis were applied "[…] so that the total method used is different from its contributory parts" (Midgley 1997).

Elements of the NAP as a complex but purposeful human action system were analysed using the systems thinking methods of Ison (2010), Jackson (2000, 2003, 2006) and Ulrich (1994, 2000). A systemic intervention approach was used to explore the expectations, roles and responsibilities of the actors at different hierarchical levels of the system. Comparative analysis of the data gathered from various sources with different methodologies, as presented above in Chapters 4.2-4.4, was performed to categorise and summarise the data (Bernard & Ryan 2010; Corbin & Strauss 2008; Kiviniemi 2001). In order to condense the stakeholders' perceptions about the implementation status of the NAP and their expectations for its evaluation, systemic intervention was applied to organise the analysis to answer the message design logic questions presented in Chapter 4.2.1: 'Who said what to whom through what medium for what purpose despite what distractions with what results?' (Willard 1989), and finally to integrate the results from separate steps of analysis to a systemic view.

Making the implicit assumptions and expectations mutually visible empowers the stakeholders to build capacity, self-evaluate and set realistic targets for their performance (Fetterman et al. 1996; W.K. Kellogg Foundation 2004). The stakeholders were thus involved in the whole process of planning, conducting the activities and evaluation of the programme. A forum for this process was provided by inviting voluntary participants to expert panel work via e-mail, to exchange their responses and comments and to review my draft outcomes and results using a member check procedure, where the final study report was checked and commented by the participants before publishing it (Flick 2007, p. 33-35; Lindqvist 1999; Varho & Huutoniemi 2014). The systemic enquiry process of critical systems practice (Ison 2010, pp. 243-265) as a way of exercising an interactive model throughout the study process was intended to enable the collective learning of the NAP community (Schön 2010) within the expert panel work, in parallel to my own desk research (see Figure 4.1).

4.5.2. Deriving root definitions for NAP interventions using Soft Systems Methodology

The NAP is a typical human activity system, and thus it was considered appropriate to explore it using soft system methodology. It is characterised by a loop where experience-based knowledge leads to purposeful action in relation to the perceived situation, and the action in turn creates new public and personal experience of the situation, which yields further experience-based knowledge (Checkland 1988). Formulating the root definitions using the CATWOE framework in the situation is the starting point of the SSM enquiry process (Checkland & Scholes 1990, pp. 27-53), as presented in Table 4.4. To explore the implicit assumptions behind the NAP, the root definitions for the specific NAP interventions were derived, as presented in Chapter 5.2.

Table 4.4. The CATWOE framework of SSM (Checkland & Scholes 1990).

C = Customers (victims and/or beneficiaries)
A = Actors ("we")
T = Transformation process: conversion of input to output
W = Worldview that makes this T meaningful in context
O = Owners (those who could stop T)
E = Environmental constraints (elements outside the systems taken as given)

Careful definition of the responsible customers, actors and owners of the transformation processes divided into specific interventions was matched within the framework. Different worldviews of their roles were considered to define different expectations concerning the transformation processes. Transformation means conversion of input to output within the system, expected to happen when implementing the NAP, and framed by the constraints to be taken as given. This analysis helped to consider the boundary definitions of the NAP as a purposeful system, as presented in detail in Chapters 5 and 6.

Root definitions were formulated for specific training interventions, requirements on specific uses, information, control, research and monitoring (as presented in Figure 5.1 and again in Figure 3.1 of Appendix 4), according to the five types of measures proposed in the Thematic Strategy on the Sustainable Use of Pesticides (EU 2006). First, each type of intervention was examined separately within the CATWOE framework to draw up the logic model for each intervention, as presented in Tables 3.1. to 3.6. of Appendix 4, and the root definitions were further utilised in the formulation of the programme theory for the NAP, as explained in Chapter 4.5.4.

4.5.3. Critical Systems Heuristics and evaluation influence pathways

The set of twelve questions of Critical Systems Heuristics (CSH) of Ulrich (1994, 2000; Ulrich & Reynolds 2010) were designed to identify, visualise, critically reflect and discuss the assumptions and normative content underlying a specific solution to a problem (Pohl 2014). This framework allows for debate between experts and non-experts, specifically aiming to emancipate those not involved but affected, and instructs the responsible actors to consider the situation from the perspective of those who cannot have a say in the matter. It is unlikely that all stakeholders the programme or policy could affect, would ever be able to participate in its planning as equal partners. Therefore, those who are actually participating should position themselves in the situation of those who cannot rationally advocate their own stakes (for instance future generations, non-human beings, the environment). For this purpose, the fourth level, the legitimating questions, have been included in the CSH model to polemically employ the boundary judgements concerning the values of the participants. In this respect, the experts are not more expert than laypersons. In addition to the prevailing reality, it considers participant

expectations concerning the desired reality, namely the course of the transition intended with the solution, in this case the NAP. Applying this tool helps participants learn from other stakeholders' perspectives systemically (Ulrich 1994, pp. 301-314).

The 12 CSH question framework was used to enquire into the diversity of the stakeholders' expectations, perceptions, values and worldviews on the boundary judgements for framing the NAP. I modified the most recent version of the framework (Ulrich & Reynolds 2010, s. 279) for the purpose of evaluating the Finnish NAP. The modified questions were posed to the expert panel participants in tabular form, as presented in Chapter 2.1 of Appendix 4. The individual responses from the experts were consolidated anonymously and circulated for further comments. The gathered views were used as material for answering research questions 1-5. The structure of the results chapters was formatted based on the analysis, and the responses from participants are presented throughout Chapters 5-9.

The matrix of evaluation influence pathways (Table 4.5) of Mark & Henry (2004) was combined with the CSH framework to enquire into alternative mechanisms that could mediate the influence of NAP evaluation likely to be performed and to explore the possible uses and users of an evaluation of the Finnish NAP. The compiled CSH responses from the experts were amalgamated with the mechanisms that may mediate evaluation influence in order to approach the possible influence pathways on which the Finnish NAP is assumed to act. This matrix enabled the heuristics to be analysed on different types of expected evaluation outcomes at individual, interpersonal and collective levels, including general, cognitive and affective, motivational and behavioural processes and outcomes, for all the twelve aspects of the CSH. The results are presented in Chapter 7.1. The results of this exercise provided material for formulating the programme theory as presented in Chapter 6.8., and for drafting the proposal for evaluation questions for different forms of evaluation, as presented in Chapter 7.2. and in Chapter 1 of Appendix 4.

Table 4.5. The matrix of influence pathways that mediate evaluation influence based on Mark & Henry (2004, p. 41). This matrix was amalgamated with the responses from experts on the 12 questions of CSH.

Type of process/outcome	**Level of analysis**		
	A. Individual	B. Interpersonal	C. Collective
1. General influence			
2. Cognitive and affective			
3. Motivational			
4. Behavioural			

4.5.4. Logic model and Systemic Programme Logic for the NAP

Programme theory can be defined as a configuration of the prescriptive and descriptive assumptions held by stakeholders on how a programme is supposed to work. It can be understood as a logic model of causal chain of assumptions concerning the resources, activities and intended outcomes linked with the goals of the programme. The terms programme theory, logic model and programme logic are often used interchangeably, although they serve separate purposes. A logic model or programme logic is a graphical representation of the relationship between the activities and the expected outcomes to highlight programme components such as inputs, activities, outputs and outcomes, to make the assumptions of a programme theory visible (Chen 2005). The structure of the programme logic can be illustrated for instance as in Figure 4.2.

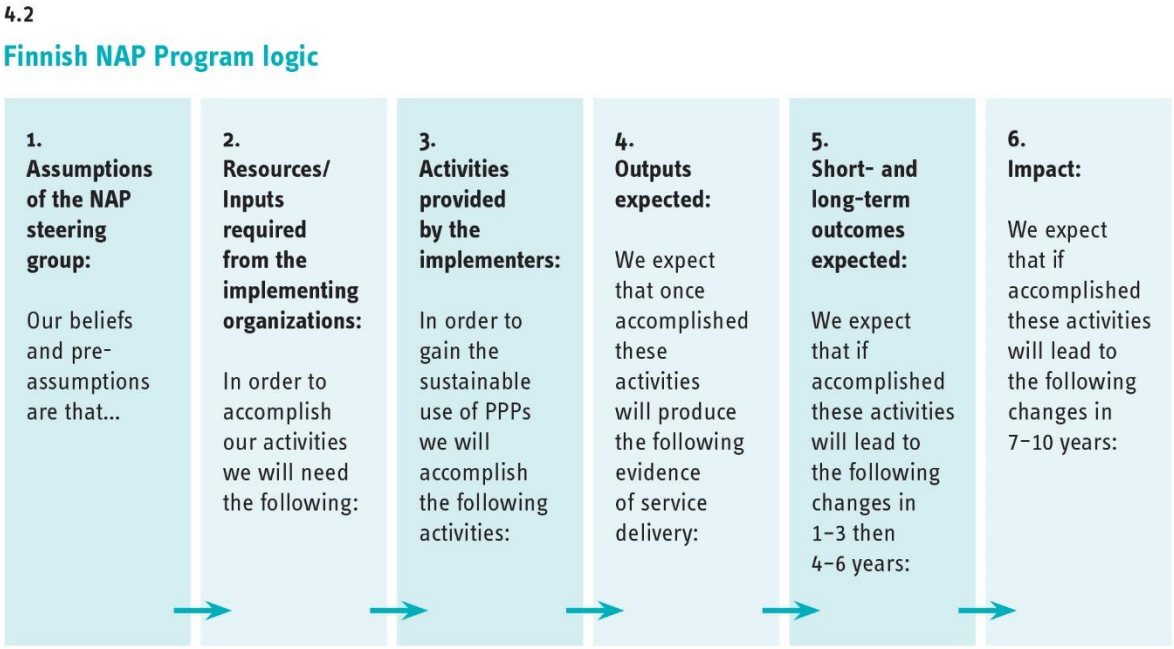

Figure 4.2. The structure of a programme logic based on the W.K. Kellogg Foundation model (2004).

Theory-based evaluation (Chen 2005; Mark 2003; Mickwitz 2003) demands a holistic approach to use the conceptual framework of programme logic for making explicit the preliminary assumptions and beliefs of intervention theory as well as the expected outcomes and impacts of a programme. Based on its conceptual framework, evaluation can explain how and why a programme achieves its results by illustrating its means of implementation as well as underlying mechanisms that influence it. The conceptual framework can help evaluators 'read' stakeholders' implicit intervention theories in a systematic way. The conceptual framework also suggests which assumptions might be weak or which elements of a theory are missing (Chen 2005). The programme theory of the Finnish NAP system could be made explicit based on boundary critiques using the three heuristic tools.

As a synthesis of the SSM and CSH methodologies described above, the common features of the separate NAP interventions were used to formulate the explicit programme theory for the NAP. The conceptual framework of logic models prepared by the W.K. Kellogg Foundation (2004) was used to visualise the stakeholders' assumptions behind the programme logic and allowed a holistic approach to the procedures for evaluating the Finnish NAP (Chen 2005, p. 31). A visualisation of the Finnish NAP programme logic is presented in Figures 3.2-3.7 of Appendix 4. The systemic evaluation framework of Boyd et al. (2007) incorporated with the systemic programme logic of Wasserman (2010) offered a basic model for drawing up the practical procedure for evaluating the NAP as presented in Chapter 6.8 and illustrated in Figure 6.6, and summarised again in Figure 3.2 of Appendix 4.

4.5.5. Evaluation questions, procedures and expected measures of success

To make the Finnish NAP evaluation tools applicable for various purposes in future, it was evident that different approaches need to be covered. Owen & Rogers (1999, p. 41-49) divided the evaluation enquiries into five categories or forms, as proactive, clarificative, interactive, monitoring and impact evaluation, and provided practical frameworks for these options. Because each form of evaluation has its specific purposes, principles and philosophical assumptions behind it, the practical methodology to be chosen for conducting an evaluation depends on these. Considering the evaluation influence pathways recognised above, a range of suggested evaluation questions were prepared to be compatible with the particular context of evaluating the Finnish NAP, and the proposal of practical frameworks and approaches for different forms and phases of evaluation was circulated for reflection by expert panel participants. The evaluation forms are discussed in Chapter 7.2, and the questions proposed for different forms of evaluation are presented in Chapter 1 of Appendix 4.

Based on the expert panel reflections and other material gathered throughout this study, the expected evidence of success as proposed appropriate measures and indicators for specific interventions of the NAP were collected in Chapter 8.

4.5.6. Process of selecting and assessing heuristic tools

The NAP and its implementation is a complex system with multiple stakeholder views, producing multiple ways of framing its evaluation. I therefore looked for some heuristic tools to address the boundary questions of framing its evaluation properly. When I started this research, I intended to create specific tools for evaluating the achievements of the Finnish NAP in particular. It soon emerged that oceans of literature have been published on different angles of public policy programme evaluation, with a plethora of researchers developing their own specific tools and frameworks, being totally convinced of the superiority of their own. Thus, instead of struggling to create further tools, I focused on familiarising myself with existing tools that I could test with my expert panel, and modifying and recommending some of them for the specific purpose of evaluating the NAP. Therefore, the heuristic tools I propose in this chapter are not my own design but workable, adapted examples of appropriate published tools that have been tested with experts who will most likely be involved with the final evaluation of the NAP. The expert panel work and reflections can therefore be considered as opportunities for collective learning to prepare to evaluate the NAP activities and achievements.

As a result of an intensive enquiry into the literature, several other frameworks were also recognised, but only the most promising tools were selected for further consideration and testing with the stakeholders. Based on the experiences gained from the testing with experts, I settled on proposing three heuristic tools.

First, the CSH framework was used to examine the diversity of the stakeholders' expectations, perceptions, values and worldviews regarding the boundary judgements for framing the NAP and its evaluation, as presented in Chapter 4.5.3. The twelve questions of CSH are summarised in Chapter 2.1 of Appendix 4.

Second, the principles and criteria for assessing the state of national sustainable development strategies (NSDS) in the framework of Cherp et al. (2004) were scrutinised, as presented in detail in Chapter 4.3.4. The authors intended the framework to be used periodically for screening the achievements of national endeavours towards sustainability. The questionnaire was adapted to portray the Finnish NAP conditions, and again tested with the expert panel participants. Responses were received from individual experts, and a group of participants additionally volunteered to test and comment on it as a team, thus allowing for a general group discussion on

sustainability criteria from their own perspectives. The individual as well as team responses were amalgamated. The sustainability screening framework is presented in Chapter 2.2 of Appendix 4.

Third, the procedure for finding and ranking the limiting factors was tested within the stakeholder workshop, as presented in detail in Chapter 4.3.3. The LFA framework is partly the opposite of the NSDS framework, which seeks to highlight the progress made, whereas LFA tackles the areas where least progress is anticipated. The two tools therefore complement on another nicely. The LFA questionnaire, with 16 limiting factors identified by the stakeholders and grouped by five themes, is presented in Table 2.3 of Appendix 4.

Fourth, the analysis of the Finnish NAP revealed insufficient consideration of the programme theory laying down the assumptions on how the NAP interventions are considered to work. It became necessary to start preparing the evaluation with making the NAP programme theory explicit, as presented in Chapter 4.5.4 above. Therefore, the Systemic Programme Logic (SPL) framework can also be considered as a heuristic tool for evaluation, and it was included as a candidate for recommended evaluation tools.

As a conclusion, the four tools to be proposed are:

- Critical Systems Heuristics (CSH: Ulrich 1994, 2000; Ulrich & Reynolds 2010)
- Sustainability screening using the framework for evaluating National Sustainable Development Strategies (NSDS: Cherp et al. 2004)
- Limiting Factors Analysis (LFA: Gullison & Hardner 2009).
- Systemic Programme Logic (SPL: Wasserman 2010 incorporated with Boyd et al. 2007).

The process of selecting, assessing and proposing the heuristic tools is illustrated in Figure 7.1.

An applicability assessment of the four evaluation tools for the Finnish NAP was conducted in the light of critical evaluative questions. The criteria of Mickwitz (2003) aim to assess whether programme evaluation questions adequately consider the environmental sustainability issues. I modified his 10 questions to assess the applicability and to illustrate the different purposes of each of the four heuristic tools I recommend using to analyse the process of implementing the Finnish NAP. Ison (2010, p. 154) emphasised the contextualisation of the practice for the situation where the relevant systems thinking tools, techniques and methods are intended to be used. This can be assisted by considering four basic questions. The expert reflections also validated the applicability of the tools. The assessment of the applicability of the four heuristic tools to the Finnish NAP is presented in Chapter 7.3.

In order to assist with the practical planning of an evaluation of the NAP, Appendix 4 was prepared as a standalone document to summarise and provide guidance on the use of different forms of evaluation, evaluation questions and heuristic tools for a range of purposes and needs for a systemic practice of evaluation.

Considering the last research question, the modes of stakeholder engagement and power sharing in the implementation actions of the Finnish NAP were assessed in the light of criteria established by van Kerkhoff & Lebel (2006) and Walls et al. (2011). The key tasks mentioned in the NAP document (MMM 2011a) and summarised in Appendix 1 were assessed according to their modes of engagement and power sharing. The results are presented in Chapter 9.1.

4.6. Summary of materials and presenting the results

The study phases and the empirical materials I collected are summarised in Table 4.6. below. The phase numbering refers to Figure 4.1, and the materials were discussed in more detail in respective sub-chapters of Chapter 4 above.

Table 4.6. Materials gathered during different phases of my study process.

Phase	Material
1. Study plan	The evaluand = the Finnish NAP
2. Literature search concerning the evaluand (= the NAP issues). Content analysis, framing and organisation of the literature as logical entities.	Literature concerning the evaluand = the Finnish NAP: -published studies concerning the priority areas of the NAP -NAPs of several other Member States.
3. Literature search concerning the theoretical grounds: philosophical, theoretical and methodological references.	Literature concerning the theoretical framework.
4. Paradigmatic and methodological choices.	Methodological guidance.
5. Document analysis: argumentation analysis of the NAP: Message Design Logic. Theory-driven content analysis applying the thematic framework for the analysis. Discourse analysis.	- Finnish NAP document + comparison to other MS' documents. - Statements from stakeholders on the NAP proposal - FAQ and citizen communications - Professional articles in media - Targeted enquiries with key informants = selected experts.
6. Stakeholder analysis. Focus group discussions with different interest groups.	Responses from the focus groups: - residents - experts.
7. Stakeholder workshop.	- Assessment of the applicability of the FVO list of indicators to Finland. - Ideas and proposals for evaluation measures, discussed and formulated during deliberation in stakeholder workshop.
8. Limiting Factors Analysis.	Responses from workshop participants to the limiting factors questionnaire.
9. Sustainability screening.	Responses of the expert panel participants.
10. Expert consultations. Variable methods of targeted enquiry: meetings, questionnaires, e-mail correspondence.	Key informants = selected experts. - To fill data gaps, add targeted data about specific issues. - To offer certain experts an opportunity to reflect on the evaluation of their specific areas of expertise.
11. Complementary data sources: cost-effectiveness analysis.	Two projects at Tukes as examples: - refining aquatic risk mitigation measures - preparing training and certification system + material.

12. Analysis of the material and building of the synthesis tool: expert panel work; triangulation in data gathering and analysis.	- Comments and responses received about proposals submitted for discussion among volunteering experts. - Workshop records. - Critical Systems Heuristic questionnaire. - Sustainability screening.
13. Analysis of the material, synthesis and theory development. Desk work by the researcher. Comparative analysis, conceptualisation. Systems methodologies: Critical Systems Thinking, Soft Systems Methodology, Reflective Practice.	- Previously published literature. - All material gathered so far. - The synthesis tool. - Systemic model (programme logic) for the evaluation. - Proposals for heuristic tools.
14. Credibility evaluation, peer review. Careful documentation. Reflections by the researcher. Applicability. Member checking with participants.	- All material gathered so far. - Responses and comments from expert panel members.
15. Report writing and publication.	

My analysis methods proceeded from classical qualitative methods of argumentative, content and discourse analysis of various data sources to systemic intervention and soft systems methodologies that were applied with the expert panel. The classical qualitative methods were applied primarily to describing the more static situation to be understood with the first two research questions, whereas systems methodologies were used to understand the actors' dynamic pursuit of the pre-set goal of increasing sustainability in the three latter research questions. Both methodologies were utilised vice versa to create the synthesis. In order to avoid duplication, I decided not to report the analysis steps of every single data set separately, because all five research questions essentially draw from the data gathered from all the different sources.

Surprisingly, after I started to write my results in this order, I found Midgley (2000, p. 367-396) explaining how a similar structure with a four-step approach was used in a systemic intervention study by Boyd et al. (1999). Regardless of the different objects of the studies – their study being about homeless adolescents – the stepwise approach described by Midgley (ibid. 2000, p. 371-372) is also a good representation of my attempt to deal with the complexity of the NAP. Therefore, the structure of my results is following: in the first phase, I identify key elements to describe the Finnish NAP in terms of systems thinking (Chapter 5), and then raise the expectations of different stakeholders in the second phase (Chapter 6); the third phase contains planning on how to realise the evaluation and gather evidence of its success (Chapters 7 and 8); and finally the fourth phase discusses the involvement of different stakeholders (Chapter 9). Along with presenting the results, I also discuss similar findings published in other studies throughout the results chapters. As a summary of my results, Appendix 4 presents the recommended procedures and heuristic tools as a 'cookbook' for instructions on how to practically conduct the evaluation of the Finnish NAP for those who are less interested in looking at the theoretical part of this study.

In the following chapters, the selected quotations represent the most succinctly expressed views of respondents, as coded in my materials. As explained earlier in Chapter 4.4.3, the identification details of the respondents are not given and in a few cases the verbatim quotations have been slightly generalised in order to protect their anonymity.

5. The Finnish NAP as a purposeful system

This chapter addresses my first research question, to characterise the Finnish NAP as a purposeful system of human action. The elements, their relationships and boundaries, as well as the inputs and outputs of the Finnish NAP are outlined here. A description of the NAP is given in terms of systems language, recalling Flood & Carson's (1988, p. 7) description of a system as an assembly of elements related to one other in an organised whole and capable of behaviour to change their significant properties in a flow of materials, information or energy between the elements, thus defining the boundaries of the system. As presented earlier in Table 4.4, Checkland & Scholes (1990) distinguished customers, actors, transformation processes, worldviews, owners and environmental constraints as the building blocks of soft systems of human action.

5.1. The roles of actors involved in the implementing of the NAP

This chapter discusses the roles and tasks of the customers, actors and owners of the processes within the purposeful system of the NAP. The NAP is a policy programme with multiple actors involved. The frequency of responsibilities of different organisations is variable and not always exactly defined in the NAP document. A summary of the responsibilities is presented in Table 5.1. below. The majority of the actions primarily require the authorities to organise interventions that are mainly directed at users, who in reality are in charge of deciding on the sustainability patterns of each use event in their practice. Because less input is anticipated from private sector stakeholders or individuals, the NAP will likely remain a top-down macro level document in administrative context (Turnpenny et al. 2008, p. 764).

Similar patterns occur in other countries. Because the competent authorities are usually responsible for the preparation and adoption of the NAPs in the Member States, the voices that emerge from the NAPs are typically those of the authorities. Furthermore, since the evaluation of the Food and Veterinary Office (FVO 2014b) also focused on the implementation of legislative provisions, the actors explicitly mentioned in the evaluation are mainly authorities. Instead of authority-driven activities, a few Member States (e.g. the UK) implement their NAPs on a voluntary basis with private sector stakeholder initiatives. It is noted that many NAPs specifically refer to the efforts made to involve all stakeholders in the development of the plan. However, some of the weaknesses noted by the FVO suggest a lack of input from key stakeholders in some of the specific areas of expertise.

Although the users of plant protection products are pivotal actors who have an influence on the achievement of the targets set in the NAPs, the FVO did not analyse the role given to users in the NAPs. While Latour (2005, p. 63-86) emphasised the role of objects of intervention as competent agents themselves, users seem to be understood as merely objects of authoritative actions in the NAP. Distinguishing between professional and amateur users implies different requirements for the two users groups in terms of training, certification, knowledge brokering and registration of the plant protection products at their disposal. In most countries, the emphasis of the NAP is on professional users. Amateur users are generally seen as consumers informed mainly by retailers and protected by means of general consumer protection legislation, while the focus in the NAPs is mainly on providing specific information and communication about the sustainable use of plant protection products to professional users. However, if we consider the results of Ahmed et al. (2011), the role of amateur users may have been underestimated in the first round of NAPs based on an assumption that products registered for amateur use only account for a small part of total PPP sales.

Table 5.1. Frequency of the participating organisations involved as responsible actors for specified measures and key tasks in the Finnish NAP. The two frequency columns refer to different chapters of the NAP document where the tasks and responsible actors are detailed slightly differently.

Actor responsible for specified measures and key tasks	Types of intervention	Number of references in Chapter 4 (pp. 10-30)	Number of references in Chapter 6 summary table of (pp. 31-35)
Ministries	Funding Legislation General steering	4	0
Competent authority: Tukes	General steering Jurisdiction of legislation Surveillance, control Advice Information	13	13
Other authorities	Surveillance, control, monitoring Advice Information	8	4
Natural Resources Institute LUKE	Research Advice Information	5	7
Finnish Environment Institute SYKE	Environmental monitoring of PPPs Research	1	7
Extension service organisations	Advice Training Information	5	4
PPP industry	Advice Information	1	1
Retailers	Information	2	2
Other trade associations	Advice Information	1	1
Farmers and other professional users	Specific requirements on safe use	3	0
Employers	Advice and information on safe working procedures	1	0

A systemic view on the multiple roles of the main actors within the NAP as a purposeful system to reduce the risks from plant protection is presented in Table 5.2 below. Several actors have multiple, interwoven roles within the system: as clients and beneficiaries of NAP activities, but who are simultaneously also subject to specific requirements, receiving services and having tasks as implementers of NAP activities. A stratified model of the roles of actors (see Mark & Henry 2004) involved in implementing the NAP was distinguished at different systemic levels, as individual, local-regional, national and international levels. The table is not meant to be exhaustive, but rather exemplifying the multiplicity of different roles and tasks.

Table 5.2. Examples of the roles of the main actors involved in implementing the NAP. Please note that the same actors may have parallel roles as beneficiaries of the NAP, as objects of NAP actions and as providers of implementing tasks and services. The systemic level gradually evolves from individuals to local, regional, national and international levels, from the top towards the bottom of the table.

Actor	**As client: benefits received**	**As object: requirements to meet**	**As implementer: services provided**
(Professional) user	- information and knowledge gained - safer working habits - improved health from less exposure - good reputation	- participates in training and gets certification - chooses non-chemical alternatives when possible - practices IPM - obeys use instructions	- makes informed crop protection decisions - responsible for exposure - informs locals and bystanders
Consumers Bystanders General public	- improved health from less exposure - gain knowledge - satisfied with food quality	- receive information - avoid using chemical PPPs at homes	- require policy actions to ensure food safety - make informed product choices (food + chemical)
Non-human environment	- good biological and chemical state of the environment maintained - less exposure received	- conditions are applicable for farming (climate, soil) - necessary risk mitigation measures are applicable	- provides ecosystem services
Storekeepers Retailers	- gain knowledge - good reputation	- participate in training and get certification	- provide information to customers
Surveillance authorities	- gain knowledge - good reputation, transparency - trust of general public	- control officers are trained - adequate resources for conducting control measures	- organise control of trade and PPP use
Training and certification providers Advisers Spray equipment inspectors	- gain knowledge - professional esteem - good reputation	- participate in training and get authorisation - disseminate knowledge - training and inspections available for all sectors and all over the land	- organise training and testing events - provide extension services - disseminate knowledge - provide sprayer inspections
Advisory organisations Producer organisations	- good reputation of the field - members are satisfied	- information is accurate and reaches all members of the field - keep up to date with scientific advancement	- responsible for organising training and testing events - responsible for extension services available - disseminate knowledge and innovations
Other sectors, e.g. beekeepers	- less damage to beekeeping	- communicate with farmers and PPP users	- provide pollinating services
Research institutes	- research initiatives - good scientific reputation - get adequate funding ?	- keep up to date with scientific progress within the field - research projects are topical and address the knowledge gaps identified - inform about innovations - research results disseminated to practice	- provide extension and risk assessment with accurate research findings - monitor the state of the environment and residues in food commodities

NAP steering committee	-reliability, professional esteem - all stakeholders' agendas taken into account - resources used accountably	- NAP is implemented as planned - effective information exchange about safe crop protection	- target setting - evaluation
PPP industry Trade	- gets authorisations for PPPs - good reputation	- applications and products on the market fulfill legislative requirements - information is accurate	- provides information - responsible for the assortment of PPPs on the market - responsible for best PPP management practices - provides sales data
Competent Authority Tukes	- reliability, accountability - resources adequate for the tasks	- NAP is implemented as planned - all parties informed	- responsible for implementing the legislative requirements - authorises PPPs prior to release on the market - provides information - owner of the process: supervises the actors' tasks
Ministries	- reliability and accountability of governance - policy objectives fulfilled	- legislation meets EU requirements and international agreements	- responsible for legislation and international cooperation - owner of the process: legislative steering

Although not explicitly highlighted in the NAP, plant protection product users play the leading role in achieving its objectives. The user roles are therefore discussed here in greater detail than the other actors' roles. Because the main aim of the NAP is the reduction of risks and impacts for human health and the environment from the use of plant protection products, the ultimate *beneficiaries* are people (users improving their health via safer working habits, as well as consumers receiving less residue from their food commodities and drinking water) and the non-human environment, including non-target organisms (receiving less exposure and effects). The aims may be valued differently by different stakeholder groups, thus suggesting that views on ultimate beneficiaries may vary.

As the core means for reducing risks is to provide training and advice to professional users of plant protection products, the *primary clients* of the NAP activities are professional users who participate in training and obtain certificates. At the same time, professional users are the *primary interveners* whose practice affects the state of the environment and the quality of crops being produced. From the professional users' point of view, some incongruity may arise if the benefits of reduced risks are not necessarily easily perceived, while, on the other hand, new requirements make their plant protection practices more demanding and are perceived as disadvantages of the NAP. The roles of an implementer and the object of requirements are therefore essentially entangled, which may cause some contextual and motivational confusion.

The individual *user* is essential in all types of intervention. The plant protection decisions and practices of individual farmers are subject to the control of compliance with several legislations, including the requirements of the agri-environmental support system. The user chooses the appropriate methods, products and timing for pest control and is responsible for following the use instructions and for minimising the exposure of workers, bystanders and the environment. The user is responsible for following the requirements on specific uses, subject

to training and certification of professional users, gaining knowledge produced by the researchers and other information providers. Monitoring can be directed for instance to water courses adjacent to an individual farm. In addition to professional users, information is made available to amateur users, citizens, consumers and bystanders. In research type interventions, individuals can be either objects of observation, participants in knowledge production, or subject to knowledge brokering.

Locally and regionally, authorised *training and certification providers* and advisors are responsible for carrying out the intervention and disseminating good plant protection practices and IPM methods to local farms. At their best, inspiring and convincing trainers can persuade users and arouse self-reinforcement processes necessary for social learning, but the motivation is fundamentally generated to change their plant protection practices. Authorised inspectors control and maintain the shape of spray equipment on farms. Local and regional surveillance authorities control the trade and use of plant protection products. Many of the communications from citizens that were analysed called for intensification of and information about surveillance visitations performed locally, in order to make citizens aware of how the authorities control the use of hazardous chemicals such as plant protection products. On the other hand, increasing control would be challenging for the public authorities, who are forced to prioritise their work under the current pressure of reducing administration.

At national and international level, the *authorities* (Tukes as the competent authority and the Ministry of Agriculture and Forestry as authority responsible for PPP legislation) are ultimately the *owners* of the NAP processes, capable of steering and supervising but also breaking off the implementation tasks within the limits of European legislation and international agreements.

5.2. NAP as a purposeful action system: systemic intervention view

This chapter discusses the interventions and expected transformation processes within the purposeful system of the NAP. Five kinds of measures for implementing the NAPs in the Member States can be distinguished according to the Thematic Strategy on the Sustainable Use of Pesticides (EU 2006):

- requirements concerning the specific use of pesticides;
- increased control and monitoring;
- enhancing research;
- providing user training; and
- information.

As presented in previous chapter, these actions are carried out purposefully by competent organisations as agents of separate areas of expertise with separate providers, and they can be considered as separate interventions for making plant protection practices more sustainable. The objects or receivers of the services are also somewhat different (see Table 5.2). Thus, the NAP can be defined as a set of systemic interventions (Midgley 2000, p. 129), where purposeful actions are performed by an agent to create change in relation to a reflection on boundaries. These reflections on boundaries are partly addressed by the legislation (e.g. requirements for professional users, spray equipment, training programmes, etc. are defined in separate articles of the SUD) and more specifically, by the NAP Steering Committee and the organisations involved in the NAP. Consequently, as a policy instrument, the NAP can be considered a systemic intervention within the realm of farming systems research (Darnhofer et al. 2012).

As presented in Figure 5.1, it is practical to evaluate the NAP as a systemic intervention, where five kinds of intervention are united and related to one other, commonly aiming to reduce the risks to human health and the environment. The training of professional users of plant protection products is the core linked to other types of intervention, and therefore it is scrutinised in more detail. Although monitoring is presented as a separate action, conceptually it can be understood to produce measures of outcomes rather than behavioural changes or transformation processes alone. Therefore, it was not considered here as an intervention on its own, although it was included in the illustration as a separate box. A more detailed discussion on monitoring will follow in the next chapter.

5.1

Relationships between the intervention types in the Finnish NAP

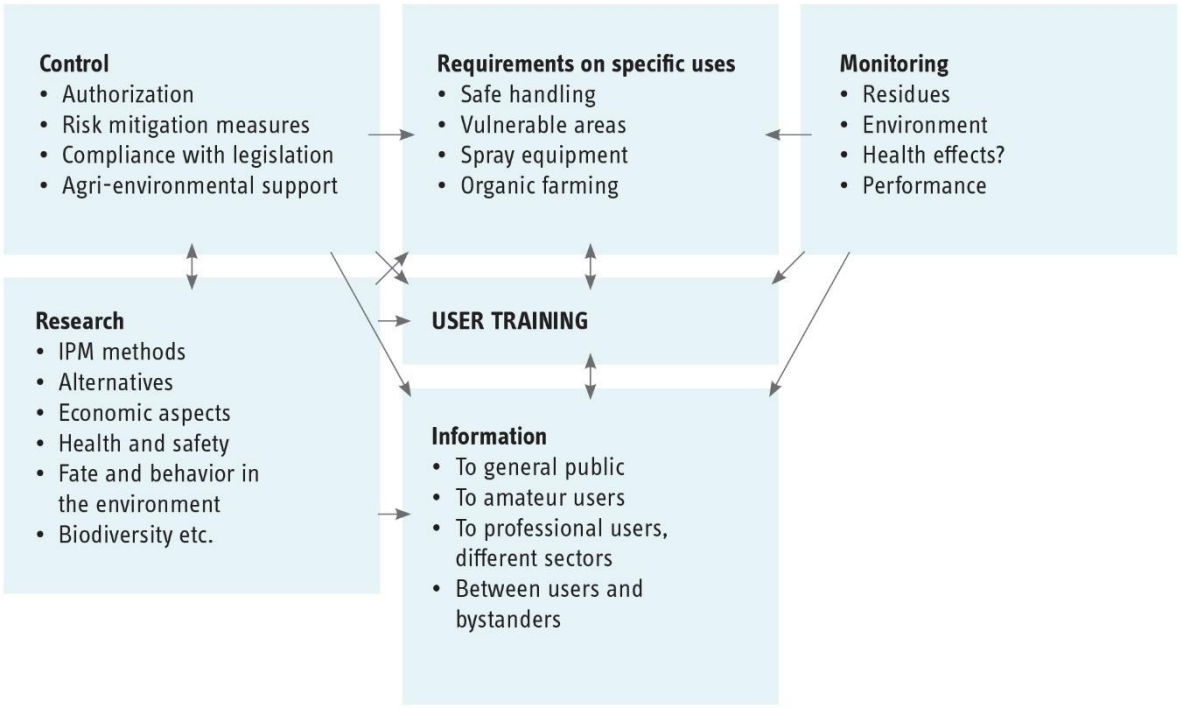

Figure 5.1. Relationships between the intervention types in the Finnish NAP.

The systems theory concept of *transformation* is used to mean the profound change in the thinking and outlooks of the human actors involved in the processes of a human action system. Interventions are expected to produce social norms that functionally guide the behaviour of participants to produce the desired change, although not necessarily stated explicitly in the programme design. In the case of implementing the NAP, transformation is perceived as a personal condition for a more general transition towards an intended goal of the policy programme, and technology transfer, for instance, can be the practical application to carry out the intended change. Hence, the process of making plant protection more sustainable essentially requires change at three levels of understanding (personal, policy and technical transformation). The NAP document does not clearly define who exactly is the targeted audience of the intended communication through the NAP. The premises of the argumentation in the Finnish NAP document are often implicit. The NAP does not explicitly mention the effective target of the action plan, who the involved actors must persuade. Who cares whether the goals are achieved or not?

To make the transformation assumptions transparent, root definitions for anticipated NAP transformation processes were formulated using the Soft systems Methodology (SSM) of Checkland & Sholes (1990). Different types of interventions in the purposeful system of the NAP can be characterised as transformation processes to carry out the desired conversion of input to outputs for human health, environmental quality, awareness, agricultural practices or administrative goals, as explained below. The root definitions reveal the assumptions that stakeholders and their peer communities have about how the interventions are expected to change practice. Hence, explaining their root definitions is essential to create the programme climate that supports the transformation processes.

Root definitions for the transformation process resulting from training users can be explained as follows. Aiming for the goal of human health, training users supports them in adopting personal protection measures, whereby their personal exposure decreases, and to adopt plant protection practices that cause less residue in plant products and hence less exposure for consumers. Aiming to reduce environmental exposure, transformation caused by user training would mean for instance adopting more precise spraying techniques that reduce spray drift outside the field and thus improve water quality and stop the decline of biodiversity. From an awareness raising perspective, the process of user training would aim to create collective learning on the safe handling of PPPs, to make the users adopt better plant protection practices, increase communication, and thus decrease the perceived risks in society. From the perspective of agricultural practices and IPM, providing users with training would mean that they prioritize non-chemical methods and choose the least harmful PPPs more cautiously and only for cases where it was absolutely necessary, they utilise spray drift reducing technologies and the risk of resistance can be avoided. The user training transformation process is aimed at the administrative goal of fulfilling the obligations of the Sustainable Use Directive, where the least harmful methods are in use, the precautionary principle is followed and plant protection practices become sustainable.

Similarly, the root definition for transformation that aims to reduce PPP use in specific conditions and areas to protect endangered flora and fauna and where sensitive populations may spend their time, is to expect causing less exposure to human health and the environment in these areas, if non-chemical control methods are prioritised in these cases. From the environmental perspective, reduced spray drift events contribute for instance to improved water quality and biodiversity. To enhance the understanding of the NAP goals, all relevant stakeholder groups should ideally receive active communications on PPP use in sensitive areas and/or specific conditions, which is assumed to lead to collective learning on the safe handling of PPPs, and thus lower perceived risks in society. Professional users will be knowledgeable about the specific requirements of sensitive areas and/or specific conditions. From the administrative perspective again, this process enhances compliance with guidance and legislation, including fulfilling the obligations from the SUD.

Research intervention includes transformation processes that should lead to increased knowledge about ways to reduce the exposure of professional and non-professional users and workers, as well as of consumers and bystanders. Studies on safe working methods and practices, appropriate use of personal protective equipment, human exposure to PPP residues via the food chain and the attitudinal perceptions about health risks would increase the knowledge base. Studies on the fate and behaviour of plant protection products in Northern climate conditions, as well as on their exposure and effects on non-target organisms, ecosystems and ecosystem services, including risk reduction possibilities, would be essential from the environmental perspective. The promotion of integrated pest management would require systemic research programmes to develop environmentally friendly plant protection practices for various plant protection problems, comparing alternative methods for conventional and organic farming, and studies on how the new techniques are best adopted into practice. Research on the communication and distribution of information would cover for instance the attitudinal change on how the new knowledge is adopted into plant protection practices, studies on the media coverage and

effectiveness of the knowledge brokering via information campaigns and on conditions of promoting collective learning resulting from NAP interventions. Research is also needed on the measures of success, such as risk indicators appropriate for Finnish conditions, and studies assessing the impacts and effectiveness of the policy options, measures and targets of the NAP with regard to the sustainable use of PPPs. Additionally, effective dissemination of research findings to the general public, users, trainers and sponsors, etc. essentially contributes to the perceived transformation as a basis of gradual policy transfer towards the goals set.

A transformation process of distributing information on human health issues would lead to better personal protection of professional and non-professional users, bystander protection and decreased residues in food. Providing citizens with information on risk mitigation measures and the proper use of plant protection products is anticipated to lead to less contamination of the environment. From the awareness-raising perspective, increased communication would lead to increased general knowledge and collective learning about the safe handling of plant protection products among both professional and amateur users, as well as decreased perceived risks in general. Following the dissemination of information, farmers are assumed to change their plant protection practices, and administrators are able to provide policymakers and citizens with information on the compliance with and achievements of the NAP.

Enhanced control and surveillance of market, storage and use is assumed to support transforming plant protection practices to comply with personal and environmental safety regulations and use instructions of plant protection products, which are subject to advance control to assess whether the environmental and health risks are acceptable and to set appropriate restrictions and risk mitigation measures prior to authorisation and release onto the market. From an administrative perspective, the transformation process of control aims to fulfil the obligations of the SUD. From the farming perspective, authorities monitor that PPPs are used in accordance with good agricultural practice and IPM principles on farms, and that they are marketed in compliance with the current legislation. In general, control interventions were perceived as mainly positive from the farming perspective:

"Surveillance and development of legislation brings equality between producers." (VII.B.1)

As a conclusion, the transformation processes are expected within the NAP system as premises for a gradual transition of the whole system towards more sustainable plant protection practices. The root definitions are thus utilised to formulate the logic model of the NAP, as presented in Tables 3.1-3.6 of Appendix 4. The influence of peer communities is illustrated in Figure 5.2 below.

The effective steering and coordinating of the NAP process is essential to achieve the expected outcomes. The administrative tradition in Finland aims for broad stakeholder participation in the policy, e.g. through ministerial working groups and hearings. The principle of stakeholder involvement in the authorisation of plant protection products originates historically in the establishment of the Pesticides Board, and thus also creates the basis for inclusive NAP implementation today. The existing models for strategic planning processes of the organisations involved create the basis for implementing the NAP, but some experts felt confusion at the level of managing NAP processes. Ministerial management by results and strategic funding was perceived as inadequately directed at the NAP implementation process, with inaccurate estimation of costs within the organisations involved in long term. Although in principle the NAP process is coordinated with its sources of funding, some respondents perceived a lack of coordination between organisations. Funding for separate projects is available mainly within the limits of the government's annual budgets. Reliance on long-term funding is essential in research projects where results are not expected within a short period, e.g. in developing IPM practices or producing time series of environmental monitoring data.

5.2

The influence of the peer communities of core actors in creating the implementation climate

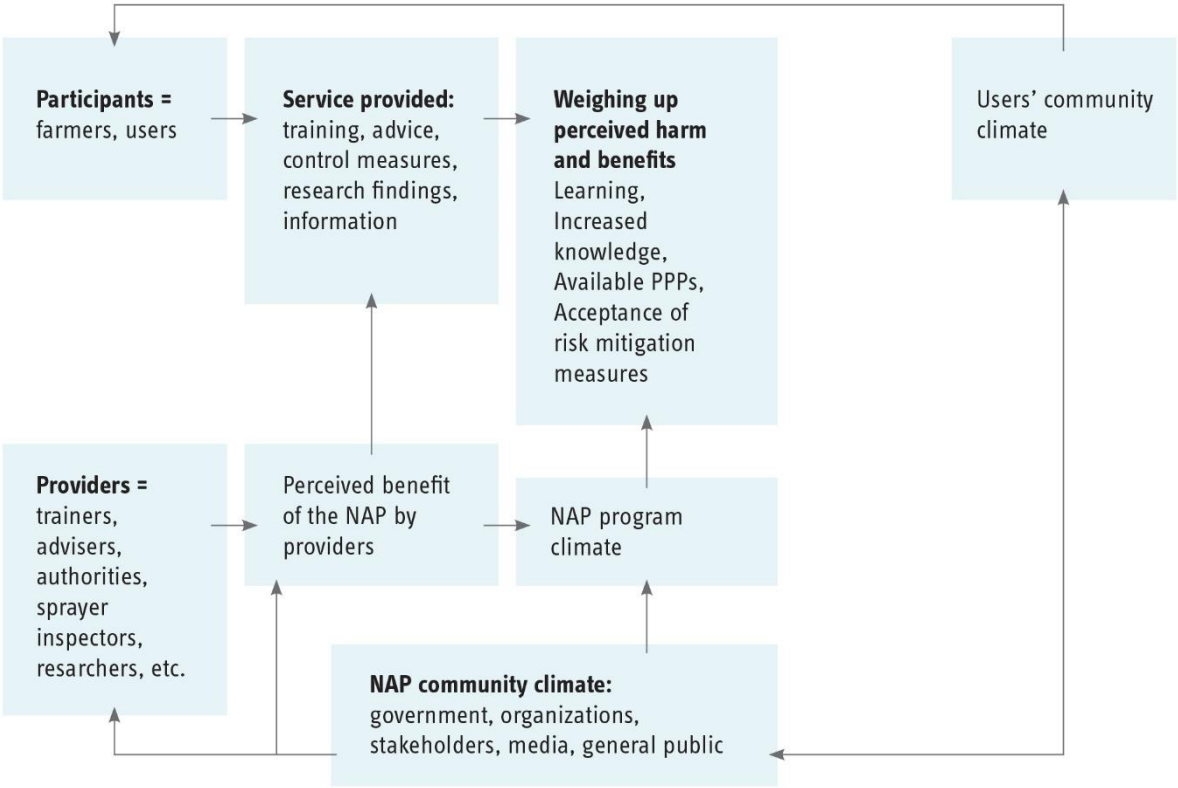

Figure 5.2. The influence of the peer communities of core actors in creating the implementation climate to support the transformation processes of the NAP.

Practical coordination of the process lies with Tukes, and potential conflicts between the organisations involved can be identified and resolved through the NAP Steering Committee. This process relies on mutual trust and respect, implying the expert status of participating peers belonging to established scientific elites (Whitley 2011), as preferred by the expert panel members. Although all stakeholders are offered an opportunity to participate, the explicit endeavour for consensus with the silencing of problematic or controversial issues that are not allowed to emerge, may be perceived as coercive by certain stakeholder groups, which probably found it somewhat pointless to participate, as will be discussed in more detail in Chapter 9.3. Therefore, although the structures for resolving potential conflicts exist in principle, testing their proper functioning may have been inadequate in practice so far (Midgley 2000, p. 219).

5.3. Setting the policy goals and expected measures of success

Consensus building is a characteristic pattern of Finnish policymaking culture (Reunanen et al. 2010) and is implicit throughout the NAP document. This document suffers from vague and general formulations due to compromises in order to reach consensus among the stakeholders that participated in the preparation. Influential stakeholders were recognised by respondents as a source of power having effectively contributed to goal setting. For instance, instead of setting ambitious exact targets, only general, approximate goals were

conveyed to satisfy the most influential, production-orientated stakeholder groups. Use reduction targets were dismissed, due to being considered unnecessary in Finland by the majority of experts surveyed for the NAP background study by Peltonen & Rajala (2009). The external pressures of goal setting in economic, socio-cultural or ecological spheres were not mentioned.

In order to understand the target setting in the Finnish NAP, it was contemplated with the expert panel participants by applying the boundary critique characteristic of the critical systems heuristics approach (Ulrich & Reynolds 2010), by comparing the ideal situation with the actual situation. While clear targets for key strategic economic, socio-cultural and environmental objectives are highlighted in sustainability screening frameworks using indicators through which achievements can be assessed, the outlined goals of the NAP are high but not quite precisely formulated. A wider discussion on setting the targets was, however, considered desirable by the experts:

> "We don't see any analysis that has been performed – for instance extensive discussion on sustainability issues – although high sustainability goals were set." (VII.C.4)

It was considered appropriate to highlight the *environmental sustainability targets* in the Finnish NAP, because the Sustainable Use Directive was understood to particularly highlight the aspect of environmental sustainability. However, the current evidence based on the environmental impacts of plant protection products was considered vague by the expert panel respondents:

> "Do we know about the level of environmental risks resulting from the use of PPPs and how much should they be reduced? When this knowledge is missing, the NAP can recommend certain actions at very general level only. Further research would be required before we could direct the means to right ends." (VII.C.4)

The health promotion goals were also perceived as partially covering the targets for social sustainability, whereas the *economic targets* were perceived as missing entirely. Consistent targets and indicators for the required level of integrated pest management application have not yet been defined, but strategic research within this field is proposed, attempting to create the criteria for the intensity of IPM. It was seen problematic that many agents have been given significant research tasks, but the realisation and search for funding is left as their own responsibility.

The ministerial working group appointed to propose the NAP recognised several gaps in the knowledge base regarding risk reduction options and IPM methods in a range of crop production sectors. The background report (Peltonen & Rajala 2009) identified and assessed the measures available and opportunities to further risk reduction from the perspective of agricultural production. The greatest lack of knowledge was perceived in relation to life cycles, identification and control thresholds of pests and in relation to preventive, biological and cultivation technological control methods, which have been highlighted in recent IPM surveys as well (Nissinen et al. 2015a-c). A great deal of the implementation measures listed in the NAP document therefore include proposals for further studies. However, being merely a list of separate enquiry tasks to be performed within the limits of the resources available during the coming years, the NAP has been criticised for lacking a more systemic implementation framework in the context of the strategic longer-term vision for Finnish agriculture in general, without committing to ensuring longer-term funding to conduct the proposed studies and to disseminate their results into practice. The vague goal setting may thus confuse the strategies for implementing the NAP.

It was decided not to set quantitative targets in the NAP document for use or risk reduction, similar to what was decided in the preceding National Programme on Dangerous Chemicals (YM 2006). The monitoring of outcomes was perceived by the experts as a core activity for producing evidence on success. It is therefore briefly discussed

here, although Chapter 8 is devoted to discussing specific measures and indicators of success in more detail, and a summary is presented in Table 4.1 of Appendix 4.

Monitoring was presented as a separate action to produce measures of outcome rather than change in behaviour. Therefore it can be contested, what kind of transformation process does monitoring of food or environmental samples imply in those to be intervened by NAP actions? Nevertheless, monitoring provides the purposeful system of the NAP with evidence of performance and measures of success, that is, essential data for evaluating the effectiveness of the programme. The monitoring of pesticide residues in the crops indicates whether the plant protection products have been used according to good agricultural practices to ensure that the level of human exposure via food does not cause a risk to consumers. The monitoring of the concentrations found in surface water and groundwater, soil and air indicates the level of environmental load and the level of exposure of non-target organisms. The monitoring of the biodiversity and sustainability of ecosystem services in agricultural areas might also be needed to create a comprehensive picture of PPP load in the environment (e.g. Kennedy et al. 2009). From an administrative perspective, timely reporting of the findings of monitoring studies to the general public in an effective way is essential for a transformation process of evaluating the success of the NAP.

The Finnish NAP was prepared for a 10-year period. The experts recognised that a wider reference framework based on a *longer-term vision* of the development of the Finnish agricultural system as a whole is missing. The tasks have been divided over the next few years, but the link to visions of Finnish agriculture is missing as guidance to direct the research, while other studies have shown that transition management requires multi-domain and long-term thinking over generations (at least 25 years) to focus on collective learning processes to bring about systems innovation alongside system improvement (Rotmans et al. 2001). The research findings are not readily available and the innovative IPM solutions will not be adopted into practice in the short-term, and the effects of transition probably require long timeframes to be visible as improvements in environmental quality. Hence it is not considered sufficient to plan the NAP actions solely within the limits of yearly budget cycles, if technological transition towards more sustainable plant protection practices is anticipated within society.

5.4. Boundaries and the environment of the NAP system

The systems thinking methodologies essentially highlight the boundary considerations of a purposeful system. Resource issues and other factors that limit the fulfilment of a programme form natural boundaries for the NAP as a purposeful system. This chapter is divided to three sub-chapters, the first of which deals with the resources available for implementing the NAP, then a case study is presented to assess the cost-effectiveness of a couple of NAP action projects, and last the factors that limit the goal-achievement of the NAP are analysed.

5.4.1. Resources available for implementing the NAP

The capacity of the actors involved to implement the NAP actions depends on the resources available for the tasks assigned to each organisation. The experts appreciated the fact that extensive personal and organisational resources, both commercial and public extension services, modern facilities and tools for research and communication were available for implementing the NAP actions. Well-functioning contacts between authorities

and politicians and the media, impartiality and lack of corruption in society in general, as well as control of compliance with legislation, were perceived as valuable political resources available for implementing the NAP.

In the Finnish NAP document, the effectiveness of the proposed actions as a function of resources available was only briefly quantified. The spending limits, budgets and productivity programmes of the central government delineate the boundaries within which the NAP can be put into operation. Some preliminary calculations on the resources required were done by the stakeholders while the draft proposal was being prepared, although they were removed from the final document during the comments period as they were considered only approximations. Obviously, the participants did not want to commit themselves to preliminary calculations for the whole programme period. Private sector actors such as training and certification providers rely on the income from organising the actions they are responsible for, and it was not clear in the preparation phase how many actors would finally be authorised during the programme period. Therefore, it was not possible to make calculations in detail beyond the preliminary rough estimate of the total cost of 7.9 million euros needed to implement the programme during its 10-year period. This estimate did not include the funding of separate research projects and therefore appears to be somewhat lower than announced by several other Member States, as presented in Appendix 3.

The choice of the most effective tasks within the limits of the resources available to the authorities was questioned by some stakeholder workshop participants. They perceived that the limited resources available to the authorities mean that actively disseminating knowledge to users regarding appropriate risk reduction and working methods is an impediment to goal achievement. The allocation of resources to Tukes was appreciated for putting the training and certification system into operation, but the responsibilities of other institutes were perceived as less defined, and thus the anticipated resource allocation for other tasks was not explicit (cf. Whitley 2011). Knowledge production was perceived as quite demanding in the situation of funding uncertainty:

> "It is assumed that the research and advisory services develop and build capacities of the NAP actors by producing new knowledge and ensuring its dissemination to the field, but there is most likely a lot to be developed, and we don't even know if the current agricultural innovation system is able to respond to the vision of IPM development. There are no resources reserved for this exploration - they must be found somewhere and that is the task of the research." (VII.C.4)

The expert panel participants identified a few research funding systems available to scientists, but lamented that the amount of resources needed to plan and execute the enquiries and other actions was not clearly reasoned in the NAP:

> “Unlike the competent authority Tukes, the research institutes involved don’t have clearly defined responsibilities and allocated resources to implement the NAP. Therefore, the research tasks defined in the NAP have not become systematically ingrained in the scientist community […]. Tasks to be carried out in addition to one’s main duties tend to be pushed aside because there are few researchers and lots to do.” (VII.C.4)

Because producing the proposed evidentiary data requires separate project funding, the researchers highlighted the importance of the extent, depth and continuation of the expensive data required. For instance, adequate intensity and spatio-temporal direction of environmental monitoring to areas with the highest environmental load essentially affect the reliability of monitored environmental concentrations as a success measure of the NAP, thus requiring careful planning that demands resources, as Biber (2013) pointed out. Similarly, intensive user surveys on perceived symptoms or other health effects cannot be performed every year, although multi-year databases need to be collected, thus requiring longer-term planning in allocating the resources.

5.4.2. Evaluating the cost and effectiveness of the NAP

As explained above, the situations of stakeholders are varied as regards resource allocation for NAP actions. As the competent authority for the provisions of the Sustainable Use Directive, Tukes was granted one additional post for coordinating the implementation of the NAP. However, specific expertise in different disciplines is required in the NAP implementation, and therefore other permanent staff at the Tukes Plant Protection Product Unit also participate in projects. Hence, part of the implementation work is carried out as normal office duties and thus no extra costs are expected apart from the workload allocated to the NAP instead of to other tasks, and provided that the government authorities keep within the spending limits, governmental budgets and productivity programmes of the central government. It has been considered necessary to internally monitor the working hours allocated to NAP implementation tasks at Tukes, but since the NAP document was prepared, there have been no joint efforts by all the stakeholders responsible for different NAP actions to aggregate the costs of working hours or any other allocated resources.

Although it was not possible to assess the effectiveness of all the NAP actions as a whole, a case study was performed to illustrate the order of magnitude of the inputs required to implement some of the NAP actions. As presented below, two implementation projects accomplished at Tukes were analysed for the working hours spent, for their direct and indirect costs and for the results achieved. The first project dealt with adjusting the aquatic protection requirement, and the second about preparation of a training and certification system for professional users, distributors and advisors. Personnel costs were calculated on the basis of the total of working hours devoted to each project, as recorded in the Tukes working time recording system. The calculations are presented in detail in Appendix 2.

The first of the projects was launched to develop buffer zones along the surface water courses, based on aquatic risk assessment instead of hazard to aquatic organisms, as used to be the system in Finland before the NAP. This project refers to NAP measure 4.3.2 or Tukes internal project code 111KSM008. The period was between 1 January 2011 and 30 September 2014. The project was carried out partly by permanent staff and partly by temporary staff hired for this specific purpose. Two different methods for calculating the unit salary cost were used: the mean salary at Tukes during the 2011-2013 project period, according to the Tukes human resource accounts 2013 (Tukes 2014a), and respectively, hourly salary based on absorption cost pricing as calculated for Tukes' fees under public law, where the indirect costs are incorporated (TEM 2013). The details of the calculation are presented in Table 1 of Appendix 2.

The workload allocated to this project was used to develop the system for setting product-specific aquatic buffer zones based on the surface water risk assessment, active awareness-rising and communication about the change of the system to the stakeholders, farmers and general public. Stakeholder hearings, discussion events, press releases and information campaigns were organised on this issue. Guidance on defining the buffer zones was produced and is now available on the Tukes website: (http://www.tukes.fi/fi/Toimialat/Kemikaalit-biosidit-ja-kasvinsuojeluaineet/Kasvinsuojeluaineet/Ymparistorajoitukset-/Vesistorajoitus-/).

Furthermore, 261 authorisation decisions were taken on the change in aquatic protection requirements, in relation to all plant protection products on the market in Finland (Kallio-Mannila 2014). Contrary to other authorisation decisions on plant protection products, the authorisation holders were not billed for these decisions, because the project was not launched at their instigation. As a conclusion, the workload of adjusting the aquatic protection requirement per plant protection product was approx. 10 hours and the cost was more than 900 euros.

DO WE LISTEN TO EARTHWORMS? TOOLS FOR EVALUATING THE FINNISH NATIONAL ACTION PLAN ON THE SUSTAINABLE USE OF PLANT PROTECTION PRODUCTS

During and after the project period, there was quite a bit of debate in the professional media about the applicability of the plant protection product aquatic buffer zones, as also illustrated in the analysis of the professional articles in Chapter 6.4. Although the driver for this project was the farmers' need to have farming practices simplified and to harmonise Finnish aquatic protection practice with other countries', concerns about the applicability of the new system to be developed were still being expressed not only from the view of environmental protection, but also from the farmers' perspective, until the new system was introduced. Following a transitional period, the new system has been obligatorily followed since 2015. Hence, it would still be premature to assess the actual impact of this project on farmer performance or on surface water quality in general.

Another project was launched at Tukes to develop a training and certification system and training material for professional users, distributors and advisors of plant protection products, taking into account the subjects listed in Annex I of the SUD. This project refers to NAP measure 4.6 or Tukes internal project code 132KE013. The period was between 1 January 2013 and 30 September 2014. This project was carried out partly by permanent staff at Tukes and partly by a designated external consultant responsible for preparing the educational video material. Two different methods for calculating the unit salary cost were used: the mean salary at Tukes in 2013, according to the Tukes human resource accounts 2013 (Tukes 2014a), and respectively, the hourly salary based on absorption cost pricing as calculated for Tukes' fees under public law, where the indirect costs are incorporated (TEM 2013). The significantly higher share of direct costs other than salaries in comparison to the previous project, was due to designating the external consultant for preparing the video material. The details of the calculation are presented in Table 2 of Appendix 2.

The workload allocated to this project was used to prepare the training and certification system, prepare the training material available to authorised trainers, active awareness raising and communication about the certification requirements to stakeholders, farmers and the general public. Training events were organised for the trainers and more than 20 lectures were given in relevant fora. The web-based training material is now freely available to individual learners, training organisers and certification providers, in Finnish and in Swedish, on the Tukes website: http://www.tukes.fi/kasvinsuojelu/story.html. The training organisers and certification providers were trained and authorised by Tukes by the end of 2014 (Kallio-Mannila 2014, 2015).

As a conclusion, the workload at Tukes for the project to prepare the training and certification system was approx. eight hours and the cost was more than 1 200 euros per training and certification provider authorised by the end of 2014. While the cost per training participant seems rather high just after the completion of the project, in time the cost will be mitigated once the training material is used by the authorised trainers who provide training to more and more participants at agricultural schools and other stakeholder events from 2015 onwards, when further trainers and professional users will become authorised and certified in future. Although Tukes charges a fee for authorisation as training and certification provider, the revenues cannot be included in the expenditure due to the gross budgeting system, where all the fees are directed to a general state account and not to direct benefit of Tukes.

At the beginning of 2015, approx. 4 500 persons were certified as professional users of plant protection products in the Tukes register, according to the new certification system. The aim of the NAP is to ensure that all professional users are certified by the end of the first programme period in 2021.

The new training materials available on the Tukes website attracted around 20 user responses from the training providers during the first couple of months. The responses are recorded in Tukes' internal files for staff training purposes. The new training materials have been met with satisfaction and the comments are very positive and supportive. In these messages, some questions were raised about the interpretation of the aquatic buffer zones

as developed in the previous project, indicating that it was sometimes still not easy to follow the new system for aquatic protection, even though it was attempted to make it as transparent as possible.

Although only a couple of the NAP implementation projects could be analysed for their costs and effectiveness, this brief exercise already reveals the workload required to carry out the intended actions explained in the NAP alongside the other statutory plant protection product surveillance tasks. A realistic approach is thus needed to carefully prioritise the actions within all participant organisations. More comprehensive cost-effectiveness analysis of the NAP actions as a whole may become necessary by the end of the programme period. The funding and conducting of the projects must be planned carefully by participants in the light of the scarcity of resources in the long term, and rapid transformations are not to be expected unless external funding becomes available. However, the statutory requirements of the SUD have been satisfactorily fulfilled in Finland according to the FVO (2014).

5.4.3. Limiting Factors Analysis

The stakeholder workshop prepared a list of *constraints* perceived as most seriously limiting the fulfilment of the NAP. In addition to the jointly deliberated view of the focus group discussion, ten experts returned their individual responses on the severity of factors that impede the achievement of the NAP goals. The limiting factors, categorised by their perceived severity, are presented in Table 5.3 and Figure 5.3 below. The factors identified were also categorised into five types: economic and resource issues, biological and environmental issues, policy issues, information and communication issues and attitudinal issues. The first value represents the estimate deliberated jointly by the focus group, following the average, maximum and minimum values perceived by individual respondents for each limiting factor identified by the focus group. The internal mean for each type of limiting factor has also been calculated. None of the constraints were perceived as completely preventing the implementation of the NAP (scored as 4) either by the focus group or by individual respondents. At least one of the individual experts perceived four of the factors as not limiting in any way, while they were jointly scored as manageable problems or limiting to some extent. The most severely scored factors (with the highest average) are positioned at the top of the table.

Table 5.3. Factors recognised as most likely to limit the achievement of the Finnish NAP goals. The abbreviations refer to Figure 5.3 below. The scoring of the severity of the likely obstacles was 0 = does not limit in any way, 1 = the problem is manageable, 2 = limits to some extent, 3 = serious impediment to work, 4 = completely prevents the work.

Score of the limiting factors for achieving the goals of the Finnish NAP (0-4)	**Jointly deliberated by the focus group**	**Average from individual responses (n=10)**	**Max from individual responses**	**Min from individual responses**
1. Economy and resource issues. Mean of five factors: 2.6				
General profitability of farming (profi)	3	2.50	3	2
Cost of introducing new technologies (cost)	3	2.40	3	2
Time and workload needed to gather and apply new knowledge (time)	2	2.20	3	1

Risks of introducing new pest management practices (risk)	2	1.70	2	0
Lack of resources for disseminating new knowledge to farmers (diss)	3	1.44	2	1
2. Biological and environmental issues. Mean of four factors: 2.0				
Problems in pest observation: use of time, identification of species (obs)	1	2.11	3	1
Lack of healthy propagation material (propa)	2	2.11	3	1
Climate and geographical location (clim)	2	1.89	2	1
Invasive alien species, new pests (inv)	3	1.70	2	1
3. Policy issues. Mean of four factors: 1.75				
Limited choice of PPPs on the market (choice)	3	2.33	3	1
Contradicting goals of legislative requirements and cultivation practices (requi)	2	1.60	2	1
Requirements set by clients, e.g. on residues in food (resid)	1	1.13	2	0
Changes in financial incentives policies, e.g. removed obligation to harvest (incen)	1	0.88	2	0
4. Information and communication issues. Mean of two factors: 1.5				
Inability to use foreign research (resea)	2	1.67	2	1
Knowledge brokering between responsible NAP actors (broke)	1	1.40	2	0
5. Attitudinal issues. Mean of one factor: 2.0				
Disregard, felt investing was uselessness (atti)	2	2.00	3	1

Limiting factors dealing with economy and resource issues were perceived by the focus group as the most severe threats to achieving the NAP goals, thus indicating that *economic sustainability* is perceived as very important in agriculture. The largest number of separate factors was categorised and the highest severity was scored within this category: three limiting factors of five in this category were perceived as serious impediments to work and two factors as limiting to some extent. The jointly deliberated estimates were somewhat higher than the individual responses. The findings are in line with the results of Marra et al. (2003) and Lefebvre et al. (2015).

Four *biological and environmental* factors were identified in total, and they were scored as limiting the achievement of the NAP goals to some extent. It is notable that the invasive alien species and new pests (inv)

were considered a more serious impediment to the work by the focus group, whereas even the maximum valuation by all separate individuals was lower than the jointly deliberated score (limiting to some extent or a manageable problem). None of the experts valued biological and environmental factors to zero, as not limiting the NAP in any way.

Disregard represented its own type of limiting factors, i.e. *attitudinal* issues (atti). The perceived uselessness of investing in new knowledge was regarded as limiting the implementation of the NAP to some extent. The responses of individual group members were divided evenly between the scores of manageable problem, limiting to some extent and serious impediment to work. Different types of incentives would be needed to alleviate these kinds of attitudes, as highlighted by Lefebvre et al. (2015).

Four different factors belonging to *policy* issues were recognised by the experts. The limited choice of plant protection products available on the market (choice) was perceived as a serious impediment to work both in the focus group discussion and by the individual respondents. Requirements set by clients (resid) and the changes in financial incentives policy (incen) were found as manageable problems or as not limiting the implementation of the NAP in any way by some individual respondents.

Similarly, two factors categorised under the *information* and communication issues were given lower scores both in focus group discussion and in the responses of individual experts. The inability to make use of research conducted abroad (resea) was recognised by the focus group as a factor that limits to some extent, whereas perceptions of the knowledge brokering problems (broke) deviated remarkably in the individual responses compared to the focus group view.

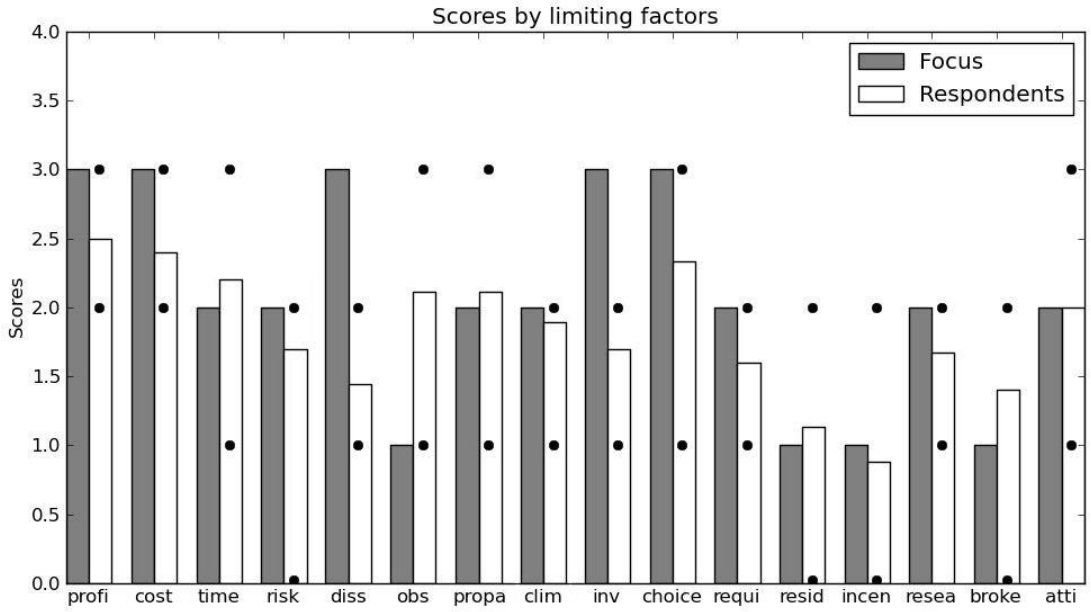

Figure 5.3. The factors recognised by the experts as most likely to limit the achievement of the Finnish NAP goals. The grey bars (focus) refer to the jointly deliberated perception of the focus group. The white bars (respondents) refer to the mean of individual respondents with minimum and maximum scores given as black dots. Abbreviations of the factors and explanations of the scores are given in Table 5.3 above.

The fact that the severity of constraints was collectively perceived as higher compared to individual respondents' views on quite a few of the limiting factors, as presented in Figure 5.3, is in line with the observation of Willard (1989, p. 246), who explained, referring to Aristotle's theory of opposition, how groups make more enlightened decisions than solitary thinkers, as individuals' vices and virtues complement one another in groups, thus emphasising cooperative criticism.

6. Stakeholder expectations on the implementation and achievements of the Finnish NAP

This chapter addresses my second research question on the stakeholder expectations for the goals and implementation of the NAP. First, a stakeholder analysis was performed to generate knowledge on how the involvement is perceived by different actors. The results of the stakeholder analysis are presented in Chapter 6.1. Then, Critical Systems Heuristics was applied to reveal the stakeholders' preferences regarding who should be involved in the NAP, as presented in Chapter 6.2. In addition to expert views, a variety of additional data sources, such as citizen communications, media articles and targeted expert opinions, were explored to analyse the expectations of as many stakeholder groups as possible, as discussed in Chapters 6.3-6.5. Sustainability screening was tested as a potential tool for assessing the achievements of the NAP. The sustainability screening results are presented in Chapter 6.6. The conclusions on the discourse about PPP use among different stakeholders are drawn in Chapter 6.7. The stakeholders' expectations are used to construct the programme theory for the NAP in Chapter 6.8, and finally, learning was recognised as the main transformation process contributing to the expected outcomes of the NAP, as presented in Chapter 6.9.

6.1. Stakeholder analysis

As discussed in Chapter 4.3.1, two *focus group* discussions were organised to study the perceptions on involvement in the NAP among experts and among those to be likely affected by plant protection, i.e. laypersons living in the vicinity of the agriculture. The participants were invited in advance to represent either the interests of lay residents or experts involved in the implementation of the NAP. Although given the opportunity to name several other stakeholder groups to represent, the participants did not want to mention other groups in addition to their pre-defined reference group. The perspectives of those who affect, those who are affected and those who should affect the sustainable use of plant protection products, as well as the jurisdictional power in implementing the NAP actions and the perceived volume of the power was able to be distinguished by the two groups consisting of either laypersons or experts, as presented in Table 6.1. below.

Table 6.1. Frames of stakeholder groupings discussed in the different focus group settings. x means less emphasis, xxx means more emphasis in the discussion.

Lay/expert interface	Those affected	Those affecting	Those who should affect	Jurisdiction	Volume of power
FG 1: lay	xxx	x	xxx	x	xxx
FG 2: expert	x	xxx	x	xxx	x

In the expert focus group, the jurisdiction of the NAP actions was emphasised as an essential marker of groups considered as stakeholders in implementing the NAP, whereas the group of laypersons had a wider perception of stakeholders as those affected by the implementation of the NAP. The discussion in the expert focus group adhered more tightly to NAP implementation issues compared to the residents group. The experts made some ironic remarks not intended to be included in the discussion, revealing their implicit sceptical outlooks. The experts perceived the interests of most stakeholder groups as rather low: only stakeholder organisations with executive power were perceived as influential stakeholders. The layperson residents had a much wider interpretation of the concepts of interest and influence. After a profound discussion, they decided on an idealistic interpretation of the interests of the proposed stakeholders, and a realistic view of their power of influence. The residents explicitly highlighted the interests of those affected but not influential, and distinguished many different stakeholder groups to represent different consumer groups (allergic, pregnant, children, future generations) or non-human and inorganic compartments of the environment (non-target organisms, ecosystems, air, groundwater). Within the residents group, consensus was reached on the importance of families, future generations, children and education as stakeholder groups having vested interests in the sustainability of plant protection. Additionally, certain respondents indicated in their personal responses both idealistically how they perceive the interests and influence of various stakeholders should be, and realistically how the interests and influence actually are in their opinion.

Midgley (2000, p. 148) warned about a tendency to focus narrowly on boundaries around industrial, economic and political systems marginalising the non-human environment, which may result in damage to humans and non-humans alike. Starik (1995) advanced the argument that the natural environment should be given an independent stakeholder status, because so many human actions increasingly affect natural environments and other (human) stakeholder groups do not adequately represent the interests of non-human environments. This kind of thinking emerged in the residents' focus group, where, for instance air, groundwater, non-target organisms and the food to be produced were explicitly itemised as groups affected by the NAP, but that no influence on the implementation of it. Environmental monitoring and environmental quality standards (EQS) were widely accepted by both experts and laypersons as important measures of the exposure for the non-human environment, hence indicating how well the needs of non-human stakeholders are considered in the implementation of the NAP.

A slight formation of alliances was observed between the focus group participants. The residents had quite lengthy discussion on the interpretation of interests and influence, where part of the group advocated for an idealistic approach and the other for a realistic one. Similarly, in the expert group, views were divided between protection- and production-orientated perspectives. To resolve their disagreements, the residents relied on courtesy and in-depth argumentation, although the participants were not used to this kind of persuasion. The experts relied on the specific expertise of each participant as well as on the individuals who were most carefully prepared for the exercise. In the expert group conflict emerged about the role of European Community organisations in the implementation of the NAPs in the Member States. They pondered whether the approval and authorisation of plant protection products should be considered as part of NAP actions or an independent task separate from the NAP. Their conclusion was that the two legislations cannot fully be separated, because deciding on adequate risk mitigation is an integral part of the approval and authorisation of plant protection products laid down in the PPP Regulation, and applying the risk mitigation measures in field practice belongs to the domain of the NAP and SUD. Thus, the European organisations do have a role in the implementation of the NAPs, although they hold no executive power in the Member States. In the expert group, on the other hand, the participants professionally distanced themselves from a conflict situation, although some of them still continued the discussion via e-mail after the group session had finished.

The experts had a rather pessimistic view on the means available for implementing the NAP. Although they perceived many stakeholders as having vested interests, their influence was seen as limited and mainly cultural. The influence and interest of the media was also perceived as contradictory. The experts had common experiences in contacts with the media and non-governmental organisations, perceived as a disturbance of their official duties. On the other hand, the general interest on plant protection and the NAP in Finland was found to be low compared to other European countries. Within the resident focus group, common experiences in plant protection were discussed regarding residue considerations when purchasing food, local relationships with farmers and the countryside as a residential environment for bringing up their children. The interests of future generations could be perceived differently, as explained by this quote:

> "In my opinion the interest of future generations can be understood in two ways: either [by studying] how our contemporary society values their interests, or by imagining what would their interests be if they could state them to us from the future." (IV.B.2)

There was total silence on gender issues in the expert discussion, although these were explicitly mentioned as an example in the questionnaire. The neighbouring laypersons focus group identified the generations to come, pregnant women and children as separate stakeholder groups, but did not discuss gender issues further either. Perhaps the conventional picture of gender relations in rural areas, based on the prevailing dominant conception of male farmers (Forsberg & Stenbacka 2013; Pini 2002; Schmitt & Inhetveen 2010), is still largely taken for granted and not challenged as an agent of performance in plant protection more than any other farming practices. According to Agricultural Statistics of Finland (2014), the gender distribution of Finnish farm owners was 87.4% male and 12.6% female, but around two-thirds male and one-third female as regards the total agricultural and horticultural labour force in 2013. It is therefore likely that both genders take part in plant protection practices on farms.

A recent consumer survey commissioned by Ecolabel Finland – Motiva Services Oy (YouGov Finland 2015) showed that 39% of Finns are concerned about chemicals in everyday consumer products, because they consider that chemicals can cause health and environmental problems that are not yet sufficiently well known. Women (41%), older persons (55+ years, 43%) and people living in Northern and Eastern Finland (41%) were the population groups most concerned, whereas men (35%) and younger age groups (18-34 years, 34%) had the lowest percentages of concern. Because that consumer chemicals available for public consumption are typically less hazardous than plant protection products that are ineligible for ecolabelling and require an authorisation before release on the market, it can be anticipated that the percentage of people concerned would have been at least similar or even higher, if agricultural chemicals had been explicitly mentioned in the questionnaire. Similarly, concerns about the health and environmental risks of plant protection products were recognised in the resident focus group, although this group also highlighted their realistic attitude on plant protection applications as part of their everyday life due to living in the countryside in the vicinity of agricultural fields.

Figures 6.1 and 6.2 illustrate the levels of interest and influence of different stakeholders, as perceived by the rural resident and expert focus groups, respectively.

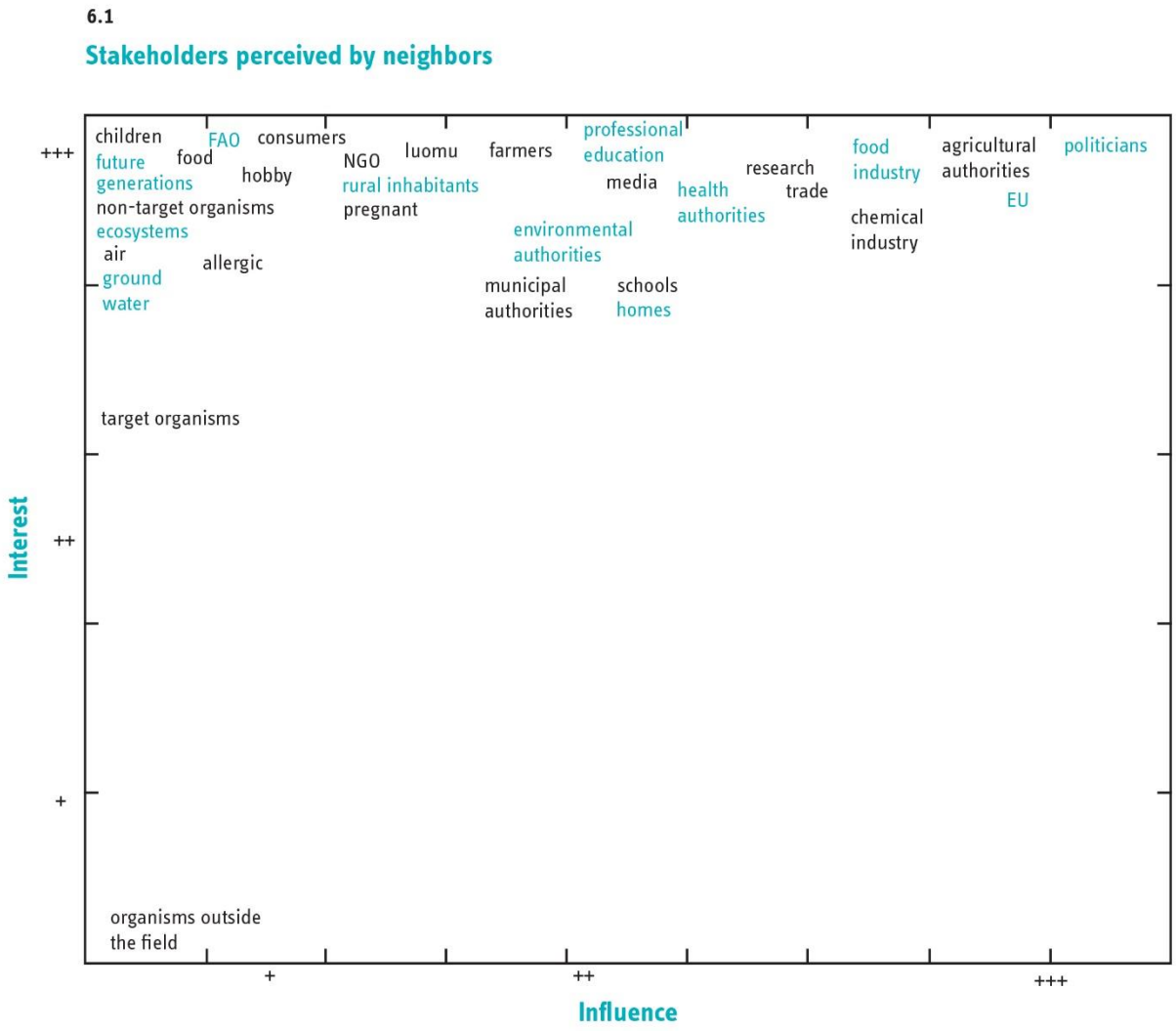

Figure 6.1. The levels of interest and influence of different stakeholders as perceived by the focus group of residents living in the vicinity of agricultural fields without being farmers themselves. The levels of interest and influence increase gradually from + to +++. Abbreviations: FAO = UN Food and Agriculture Organization; NGO = non-governmental organisations; EU= European Union. Different colours are used only for illustration purposes.

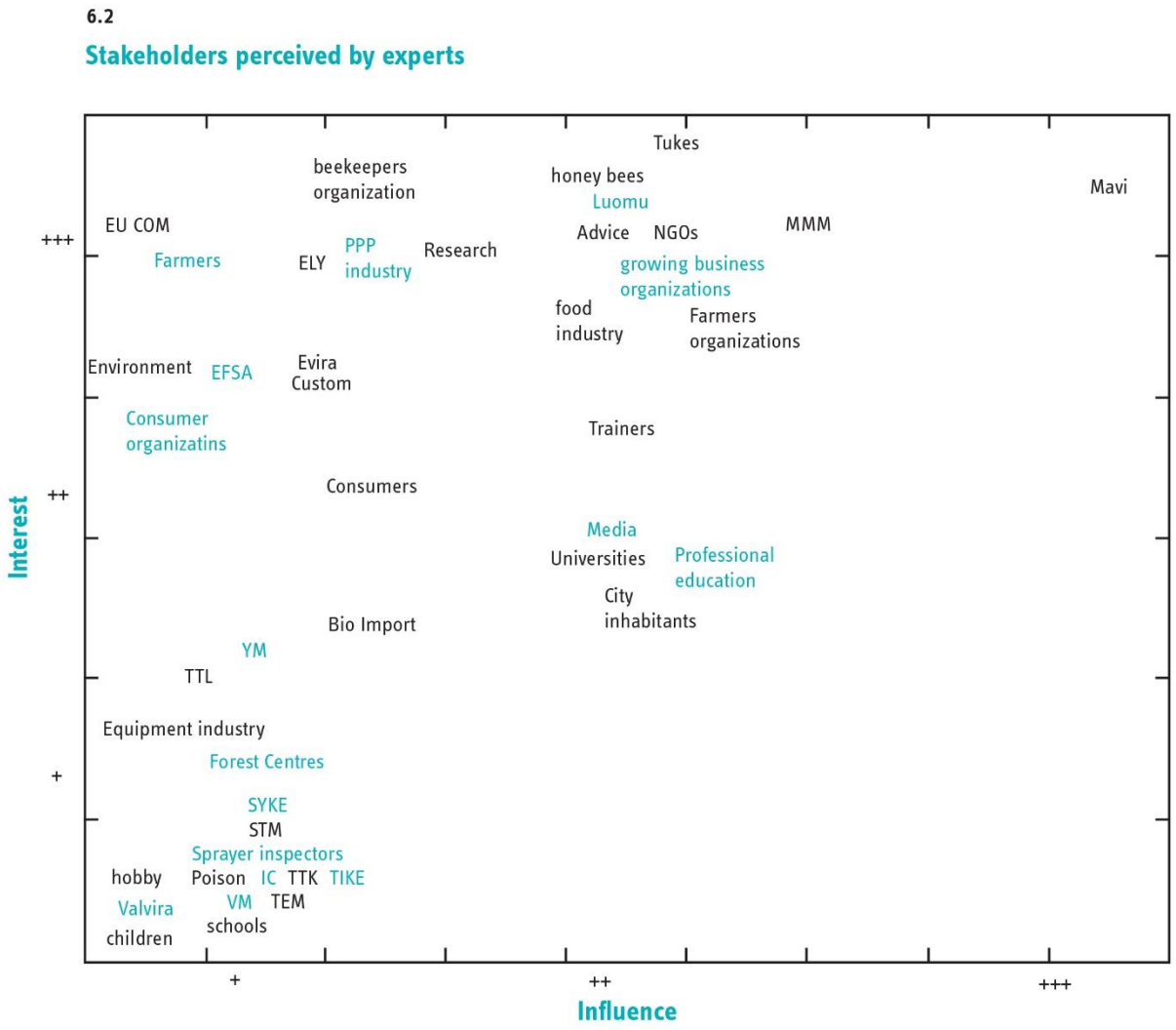

Figure 6.2. The levels of interest and influence of different stakeholders as perceived by the focus group of experts. The levels of interest and influence increase gradually from + to +++. Abbreviations: EU COM = European Commission; EFSA = European Food Safety Authority; YM = Ministry of the Environment; TTL = Finnish Institute of Occupational Health; SYKE = Finnish Environment Institute; STM = Ministry of Social Affairs and Health; hobby = non-professional users; Valvira = National Supervisory Authority for Welfare and Health; Poison IC = Poison Information Centre; TTK = The Centre for Occupational Safety; TIKE = Information Centre of the Ministry of Agriculture and Forestry; VM = Ministry of Finance; TEM = Ministry of Employment and the Economy; ELY = The Centres for Economic Development, Transport and the Environment; Evira = Finnish Food Safety Authority; Custom = Customs; Bio Import = Importers of biological control agents; Tukes = Finnish Safety and Chemicals Agency; Luomu = organic farmers' association; Advice = agricultural extension services; NGOs = non-governmental organisations; MMM = Ministry of Agriculture and Forestry; Mavi = Agency for Rural Affairs. Different colours are used only for illustration purposes.

6.2. Who should be involved?

As mentioned in Chapter 4.5.3, I tested the twelve questions of Critical Systems Heuristics (CSH) with my expert panel in the context of clarifying their underlying assumptions to understand their 'distinction-background' (Lopez-Garay 1999) on the NAP. In the dialectical questioning of the CSH, the underlying value assumptions of experts and laypersons (witness/emancipation/worldview) are juxtaposed, and the legitimating questions in particular are aimed at the polemical employment of boundary judgements, where those involved (participants) should place themselves in the positions of those who cannot argue their concerns, such as future generations, non-human nature and the environment. In this respect, the experts are no more experts than the laypersons. In addition to the prevailing reality, the CSH framework is useful in revealing the expectations concerning the desired reality of the NAP.

The view of the expert panel respondents on the source of legitimating was quite similar to the views gathered in the expert focus group, as discussed in previous chapter. Reference was made to the privileged parties involved, such as opinion leaders, famous researchers, experts and stakeholder organisations, as they were seen as being responsible for also advocating those who cannot be involved in the implementation of the NAP. The expert panel participants did not consider it sufficient just to report to the EU about carrying out tasks that come from above; rather, empowering users to evaluate the consequences of their practical choices was considered more important for improving their understanding of sustainability:

> "Practitioners should define the boundary preconditions - what is possible and workable." (VII.B.1)

Those *affected* were perceived as human stakeholder groups only, namely consumers and citizens, and any non-human entities were not mentioned. Furthermore, those not involved were clearly considered as standing outside the boundaries of the NAP system. Communication to those not involved was perceived mainly as unidirectional, top-down from the experts to the citizens, although open discourse was mentioned as important for taking the needs of different stakeholder groups into account. It was appreciated that as many parties as possible could express their opinion on plant protection practices. The plurality of worldviews was recognised, but fact-based consensus was considered an important value in implementing the NAP. While the importance of decision making in consensus was highlighted, the experts did not explicitly propose how potentially conflicting views could be reconciled. It seems that consensus is interpreted as prevailing among the knowledgeable actors involved and represented in the NAP Steering Committee, easily resulting in silencing potentially contradicting views.

As regards the worldview steering our vision of the NAP implementation, basic security issues of food safety and food security were perceived as primary values, as expressed by some of the experts:

> "It is important to ensure that the citizens are offered a sufficient amount of safe food in all circumstances. The other values are secondary." (VII.B.5).

A high level of expertise is obvious and appreciated among the implementers of the Finnish NAP. The preparation process and leadership of its implementation is managed by the Ministry of Agriculture and Forestry, while influential stakeholder groups were recognised to have significantly influenced the content. The respondents perceived the status and knowledge of participants regarding plant protection issues to generally relate to conviction. The commitment of the stakeholders involved is evidenced by unanimous approval of the NAP by the high-level participants appointed to the ministerial working group and the steering group for its implementation,

as responsible actors in the process. Consequently, the NAP's approach was considered highly top-down by respondents, and doubts about political-level involvement were expressed:

> "The NAP is a rather authority-drawn activity. What else should the politicians know about the NAP? And how much do they know and support it?" (VII.C.4)

The NAP preparation documents revealed that participation by those involved was considered important, but the values and preliminary assumptions of participants were not properly analysed by the working group appointed to prepare the National Action Plan on the sustainable use of PPPs.

The coverage of professional stakeholder groups within the production sector was excellent in the working group, resulting in a multiplicity of views and attitudes framing the background of the work while aiming at a final consensus. However, those considered to be less knowledgeable may have been easily ignored and excluded (unintentionally or intentionally?) from the discourse between stakeholders who actively contributed to preparing the NAP. Although different parties obviously had differing insights at the beginning of the NAP preparation, the opinions were incorporated into a common position as a result of a deliberative working process, which presumably caused the rather vague wording but enhanced the wide acceptance of the final proposal. The justification that the likelihood of support for the objectives would be greater if the level of ambition was not too demanding, remained implicit in the NAP document, although remarkably framed the working practice. Consequently, in their statements some NGOs criticised the draft proposal on the modest target setting for risk reduction, but their comments did not change the final proposal. As the adoption of the NAP was considered beneficial overall, they were finally satisfied with the proposal and refrained from further influencing its implementation.

It was noteworthy that socio-cultural sustainability, gender issues and the needs of disadvantaged and marginalised groups were excluded from the NAP discourse in Finland. The discourse was mainly restricted to pragmatic *technology transfer* kinds of issues (van Kerkhoff & Lebel 2006). It was even questioned by some of my respondents, whether social sustainability really should be a relevant issue to be promoted with the NAP in general in Finland. This issue is further discussed in Chapter 9.6.

Essentially, different frameworks could be built by the stakeholders for the NAP discussion in society, in line with the theories of other authors (Benford & Snow 2000; Vliegenthart & van Zoonen 2011). Framing the collective action of implementing the NAP tightly as an issue only to be dealt with between practitioners – in other words providing professional users with training by plant protection experts, organising control and monitoring measures by competent authorities and disseminating information by experts to less knowledgeable receivers – may easily marginalise non-professional users, consumers and proponents of environmental issues from the discourse (Midgley 2000, p. 287). Given that the experts mainly preferred the involvement of peer practitioners, it will be challenging to include the views of other stakeholder groups in the risk communication and discourse to create general trust regarding the sustainability of plant protection, as highlighted by Renn (2008, p. 222-227). Similarly to my results, Valve (2002) noticed the limited participation of the representatives of non-governmental organisations in programme implementation in the UK, thus leaving the field to authorities and private sector entrepreneurs. I invited a range of organisations to the workshop and expert panel work, but not a single person from any of the NGOs responded or accepted to participate, although the other stakeholder groups did. The non-attendance was confirmed by further e-mail and telephone communications, without anyone volunteering to participate in this research. Some respondents apologised for their lack of time, but mostly did they not even respond.

Before finalising the NAP document the draft was circulated for comments, and the only NGO to submit comments was the Finnish Association for Nature Conservation (FANC). When a steering group was appointed

for implementing the NAP, the FANC was also invited to participate, but it apologised for its inability to participate due to a lack of human resources. There was no response from any other NGOs with either environmental or consumer protection concerns. Consequently, no comments or ideas for evaluating the NAP were received from the NGOs either. They are certainly free to choose their fields of interest based on what their supporters find most topical, as engagement is based on personal interest and willingness to volunteer. The Agricultural and food production issues are apparently not highly prioritised within the conservation-inclined NGOs in Finland. This is somewhat different from the situation elsewhere in Europe, where the NGOs represent an influential lobby in calling for a shift towards more sustainable plant protection practices (e.g. PAN 2013). As a result, the level of ambition in setting the targets for the Finnish NAP can be viewed as somewhat biased:

> "Settings of power probably had a strong influence on the goals of the NAP, for instance on not setting any use reduction targets - maybe it was not even considered necessary in Finland. Can we see this attitude in the IPM decree in its turn?" (VII.C.4)

There may also be varied acceptance of the evaluation outcomes by the stakeholders as proof of successful implementation, illustrating the different meanings the stakeholders are constructing about how the sustainability of plant protection is perceived (Wagenaar 2011). For instance, adjusting the environmental risk mitigation measures may seem like an achievement for ecotoxicologists, while at the same time users may perceive them as obstacles for their practice and thus impediments for achieving economic sustainability. Instead of explicitly explaining how the concerns of different stakeholders would be reconciled, the emphasis on consensus may appear to be ignoring the deviating realities of those affected but not involved. In coercive situations, debate can easily be closed by those with authority in the name of consensus (Midgley 2000, p. 208; Pini 2002), which could also explain why the NGOs have not shown an interest in participating in the NAP evaluation process.

Interestingly, the expert focus group distinguished a new influential stakeholder group of individual, modern city-dwelling consumers who do not have any knowledge of the realities of food production, while simultaneously requiring high-quality food commodities, the so-called 'sprout hippies' (IV.C.10). Their cultural influence was perceived to arise from actively using social media as their communication vehicle, as opposed to traditional consumer organisations, which were perceived as less powerful in their influence on pesticide use. However, although this group of consumers was considered to be influential, they were not counted as preferred discussion partners. The experts' obvious fear of not being able to persuade this group of consumers appeared to be exaggerated in the light of the evidence on non-interest in participating in the expert panel work or discourse on PPP use among different interest groups.

The participants appreciated the plurality of views and open communication between the different stakeholders involved in the NAP process, including listening to different opinions. As previously explained, not all stakeholder groups were able to participate in the NAP Steering Committee work, participatory workshop, focus group or expert panel work of this study, so other means were necessary to generate their views.

6.3. Expectations of individual citizens

Contrary to some other Western countries, the use of plant protection products only recently emerged as a topical discourse in Finnish society in general. Nevertheless, the safe use of plant protection products occupies the mind of the public to some extent, as can be interpreted from the references by citizens. To explore the views

of citizens, a sample of 22 communications from private individuals concerning the use of plant protection products was analysed, as described in Chapter 4.4.1 above. For several years, some cases of citizen communications have been recorded anonymously in the corporate files at Tukes. It is not a standard operational practice at Tukes to systematically record all communications received. Therefore, the sample is not representative of all the references received from citizens; rather, it reflects typical or especially difficult cases that have been considered useful to record 'frequently asked questions' for internal training purposes. Accordingly, the sample analysed does not show the total number of actual communications received, but instead illustrates the typical questions the experts end up answering. Because some of the messages were originally received by telephone, in these cases the answering expert recorded a written case description afterwards. Therefore, not all cases contained the actual message from the sender. Moreover, although the original sender was not entered in the records, it could be concluded based on the content of the message that 11 communications were from concerned citizens such as residents or neighbours of PPP users, six were from professional users or farmers, three from other entrepreneurs such as beekeepers and two from salespeople.

Most of the questions typically dealt with several subjects concerning the use of plant protection products. 16 communications covered human health issues, 15 environmental effects, five communications were about general awareness, 13 about cultivation practices or use instructions of a certain plant protection product and four communications dealt with legislation issues. Particular questions were sometimes answered by more than one expert and even several times until satisfactorily resolved. Therefore, the total number of subjects discussed is higher than the number of original communications in the sample. At the same time, similar perspectives recurred in questions about different subjects: for instance, suspected uses breaching the authorised use instructions and local problems occurred repeatedly in questions about human health, environmental effects, awareness raising and agricultural practices.

The messages recorded do not reflect average citizen awareness about plant protection problems. They instead represent the views of the most active and capable persons, illustrating their deep concern and feeling of grievance. No one who communicated questions approached the experts on weak grounds; rather, the problems were considered to be of major significance before the senders took the step to contact the authorities. Therefore, the messages from the citizens filed at Tukes most likely do not reflect the average interest, but the perceptions of the most active citizens who are deeply concerned about the problems of plant protection. This pattern can be associated with citizens' perception of the public administration as an oligarchy and elite, which was already explored by Max Weber (1978, pp. 956-963) for instance. However, governance can be considered more flexible today, as some experts reported abundant contact with citizens, although this was not always recorded in the files. In some cases, the sender had already been led from one authority to another when that person had experienced not being taken seriously. A few people also expressed their distrust of the ability and willingness of the authorities to take control measures. In such cases, the tone of the messages was frustrated. It is therefore a challenge for plant protection experts to be able to provide citizens with information that results in the person feeling like they have been heard and answered, although not necessarily promising to take all the measures that person is requesting.

Questions about health and environmental effects from inappropriate uses typically covered plant protection products that were not authorised at all, specific uses that were not authorised in Finland or products otherwise used in breach of their instructions. The risk assessments of particular products induced questions about the adequacy of the research data used for the environmental and human health risk and safety assessments, as well as the reasoning and schedules of decision-making for particular problematic PPPs. Operator and bystander protection, guidance for choosing the appropriate personal protective equipment and preventing spray drift to neighbours, labelling treated plants as well as describing symptoms following exposure to particular products were also frequent human health concerns. Groundwater protection issues such as use in the vicinity of drinking

water wells in the neighbourhood or on defined groundwater areas were frequently asked questions. The buffer zones required to protect surface waters and the available spray drift reducing nozzles were also typical questions concerning environmental protection. The protection of terrestrial non-target organisms such as plants and honey bees concerned several questioners. Events concerning the collapse of honey bee colonies in particular were suspected to have been caused by PPP use.

Several communications included requests to organise control measures and official visits to places where plant protection products were suspected to have been used inappropriately, e.g. on defined groundwater areas, in forestry, storage of obsolete PPPs or caused damage to neighbours. The organisation of visits was delegated upon request to the regional authorities responsible for local surveillance activities, the Regional Centres for Economic Development, Transport and the Environment (ELY). Inadequate communication between PPP users, neighbours or beekeepers was subject to claims from citizens in several cases. Furthermore, questions were asked concerning awareness raising, on classification and labelling of certain PPPs, on certification requirements of professional users and on the information available for professional and amateur users. Good agricultural practices of specific authorised plant protection products, such as the transferability of use instructions from one product to another, observed spray injuries or residues in crops caused by certain uses of PPPs, were discussed frequently. Additionally, legislative questions, such as who is responsible for keeping records of PPPs, or the permissibility of import for private use, were among the citizens' concerns.

Some questioners also openly distrusted the ability and willingness of the authorities to take measures to restrict or withdraw certain plant protection products. It is therefore challenging for the experts to answer the questions in a way so that the sender feels understood and answered, although the authority cannot necessarily promise the suggested actions. Therefore, the systematic recording of the frequently asked questions and answers would enhance the experts' collective learning and would be favourable to the development of customer service practices at Tukes. The same obviously applies to other implementing organisations as well.

6.4. Use of plant protection products in agricultural trade papers

A complete media coverage evaluation about the issues included in the NAP was not possible in this study. However, a targeted analysis on the discourse about implementing particular NAP actions was performed on a sample of 34 articles published in selected agricultural trade papers that were widely read by farmers in Finland between 2012 and 2014. Details of the sampling were given in Chapter 4.4.2.

The need to use chemical plant protection was not challenged in any of the articles. The reason for setting restrictions on the use of plant protection products on the grounds of their environmental risks was not generally discussed in the articles at all; rather, the restrictions were seen as obstacles to exercising the agricultural profession. The discourse on health effects or personal protection was not considered important or was nearly totally omitted in these articles.

Two projects to implement the NAP were topical during the article publication period: the amendment of the use restrictions for plant protection products on aquatic buffer zones and building the training and certification system for professional users and retailers. Therefore, the subjects of the articles also mainly considered the environmental restrictions on use and the training of the professional users of plant protection products. The themes related to the aquatic buffer zone project are discussed below and an overview is presented in Figure 6.3. below.

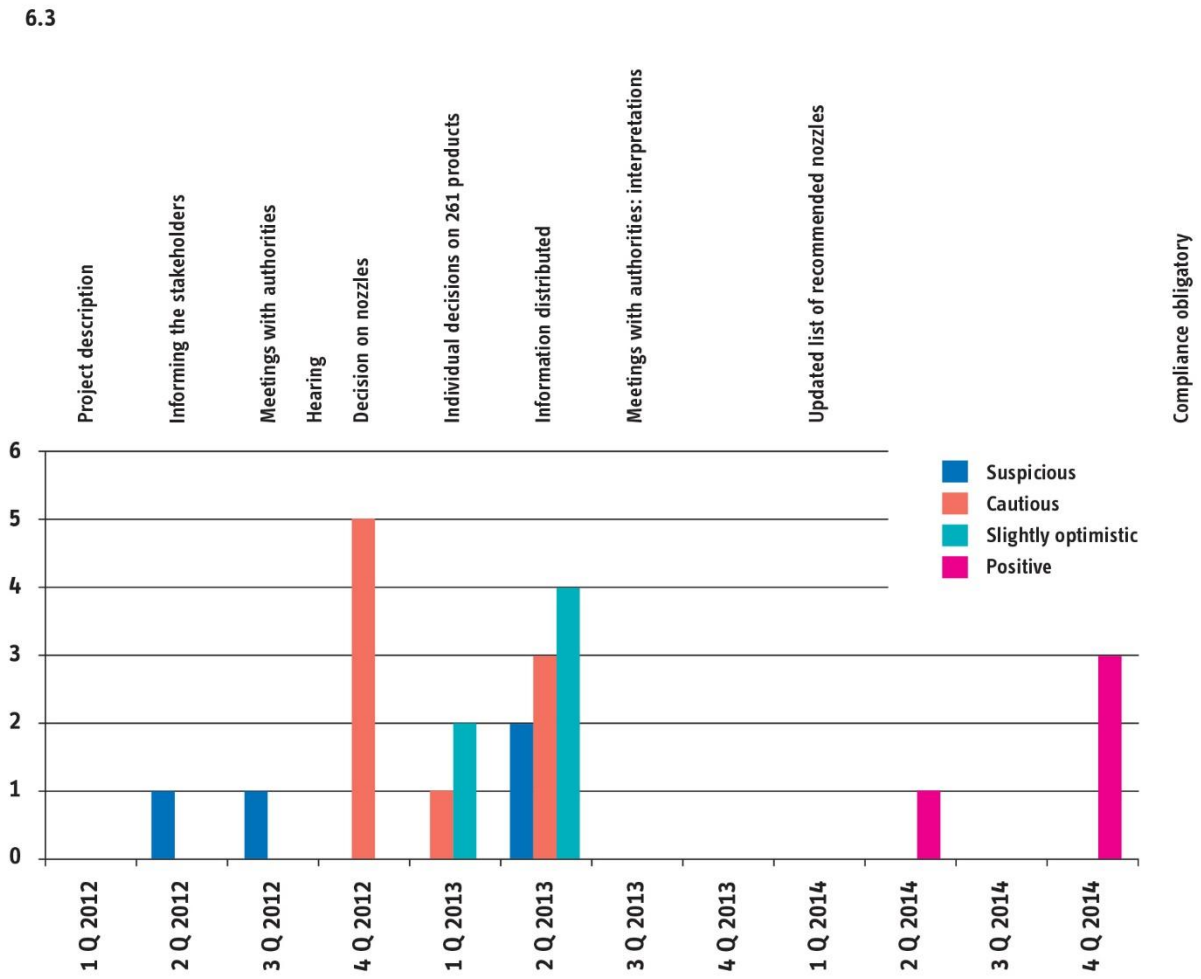

Figure 6.3. The development of attitudinal change in articles about the amendment of aquatic restrictions over the course of the project (Tukes 2015d). Number of articles with different outlooks over time.

The case of amending the aquatic protection zones of plant protection products (Tukes 2015d) was much debated in the agricultural trade papers during the period analysed. The protection of surface waters in general was perceived as significantly restricting agricultural entrepreneurship. The obligation to choose the least hazardous product was specifically mentioned. Seven articles dealt with amending the buffer zones for surface water courses. Several articles expressed the farmers' confusion even though the aim of the reform was to make their practices easier. The earlier version of the aquatic restriction may not have been seen as obligatory, whereas the reform was felt to contribute to further restricting the prevailing agricultural practice.

Compliance control was largely perceived as a concern. A positive message emerged during the course of the aquatic restriction project: you can cope with the new buffer zones; however, collective learning is necessary to adapt the cultivation routines to the new system. A positive response was presented from a forward-looking, skilful farmer about the applicability of the new buffer zones. It was appreciated that there is information available on the Tukes website, although the need to also have information in Swedish was highlighted: the Plant Protection Product Register was mentioned in particular. The training materials to be produced should cover the buffer zone issue in detail. The transitional period for the reform was discussed: the implementation of the new system on farms was recommended straight away, but to be obligatorily followed from 2015 onwards.

More user responsibility specifically in managing spray drift was called for in two articles. Spray drift was perceived a treatable problem that requires know-how and skills from the user to create good practices and strong routines in plant protection operations. The ability of advisory services to provide the farmers with simple and comprehensible advice and guidance in a personal way was emphasised.

Comparison was made to the practices in other countries, where earlier practice had been considered stricter, but acceptance of the Finnish reform was predicted because of the effort to harmonise the practices with other countries. It was highlighted that Swedish practice takes into account the circumstances at the spraying moment, not only waterways but also residential areas, other cultivations and organic farms.

A market-driven view on drift reducing nozzles was presented in five articles. There are plenty of different types of spraying equipment and nozzles on the market, solutions to different conditions are available and an increase in equipment sales was foreseen, but agricultural machinery sales personnel need to be trained. However, it was considered problematic that the authority recommends specific equipment brands, and equal treatment of companies was required. Guidance and training for farmers was required to make the most appropriate decisions in spraying situations. Concerns over efficacy were raised if increasing the droplet size would compromise the control effect of herbicides.

The cost of updating existing spray equipment was calculated to be more than 1 000 euros, thus affecting the profitability of farming. The existing spray equipment in Finland tends to be quite old fashioned with a slow turnover, and it was questioned whether changing the drift reducing nozzles on old sprayers would actually work. A personal experience on the latest technique was praised as a tribute to large farming: a made-to-measure sprayer is an expensive investment, but one that increases reliability to reduce mistakes in spraying. It was highlighted that well-educated and skilful farmers are able to invest in know-how and diligence, although spray equipment inspectors also need to stay trained about the latest progress within the field.

Confusion about the definition of waterways was addressed in four articles. The distinction between waterways and ditches in the new Water Act requires different buffer zone widths. Concern about variation in the interpretation between different authorities is perceived as a contest between the responsible authorities. Possible errors in the channel network mapping data were predicted to cause problems in individual control cases, where the different interpretations would lead to claims to recover subsidies already paid. The farmers' own voluntary precautionary interpretation of applying the three-metre buffer zone for ditches as for waterways was proposed as a solution to the interpretation problem.

In the initial phase of the project, suspicion and criticism of and resistance to change was explained in several articles, although one of the aims of the project was to make the restrictions more user friendly. The tone in the articles was sometimes even arousing fear, seeing the farmer as a victim of the despotism of the authorities. Less frequently, the interplay between users and authorities was brought up as a possibility for suggestions. However, following the information provided and hearings organised for stakeholders during the course of the project, those who had been suspicious first turned cautious, and then satisfied and slightly optimistic voices emerged.

The proposed decisions did not draw much comment from the authorisation holders in the hearing. Finally, towards the end of the project, the general attitude appeared more and more positive: the farmers can live with amended aquatic protection zones, although collective learning is required to get used to the new practices, and the benefits of the new system were highlighted. This turn is illustrated in Figure 6.5 with the different colours of the bars over the course of the project.

From the evaluation point of view, it would be interesting to study how the amendment of the aquatic protection zones will affect the market for drift reducing nozzles and the results of spraying equipment inspections. Statistics about the share trends of sprayers equipped with drift reducing nozzles should be collected. Inspectors could report their observations about the condition and reliability of sprayers equipped with different types of nozzles. Presumably, the drift reducing nozzles should also affect the aquatic concentrations of plant protection products, which should be reflected in monitoring studies. Concerning health effects, one issue to evaluate is the possible exposure of users if the nozzles need to be changed by hand in different phases of the spraying work in the field. The risk of leakage may increase when the nozzles are changed in the field. Thus, it is not always simple to reduce the overall risks.

Concerning the other environmental restrictions, restricting the use of mobile plant protection products on defined groundwater areas was perceived as a significant obstacle to agriculture. Legal protection of the farmers was highlighted in the cases where their fields are located in the groundwater areas, and scientific mapping of the boundaries of groundwater areas was required all over the land.

Controlling compliance with the use restrictions and other legal obligations was often framed as a threat to continuing the cropping business. The interpretations of different authorities were perceived as confusing. However, for farmers who are aware of the requirements, follow good agricultural practices and use instructions and keep records of all decisions according to the legislation, there should be no fear of sanctions. Moreover, if they observe the precautionary principle, as one of the interviewed farmers explained, introducing buffer zones on water channels, interpreting them as river beds instead of ditches, then the surveillance authority has no reason to criticise this decision.

Concern about the insufficiency of the current warnings to protect honey bees was explained and the benefit of the ecosystem service that honey bees provide by pollinating the crops was highlighted in one article. More specifically, the need for exceptional permission for neonicotinoid seed dressings for spring-sown Brassica oil plants was one issue considered in two articles. Neonicotinoid seed dressing was considered justified by a lack of alternative products, and because all alternative chemicals are undesirable for pollinators (Ketola et al. 2015). However, no discussion on longer-term solutions was presented, such as how cultivation practices would need to be improved to avoid the damage. Although beekeepers expressed their willingness to compromise with farmers, it was not obvious from the articles whether they get positive response from the farmers' side.

Other environmental issues discussed in the articles analysed were the new proposed risk mitigation to protect terrestrial non-target plants, which was perceived as excessive, and the impact of climate change on cultivation practices, specifically plant protection during the rainy growth seasons when surface water runoff is increasing.

The training and certification system for the professional users and retailers of plant protection products was under construction during the period when the articles were written. This was reflected in three articles. Offering training events was considered as important, but the need to participate in training was questioned to some extent, as the knowledge can also be gathered by persons individually. However, it was recognised that the field of the sustainable use of plant protection products is developing so quickly that continuous training and updating of skills is necessary. Thus, it was questioned whether one half-day training and testing session in four or five years is sufficient to keep knowledge up to date. Adopting the information provided in the training sessions is a central element for evaluating the sustainability of plant protection practices. Persuading farmers to participate in training events requires high quality educational material and skilful trainers. Readers were informed about how user training is turning into certification: anyone who takes spraying decisions, professional users, sales personnel and contractors are subject to certification, which promotes the sustainable use of plant protection products. The revisions of environmental restrictions call for the continuous training of users. IPM is a

management system that is based on know-how and continuous training. The general attitude towards certification was positive. From a user's point of view, it was seen as appropriate to certify the users of plant protection products as with other dangerous chemicals.

The responsibility of farmers to future generations was explained in one article, where a farmer was interviewed about his perceptions of IPM. He recommended adopting the metaphor of medical doctor as a guiding principle for the professional ethics of applying IPM in the long term. This idea is a good example of sustainable agriculture, taking into account not only the fertility of the soil, but also the other compartments of the environment such as water courses and biodiversity within the farm. IPM was considered to be deliberation and common sense, forethoughts and monitoring of plant protection decisions. Sustainable agriculture requires long-term perspective to take future generations into account. Practising IPM is a way to participate in the discourse of society, 'PR for agriculture'.

The vantage point in these professional articles is that of the farmers who actually take the decisions and apply the plant protection products in the fields. All the farmers interviewed were male, although some of the authors were female. A distinctive feature of the discourse was that the authorities interviewed were typically female, often giving an impression of pedantic authorities setting idle impediments to farmers' business as usual. The professional users' view of the authorities responsible for implementing the legislation was often remote, estranged from the practice and even arbitrary, and the decisions taken by the authorities were seen as unexpected. Both sexes were represented among the advisors and researchers who were interviewed, and the tone was usually mutually appreciative.

6.5. Expectations of selected experts

In order to clarify specific issues and data gaps in other materials collected so far, I asked several experts a number of focusing open-ended questions during the data collection process, as described in Chapter 4.4.3. Depending on their sectors and fields of expertise, the specific questions as well as the means of discussion varied from person to person during the study course. I received data from 18 individuals in total: researchers, authorities and other experts representing five institutes involved with the NAP actions, plus two organic farmers who recently participated in the training. In order to ensure their anonymity I will not give their identity. I met some of these people face to face or via video conferencing, while others answered my questions by e-mail and sent me additional documents.

The discourse among the consulted experts dealt with slightly different themes than those raised by the citizens (see Chapter 6.3) or discussed in the media (see Chapter 6.4). This is certainly due to the specific questions directed at the experts given their areas of expertise, so the discourse among the selected experts was anticipated to focus on issues that were not fully covered by other means of data. Naturally the views of the experts were linked to their roles as implementers of the NAP actions, and also represented their institutions in general. The need for improving the scientific knowledge base for the implementation of the NAP actions, challenges in the training and education of the farmers and other users, plus knowledge brokering and communication between scientists, agricultural practitioners and the general public were issues that came up regardless of the discipline of each expert and are discussed in more detail below.

As one main type of intervention, research is mentioned in many sections of the NAP document as a key task. Research needs were divided separately into different sectors within the NAP document. However, in the expert

panel discourse, scientists representing various areas of expertise called for research collaboration integrating different domains to cover the transdisciplinary, holistic, systemic nature of knowledge needed today to support the implementation of the NAP. A challenge for the agricultural innovation system (AIS) is to create a dynamic IPM research agenda that supports the farmers' transition in a timely way from lower levels of IPM implementation towards a higher level, focussing on ecosystem processes. The development of the IPM research programme is ongoing (Nissinen et al. 2015a-c). It was observed that the topical discourse of the farmers have moved from reducing the use of chemical PPPs to replacing them with biological, physical and mechanical control methods within 2-3 years. A shift to increasingly ecological perspectives of sustainable crop protection was envisaged in future agricultural research, with participatory designs promoting social learning processes of the agricultural community as a whole.

Similarly, the environmental monitoring research intends to utilise the regionally variable usage data for focusing the sampling to areas with the most intensive PPP release into the environment (Karjalainen et al. 2014). A holistic view and collaboration with researchers and institutes is required in an attempt to detect the sites with highest risk and to target the risk mitigation measures for improving the ecological water quality in sites where the number of detected compounds is highest, while the overall concentrations of PPPs in Finnish surface waters are very low, and the allocated monitoring resources are limited.

Research collaboration needs between health and agricultural researchers were recognised in operator protection issues such as the factors affecting the efficacy of personal protection equipment or the actual concentrations in tractor cabins during the application of PPPs. It was also noted that contract sprayers conducting sprayings to order by other farmers will likely receive more exposure when this type of application becomes more common. The contract operators would therefore be an interesting group to focus the health effect studies on in future. It was highlighted that the current occupational health statistics do not adequately separate the possible operator health effects caused by PPPs from other causes, and are therefore not appropriate indicators for reducing the health risks from PPP use. Additionally, perceived symptom description studies would be useful, and some projects are ongoing.

The role of *training and education* was highlighted in the experts' discourse. The implicit pre-assumption of the Finnish NAP is that providing the users with training and education would bring about more cautious use plant protection practices. This assumption has not been challenged, although contradicting evidence is available in the literature on the effectiveness of educational interventions associated to the use of plant protection products in promoting health, e.g. by Lehtola et al. (2008) or Lichtenberg & Zimmerman (1999). Indeed, it will be important to evaluate the actual achievements of the Finnish training and certification system set up as the most topical intervention to implement the NAP. From an occupational health point of view, the right choice of personal protection equipment, hygienic working practices and guidance on how to ensure the purity of the tractor cabin indoor air were seen as key items for user training. The assumption of the effects to be achieved by providing the PPP users with a short training event begs the question, how likely is the change of attitudes of the participants in long term and how do we expect the new knowledge to cause a change in practices? Should we separate the short-term learning from the more persistent attitudinal change? The fast development of the IPM discourse is a challenge not only to the scientists but also to the training providers who should be able to respond to the topical knowledge needs of the farmers (Nissinen et al. 2015a-c).

Based on the responses from organic farmers, the training available today does not consider adequately the specific knowledge needs of plant protection issues in *organic farming*. Especially a novice producer or one who is moving from conventional to organic farming would need very comprehensive and practical training and education in biological control and alternative methods of controlling weeds, pests and plant diseases. However, one responder noticed positively how the conventional farmers were also actively prompted in the training to

choose primarily other means than chemical plant protection products. A short and general one-day event for passing the certificate is definitely not enough, but further in-depth training and advisory services should be available to make the learners proficient in practical problem-solving in field situations. Instead of lectures, a more practical demonstration-based and deliberative mode of training was requested. In addition, the need to link the training of beekeepers and farmers in tandem was brought forward, as beekeeping is a significant secondary income to many farmers and the ecosystem services provided by the bees to the agriculture are increasingly appreciated. Shared training would help both branches to understand each other's problems and encourage solutions that benefit both parties.

In addition to training events, material for self-directed learning should be available. There has been a good response from the users on the training material developed which is now available at the website of Tukes (Tukes 2014b). Additionally, the users would appreciate a platform where materials from training events, presentations, publications and guidance documents would be available online. A number of IPM projects aim to respond to this need, e.g. PesticideLife (2010-2013) where all seminar materials, publications and training videos produced during this project are available at: https://portal.mtt.fi/portal/page/portal/mtt/hankkeet/pesticidelife, or IPM-APU (2011-2013), where the development of a user supporting Internet-based data management system (IPM portal) was initiated. Provided that the funding for the further development of the IPM portal will be guaranteed, the portal will be a solution to this demand in the future (Rajala 2013, Vänninen et al. 2014). The training and advisory services should guide the professional users to seek information from these sources independently.

The role of the NAP Steering Committee was experienced as unclear by some actors. Indeed, it has not been mentioned at all in the NAP document, but the Competent Authority Tukes set it as an informal consultative group where all stakeholders were given a possibility to be represented. Not all stakeholders used this opportunity, and depending on each organisation the flow of information from the participants to other colleagues may vary. The questions to be shared with the NAP Steering Committee members depend on what the participants are willing to bring to the agenda. Some experts also proposed whether substance-specific sub-groups for deciding on specific tasks (like on the adequacy of monitoring) would allow better guidance for the practical implementation of NAP actions.

It was noteworthy to observe that consumer communication was perceived to be rather difficult by the experts. A few of the experts found some confusion on the responsibility of communicating the NAP and IPM research findings to the general public. Although knowledge brokering to the professionals within the agricultural sector (advisors, farmers) belongs to their core actions, they felt it difficult to communicate to lay people on how IPM makes difference compared to conventional farming.

> "[…] inform consumers that PPPs are used systematically and when needed, which means ecological sustainability, when inputs are not lost." (VII.B.4)

The varying information needs of different consumer groups have not been defined in detail in the NAP. Neither does the NAP document take a stand on the exact roles of independent actors as knowledge brokers, but assumes the communication is a collective effort, with each organisation bearing the responsibility for its own part. The multi-actor nature of the NAP suggests that any actors producing new data are responsible for communicating it independently to the citizens through the most appropriate media, without any kind of approval from the NAP Steering Committee. The yearly communication plan only considers the information campaigns planned in Tukes, not the other independent actors involved, who make their own decisions about communicating their research results or other important issues independently.

The data available on the websites of the organisations implementing the NAP – including the sales and usage statistics, and monitoring results – also serve the communication needs of the general public. A timely publication of these data was therefore considered to be very important by the experts. However, producing more detailed analysis of the use patterns from the statistical data beyond what is required in the legislation would need further resources and can only be realised temporarily on a separate project basis. The messages and questions from individual citizens to the authorities are an important and timely way of communicating the sustainable use patterns of PPPs to the general public and bringing forward the voices of those affected but not involved. Examples of these questions have been discussed in detail in the previous chapter. As direct contacts with citizens such as a presence on social media (Facebook, Twitter, etc.) and at fairs and exhibition events, will obviously be increasingly important in the future, the experts would benefit from receiving training on public appearances and the popularisation of science. However, struggling with the balance of reducing resources means that prioritisation is necessary, with inputs required to awareness-raising activities.

6.6. Screening the sustainability goals of the Finnish NAP

The current progress of the Finnish efforts on implementing the NAP was assessed with the expert panel using the sustainability screening framework of national sustainable development strategies, NSDS (Cherp et al. 2004). As described in Chapter 4.3.4, the NSDS framework consists of five principles of sustainability, with their criteria, explanations and ranking. The authors intended the framework to be used periodically for screening the achievements of NSDS towards sustainability.

The questionnaire was adapted to portray the Finnish NAP conditions for the specific purpose of evaluating the NAP and tested with the expert panel. Though the original scope was for national level analysis, the experts felt that the principles and criteria can also be adapted to the purposes of lower level screening, or to only cover particular issue-specific sectors by simply omitting some of the criteria that are considered not relevant for the sectors to be considered. Responses were received from individual experts, and a group of participants also volunteered to test and comment on it as a team, thus allowing a general group discussion on sustainability criteria from their own perspectives. The individual and team responses were amalgamated, and it appeared that although verbal comments on specific criteria indicated the respondents having essentially similar views, the rankings given for them varied significantly, as shown in the right-hand column of Table 2.2 in Appendix 4 and depicted in Figure 6.4, where the extremities of current ranking given by the expert panel participants is presented. Therefore it is not appropriate to use the ranking as a quantitative measure of progress, but rather as a hint of areas requiring most effort in the future. To follow up the progress in implementing a sustainability strategy, its ranking can be repeated from time to time. The ranking is:

- A = all of the requirements of the criterion are fully met;
- B = all the requirements of the criterion are satisfactorily met, although some further improvements are desirable;
- C = some requirements of the criterion have been satisfactorily or fully met, but others have not yet been satisfactorily met;
- D = few of the requirements of the criterion have, as yet, been satisfactorily met.

Areas where most significant progress was observed by the experts are: compliance with international agreements (1.4) and high level governmental commitment (3.1) with rankings yielding from A to B. In addition, broad-based political support (3.2), assigned responsibilities for implementation (3.3) and building on existing

strategic planning processes (4.1) were perceived as fully or satisfactorily met with rankings from A to C. Respectively, under almost each principal area there are issues where the progress was perceived as less satisfactory so far, thus indicating the most urgent need to focus further work. Consideration of social and economic issues (1.2), decentralisation to more local contexts (4.4) and setting of targets and indicators (5.3), with rankings from C to D, are in areas with the least progress. Additionally, five more areas were recognised with rankings yielding from B to D: integrated analysis of economic, social, and environmental issues (1.1), maintenance of sustainable levels of resource use (1.3), long-term vision for the development of Finnish agriculture (2.4), analysis of national resources and capacities (4.3), and existence of mechanisms for monitoring the achievement and feedback (5.4). As a conclusion, there are quite a number of areas where the NAP progress towards sustainable plant protection is considered to be still in its infancy, while the general progress within the area of ownership and commitment was considered as most satisfactory by the experts. If the screening is repeated in a few years, it will be interesting to see the areas with most intensive progress as well as the least developed areas.

6.4

Expert panel assessment on the Finnish progress in the implementation of the NAP

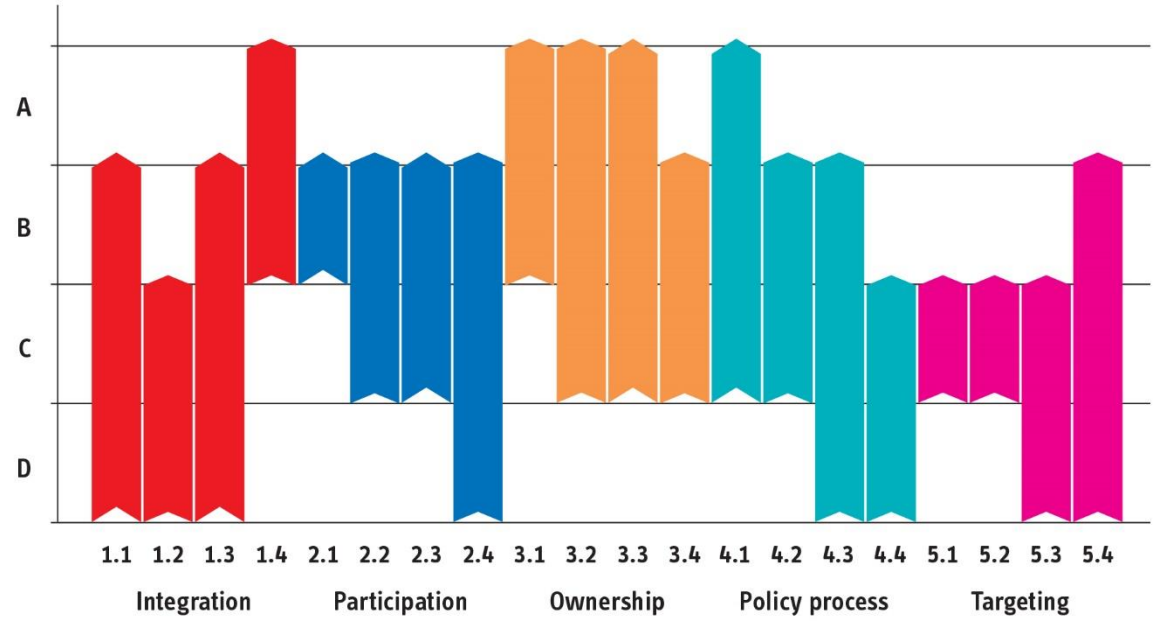

Figure 6.4. Expert panel assessment on the Finnish progress in the implementation of the NAP in the light of sustainability screening NSDS framework by Cherp et al. (2004) by spring 2015. The coloured bars refer to the five principles of sustainability: 1. Integration of economic, social, and environmental objectives, 2. Participation and consensus, 3. Ownership and commitment, 4. Comprehensive and coordinated policy process, and 5. Targeting, resourcing and monitoring. The ranking is from A = all criteria fully met to D = few met as yet, as explained in the text above. The numbers refer to the specific criteria of the principles as presented in detail in Table 2.2 of Appendix 4.

6.7. Conclusion on the discourse about PPP use among different interest groups

Different perspectives of the interest groups in the multi-voiced discourse about sustainable use of plant protection products are illustrated below in Figure 6.5. Some core projects and actions of the NAP as well as key stakeholders were placed on the grid, where the vertical axis represents the continuum between the individual and organisational perspectives, and the horizontal axis between the stances of environmental and human health protection versus agricultural production. The positioning of different actors in this graph portrays the perspectives surfaced in the different materials I analysed: focus group discussions, citizens' communications, professional articles in agricultural papers and focused consultations on specific specialists.

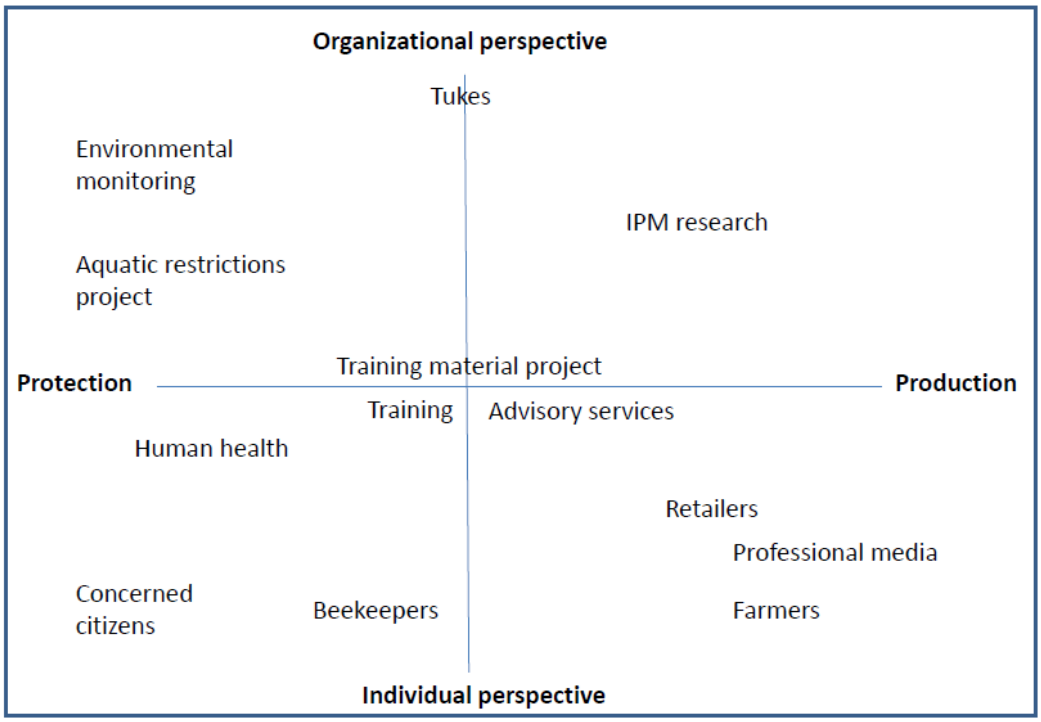

Figure 6.5. Typical perspectives of the participants and interest groups in the multi-voiced discourse on the sustainability of PPP use (modified from the model of Engeström 1995, p. 51).

Stakeholders' views on sustainable use of plant protection products vary from ecological conservation and transition to organic farming to economic profitability of the conventional farmers in order to change the current plant protection practices as little as possible, thus suggesting separate advocacy coalitions in framing the discourse on plant protection. People's core beliefs as regards policy are relatively stable and require external events and long time periods to change, thus maintaining quite persistent structures of advocacy coalitions, as explained by the Advocacy Coalition Theory (Sabatier 1998; Sabatier & Jenkins-Smith 1999; Weible et al. 2009). While the production-inclined coalition appeared to be consistent and well organised (probably due to better resourcing), the voices of the protection-inclined coalition remained disconnected. The diversity of views in the policy evaluation could be seen as an asset instead of a hindrance. For instance Schreuder (2001) argued that participation of all different stakeholder groups in environmental policy-making increases its success, expecting

that participants who perceive they have a say will more likely comply and follow through on the agreed policy. Wagenaar (2011, p. 296) holds discursive policy analysis as an emancipatory promise for the future to sum up complex phenomena as being able to cope with complexity, time, and deep value differences by amplifying weak voices and unearthing deep assumptions kept by institutional forces and not easily dislodged.

6.8. Constructing the programme theory for the NAP

The expectations of stakeholders have implications on the programme climate that supports achieving the goals of the NAP, thus making the programme theory of the NAP explicit. Programme theory is used to understand the programme to be evaluated and guide its evaluation. The assumptions on how the Finnish NAP is going to work (how the NAP activities are assumed to produce the outcomes, reduced risks) were left implicit in its preparation phase, and therefore it was necessary to formulate an explicit programme theory for the NAP. Without making its programme theory explicit, the evaluation would not be able to understand the causal links of the inputs, actions and desired outcomes, thus considering the programme as a black box. The programme theory influences the evaluation procedures to be chosen. Therefore the insights of various NAP stakeholders were gradually constructed into the programme theory of the NAP before applicable tools and procedures for its evaluation could be proposed in Chapter 7.

Programme theory can be defined as a configuration of the prescriptive and descriptive assumptions held by stakeholders on how a programme is supposed to work. Providing training and advisory services is considered the most focal type of interventions in the NAP, because the (trained professional) user is the key player responsible for the actual use patterns in every spraying event of plant protection products. The intervention theory behind the model is that providing training and advisory services, information, control and surveillance measures and research findings accessible to farmers and professional users of plant protection products improves their capability of using safer working methods and knowledge of IPM, which in turn leads to less exposure and reduced risks.

A *logic model* is a graphical representation of the relationship between the activities and the expected outcomes to highlight the programme components, including inputs, activities, outputs and outcomes to make the assumptions of a programme theory visible, as presented in Figure 4.2. The programme theory behind the Finnish NAP was not discussed in detail during its preparation in the ministerial working group, which largely relied on the background study of Peltonen & Rajala (2009) as a needs assessment. An overarching principle was to avoid unnecessary administrative workload and minimize the burden from new requirements to the farmers. Based on the contributions of my expert panel and after discussing the assumptions behind the programme theory of the Finnish NAP as presented in previous Chapters, I drafted the programme logic for the five types of interventions on the basis of preferences, expectations and views that came up during the expert panel working. My proposal draws from the frameworks of the W. K. Kellogg Foundation (2004) and Chen (2005). In case where the stakeholders may have different interpretations on the NAP and its evaluation, separate logic models for the interventions may help overcome possible disagreements (Worthen et al. 1997, p. 224). Taking the multitude of views of different stakeholders, this proposal cannot be regarded as any consolidated view of all stakeholders, but can serve as a proposal to illustrate what kind of promises a programme logic of the Finnish NAP could include, to be further refined by the Steering Committee when the evaluation actually begins. Regardless of the obvious repetition, I have aimed for maximal clarity, and therefore I have presented the logic model for the five

types of interventions on separate sheets. I assume this grouping to serve different stakeholders who can reflect their own assumptions more easily, when the logic models are separated.

My proposal for expressing the logic model for providing the professional users with training and certification is presented in Table 3.1 of Appendix 4. A logic model for the requirements related to PPP uses on sensitive areas and/or in specific conditions is presented in Table 3.2 of Appendix 4. A logic model for promoting research of sustainable use patterns is illustrated in Table 3.3 of Appendix 4. A logic model for raising the awareness on safe uses of PPPs is presented in Table 3.4 of Appendix 4. A logic model for increasing the control measures appears in Table 3.5 of Appendix 4, and finally, a logic model for developing adequate monitoring system for demonstrating the evidence of the NAP outcomes is illustrated in Table 3.6 of Appendix 4.

Deriving from the explicated logic models of separate interventions, the *systemic programme logic* of the NAP could then be conceptualised based on the systems oriented theory-driven evaluation frameworks of Boyd et al. 2007, Jacobs et al. (2012) and Wasserman (2010), as presented in Figure 6.6. and repeatedly in Figure 3.2 of Appendix 4.

6.6

The systemic program logic of the NAP interventions, based on Wasserman 2010

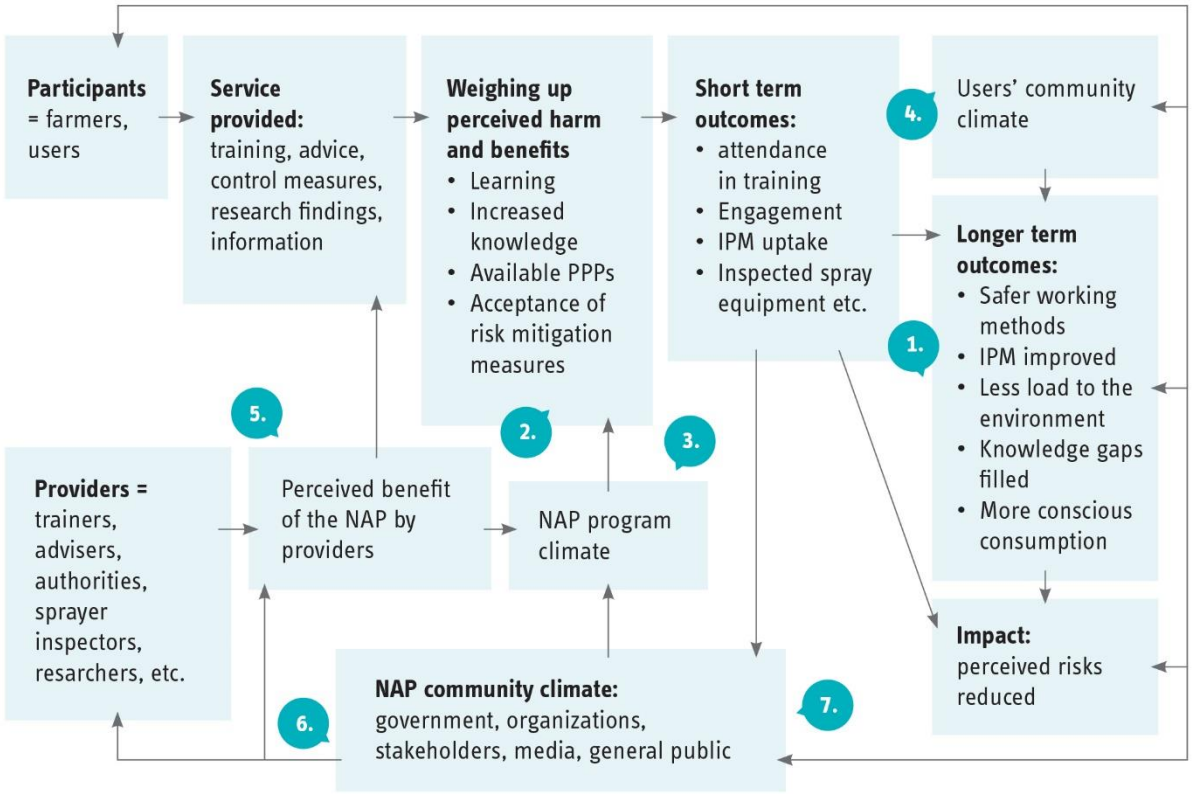

Figure 6.6. The systemic programme logic of the NAP interventions, based on Wasserman 2010. The numbered evaluation points are explained in the text below.

The systemic programme logic illustrates how the participants, service providers and their peer communities interact to produce the expected outcomes and impacts. The numbers refer to following evaluation points in Figure 6.6:

1. Participant to outcome
2. Participant to programme activities
3. Participant to provider
4. Relationship of the participant's own social community of peers (farmers, professional users etc.) to participants' outcomes
5. Providers to their outputs
6. Providers to sponsoring organisations
7. Providers' functionality as buffer of evaluation results.

The measures to the evaluation points 1-7 can be either quantitative (e.g. Likert scale responses to questionnaires surveying the attitudes) or qualitative (e.g. open-ended interview data). Suggestions to possible measures for each evaluation points are presented in Chapter 3.2 of Appendix 4. Depending on the purpose of the evaluation, the type of data to be gathered and resources available, case-specific evaluation questions for each evaluation point can be modified. Evaluation questions specified for different evaluation forms, as presented in Appendix 4, Chapters 1.1 - 1.5, can be modified to each evaluation point of the systemic programme logic. The systemic programme logic intends to describe the individual motivation for transformation. Thus different system levels can be incorporated in the policy evaluation when this framework is used to set evaluation questions.

In the systemic programme logic, both the receiver system and service provider system are taken into account in the evaluation, which in case of the NAP means that the perspectives of both participants in training and service providers should be included. In addition to a change model that illustrates the causal relationship between the intervention and expected outcomes, and an action model associated to the protocol of producing the change, Wasserman’s (2010) systems orientation is based on a foundational theory that explains the motivational effects of both participants and providers that contribute to the success of a programme. Self-determination theory of Ryan & Deci (2000) as the foundational theory explains the success or failing of human service programmes which has been tested in a range of programme evaluations, as intrinsic motivation arising from the satisfaction of basic psychological needs for relatedness, competence and autonomy predicts the longer term achievements, whereas external motivations (e.g. rewarding or sanctions) only function short-term and predict less success of an intervention. Basic psychological needs satisfaction is the driver of personal motivation of both participants to attend programme activities (farmers participating training events and receiving advisory services) and commit to its targets as well as of service providers to provide high-quality training, research and other services in line with the programme goals.

Applied to the Finnish NAP, the self-determination theory would mean that in order to induce desired longer-term outcomes like safer plant protection practices and thus less exposure into the environment, both the professional users and their training providers need to feel intrinsic motivation and perceive personal benefits from training or other interventions in which they are engaged. If the interventions are perceived rather as punishments or hindrances to business, the likelihood of achieving the NAP goals will be minimal.

In this conceptualisation of programme systems, outcomes exist in the context of programme participation and participants' existing conditions. Moreover, the system includes formal and informal programme evaluation feedback. Service providers receive feedback both through participants' community (e.g. farmers evaluating the

training events and proposing training subjects) and from administrators, authorities, researchers and other stakeholders of the NAP community. For participants, feedback about programme success arrives usually through advisors, trainers and possible control authorities, as well as through their peer community. The attitudinal climate within the NAP implementers (NAP programme climate), the wider stakeholder community (NAP community climate) and within the participants' peers (Users' community) is essential with regard of assessing the achievements, in supporting both participants' and providers' basic psychological needs satisfaction, appreciating their efforts towards the shared goal of risk reduction.

6.9. How learning contributes to the programme logic and anticipated NAP outcomes

As explained before, the self-determination theory defines the *intrinsic motivation* to be the foundation for learning that steers the personal transformation process embedded in the NAP. Professional user of plant protection products is required to act responsibly, that is, to control pests on crops so that the risks to human health and the environment are minimised. According to the programme logic of the NAP this will be achieved by providing the user with training, information and advisory services to enhance his or her learning about the safe use of plant protection products. As a proof of the knowledge gained, the professional user has to pass an examination.

The Finnish NAP does not explicitly take a stand on what kind of learning processes are anticipated in professional users in consequence of providing them with training, certification or advisory services, or in participating organisations. Nevertheless, the role of training and education was highlighted in the expert discourse and thus learning is the core of the programme theory. The experts conceive the comprehensive changes of pest control practices as a whole as well as the learning of users and consumers as measures for the achievements of the NAP implementation.

The expert panel respondents see the advisors (both commercial and public) indispensably involved in the implementation of the NAP as important facilitators to support the learning of the PPP users. Advisors working for the extension services are typically also certified for training and certification providers. The relevant educational background together with the work and training experience are the key criteria for the authorisation of training and certification providers (Tukes 2015b). In the absence of educational qualifications, plant protection-related work experience of more than a few years is also accepted. These requirements have been agreed between authorities, actors within the plant protection sector and prospective training providers. No applicants have been rejected either on the basis of their plant protection or training experience so far (Laitinen 2015a, personal communication).

The pedagogic methods and skills of the trainers and advisors have not emerged in the discourse on the implementation of the NAP yet. Their professional knowledge about plant protection practices and training experience is assessed during the authorisation of the trainers, but they are neither obliged to explicitly demonstrate in practice their pedagogic skills or methods to be used, nor explicate their theoretical approach to the vocational training. The interventionist individual learner paradigm presents itself as trust in conventional classroom lecturing as the prevailing training method, thereby not challenging participants towards shared knowledge production and collective learning during training sessions. Some of the trainers, such as vocational teachers in agricultural schools, certainly also have teaching methods that are more participatory than lecturing, but variation is anticipated among actors as the NAP legislation does not lay down any specific requirements on

the pedagogic skills of the training providers. To improve this situation, further training of the trainers provided by Tukes could consider also the pedagogic aspects in effective knowledge brokering to allow collective learning.

According to the expert responses, the greatest interest is in benchmarking and social learning from the most skilful and progressive farmers and demonstration farms, where the IPM practices are tested and put into operation. This emphasis brings forward the most successful individuals as role models, but any larger scale transformation is not expected until the new innovative IPM methods are adopted also by the masses of average performers (see e.g. van Eerdt et al. 2014, Wijnands et al. 2014).

For new knowledge to become profoundly adopted, individual, social and collective learning processes need to occur simultaneously between those to be trained and their trainers. The transformation in attitudes does not happen in a moment. The assumption of changing the behaviour of the PPP users by providing them with a one-day training and testing event begs the question of the likelihood of their attitudinal change that would in reality lead to a lasting change of their practice at levels 3-4 in Kirkpatrick's model of training evaluation (Kirkpatrick & Kirkpatrick 2006). Shouldn't we rather separate the short term learning (Kirkpatrick levels 1-2) from the more persistent attitudinal change in professional users? Without finding out about the values and attitudinal climate of the users' communities it is difficult to evaluate the actual outcomes and impacts of the NAP interventions. In the evaluation, the short term learning of the participants in training can well be measured by statistics on passed examinations, but revealing if attitudinal change towards sustainability has actually been achieved, has to be investigated by other means such as surveying and interviewing the participants (e.g. McEntee & Vazquez Brust 2011, van Eerdt et al. 2014). Attitudinal issues to be studied could, for instance, be their preferred learning styles, how they perceive the authoritative instruction in their practice, how they perceive their social and environmental responsibility and the environmental and health risks, and their willingness to adopt new IPM practices in a wider context, as justified by one of the respondents:

> "Knowledge adds pain, but also motivates a person to take right decisions. A farmer takes more likely good and right decisions, if s/he knows how the environment works." (IV.A.2)

Although the issues of organic farming have recently been increased in agricultural training, responses received from organic farmers suggest that the training available does not adequately consider the specific knowledge needs of plant protection in organic farming yet. A novice producer or one who is turning from conventional to organic farming would in particular need very comprehensive and practical training and education in biological control and alternative methods of controlling weeds, pests and plant diseases. Therefore, a general one-day event for passing the certificate is definitely not enough, but further in-depth training should be available, preferably rather in the form of demonstrations than lectures. Linking the training of beekeepers and farmers in tandem was also proposed, as beekeeping is a significant secondary income to many farmers and the ecosystem services provided by the pollinators to the agriculture are increasingly appreciated. Shared training would help both branches to understand each other's problems and encourage solutions that benefit both parties.

As a conclusion, in addition to the substance knowledge on plant protection practices of training providers and advisors, their pedagogic knowledge on learning theories about individual, social and collective learning processes and diverse participatory educational methods also contribute to the success of the training events and participants' professional learning. However, stakeholder participation and taking responsibility of one's own learning is equally important. It is ultimately the individual user who is responsible for the outcomes of the NAP to be evaluated as opportunities towards more sustainable plant protection practices.

7. Tools and procedures for evaluating the achievements of the NAP

As described earlier in Chapter 3.2, there are numerous ways to conduct a programme evaluation depending on who needs and uses the evaluation, for what purposes and by whom it will be performed and at which stage of the programme it will be conducted. To address my third research question, I explain and propose heuristic tools and procedures that could be applicable for evaluating the Finnish NAP in this chapter. A model for influence pathways of an evaluation is constructed in Chapter 7.1. As for the responsible actors defined in the NAP, the users of its evaluation can also be categorised at different systemic levels, each of them having distinguished influence processes in general, cognitive, motivational and behavioural domains and hence also different needs for the practical forms of performing the evaluation, as presented in Chapter 7.2. In Chapter 7.3 I discuss the process of selecting heuristic tools for framing an evaluation of the NAP. Because a plethora of appropriate frameworks have been developed and published for policy evaluation purposes, I decided to screen the literature and pick a few most prominent tools, which I tested with my expert panel participants and applied to the context of the Finnish NAP as described in previous chapters. In Chapter 7.4 an assessment of the applicability of these tools is provided. It is not necessary to use all tools I propose together, but depending on specific needs, different choices can be made. However, common to these tools is to consider evaluation as an intervention purposefully contributing to the improvement of the NAP and its outcomes (Midgley 2003).

7.1. Influence pathways of the evaluation of NAP

Evaluation results can be used in several ways, either instrumentally, persuasively, conceptually or symbolically, and by different users, likely also by unexpected users who are not under control of the sponsors, clients and implementers of the programme. Therefore potential uses of an evaluation of the NAP were explored. As outlined in Chapter 6, the expectations of the stakeholders on the goals and implementation of the NAP are variable, and hence also the uses of its evaluation may be divergent. The expert panel responses on the heuristics of expected evaluation outcomes were analysed at three systemic levels of analysis combining the framework for distinguishing key mechanisms through which a programme evaluation may have its effects (Mark & Henry 2004) with the twelve questions of Critical Systems Heuristics (Ulrich & Reynolds 2010). Sources of motivation, control and knowledge and sources of evidence of evaluation uses were considered at individual, interpersonal and collective levels, as summarized in Table 7.1.

From an *individual*'s view, users of plant protection products – especially the Finnish farmers putting into practice the IPM requirements, as well as consumers purchasing agricultural products and bystanders, residents and neighbours living close to agricultural fields – could be distinguished. They could benefit from an evaluation in their individual learning process, knowledge gaining and making sense of the plant protection. The farmers' motivation for this process comes from their need to set their production and livelihood goals within the boundaries of IPM requirements and economic profitability, and, if perceived reasonable, can lead to behavioural outcomes in their cultivation and plant protection practices, as explained with the programme logic. So an individual need to understand the causes and consequences of his or her own practices and to evaluate the choices made is the driver for evaluation mechanisms from an individual farmer's view. At an individual level, consciousness about the evaluation of the NAP can provide the professional users and trainers with heuristics for skill acquisition as objects and providers of an intervention. Cognitive and affective processes in handling the opinions and values of users, consumers and bystanders are prerequisites for individual knowledge increase, where information in an easily comprehensible form should be available. At personal and interpersonal levels, the experts highlighted the importance of discourse skills of the individuals that jointly discuss about the

progress. Being responsible for handling plant protection products safely, the user promotes the general good reputation of the entire agricultural sector and thus produces evidence for the evaluation. Learning to continually assess and record their progress and to reshape the plant protection practices accordingly fosters the self-determination of the users as responsible actors instead of subjects of training interventions. Record-keeping of individual farmers and of spray equipment inspectors was recognised as appropriate data to be produced for an evaluation. Surveying the professional users' experiences, attitudes and opinions would better explain their motivational process for behavioural changes instead of simply recording the total number of passed exams.

Table 7.1. Examples of influence pathways of a NAP evaluation for main actors involved in the implementation of the NAP. The systemic level gradually evolves from individual to interpersonal and collective levels from the top towards the bottom of the table.

Actor	Sources of motivation for NAP evaluation	Sources of control and knowledge about NAP evaluation	Sources of evidence of the use of NAP evaluation
(Professional) user	- to understand causes and consequences of own (IPM) practices - to gain knowledge and skills for improving own practices - to evaluate the choices made	- heuristics for skill acquisition on sustainable use of PPPs - improved discourse skills	- behavioural outcomes in cultivation and plant protection practices - evidence on economic profitability of IPM practices related to environmental benefits is appreciated
Consumers Bystanders General public	- to gain knowledge for making more informed purchase choices - to understand the plant protection practices in the neighbourhood	- increased self-esteem as participants - increased discourse skills	- behavioral outcomes in changing own practices: consumption, amateur uses of PPPs, local participation etc.
Training and certification providers Advisors Spray equipment inspectors	- to understand causes and consequences of the services provided - to gain knowledge and skills for improving own practices - to support the users in adopting IPM practices - to evaluate the choices made	- heuristics for skill acquisition as change agents for sustainable use of PPPs - improved knowledge brokering	- results from surveys - feedback from services provided - satisfaction of clients - behavioral outcomes in changing attitudes
Surveillance authorities	- to gain knowledge and skills for improving own practices - to evaluate the choices made	- heuristics for skill acquisition as change agents for sustainable use of PPPs - improved knowledge brokering	- risk-based focus of the surveillance visitations - behavioral outcomes in changing attitudes
NGOs Stakeholders	- to advocate the needs of those affected but not involved, e.g. the non-human nature and future generations	- policy-orientated learning - increased discourse and advocacy skills	- behavioural outcomes, empowerment in participating the implementation of the NAP

Advisory organisations Producer organisations	- to advocate the needs of specific production sectors, e.g. organic farming - social reward from appreciated peers	- policy-orientated learning - increased discourse and advocacy skills	- ownership related to (re)drafting of legislation - setting new standards
Research institutes	- to enable strategic planning of research programmes - to improve the effectiveness of research on NAP activities	- policy-orientated learning - systemic integration of knowledge from different disciplines to serve the NAP implementation	- accurate data produced for supporting a systemic view on the agricultural innovation system in the society - setting new standards
Authorities	- to streamline the NAP processes - to enable strategic planning of administration - to improve the effectiveness of NAP activities	- policy-orientated learning - systemic integration of knowledge from different disciplines to serve the NAP implementation	- accurate data produced for the evaluation - ownership related to (re)drafting of legislation - structural incentives - policy change
NAP community as whole	- to make informed decisions - to review the goals and set targets	- policy-orientated learning - systemic integration of knowledge from different disciplines to serve the NAP implementation	- accurate data produced for the evaluation - ownership related to (re)drafting of legislation - implementation of higher systemic level agroecological IPM practices - decreased dependency on chemical PPPs - improved quality of the environment

Interpersonal relationships influence the evaluation mechanisms, when there is a need to evaluate how the advisors and trainers act as change agents to persuade and support the professional users to adopt more sustainable plant protection practices, how control authorities perform enforcement visits in local farm settings or how neighbours or beekeepers are heard when they express their concerns or request information on spraying events, for instance. Appreciation by the peers of prosperous farmers within the agricultural community was recognised to produce motivation by social reward. Training and certification providers, advisors and information campaign organisers are very important knowledge brokers and change agents who have a pivotal influence on the attitudes of both users and consumers. The empowerment approach redefines the professional's interpersonal role relationship with the participants: the service providers work with participants instead of advocating for them, thus facilitating and coaching their self-empowerment and maintaining an atmosphere of active knowledge exchange and mutual data sharing. Knowledge brokers can identify the benefits of evaluating their own practice. Policy-oriented learning from the evaluation can empower stakeholders not yet involved, motivating them to advocate more explicitly the needs of those affected, including non-human nature and future generations. Representatives of NGOs and other stakeholders, constituting their interests and values explicitly in the discourse related to sustainable plant protection, can influence in the local and general climate of social rewards of respecting the injunctive norms of good agricultural practices, thus possibly leading to a more collective change in practices compared to what single individuals can gain.

From a collective and *organisational* perspective, obvious users of an evaluation are the NAP Steering Committee, authorities and policy-makers who have an ownership relation to the evaluation, report their efforts and results and review the goals and set targets for future work. Research institutes can also use evaluations for planning their research projects to respond the call for knowledge needs on plant protection issues. Societal uses of an evaluation can include policy considerations like (re)drafting legislation and setting new standards and guidelines, but also formation of coalitions and ritualistic uses. At this level, an evaluation may require a more systemic view about the agricultural innovation system in the society and about whether certain achievements and failures are factually due to the NAP or whether they happened unintentionally. A collective behavioural outcome would be, for instance, the explication of willingness and evidence of shifting agriculture towards higher levels of agro-ecological IPM integration. The importance of policy-oriented learning within the organisations involved was emphasised by the respondents, as:

"[…] there is a lot of expertise, but integrating the data is still inadequate." (VII.B.3)

Ideally, an evaluation would produce meaningful evidence at all three levels of interest, to be useful for individuals, interpersonal as well as organisational situations. This may also be problematic for a policy programme like the NAP, being rather abstract from an individual users' point of view. In addition, the usually long-term horizons between interventions and assumed measureable impacts in the environment may make the evidence uncertain (Hildén 2009) and hence impair the motivational process of stakeholders. In general, quantitative evidence on participation in NAP activities at individual level are reasonably available in different statistics, e.g. on participants in training events and on certified users. However, an evaluation performed as a facile outcome monitoring will not help us to understand the cognitive, motivational and behavioural processes that drive the individuals to make use of the NAP interventions in their practices. From a lay perspective, the popular form of published evaluation report with a limited number of critical endpoints makes the evaluation more likely to be useful, and enhances the public discourse and awareness of the general public. As expressed by several expert panels and farmer participants of this study, the economic sustainability of plant protection is a very important issue for the professional users, and therefore evidence of likely win-win situations where economic profitability appears together with the environmental benefits could relieve the concerns of individual farmers. Evidence on availability, quality and usefulness of extension services and training would encourage the professional users to happily seek advice and training. Therefore feedback and surveys on the quality of these services are measures of motivational success at interpersonal level and lead in turn to behavioural outcomes of increased willingness of the users to introduce the new practices supported by the advisors and trainers.

At the *societal* level**,** evidence of decreased dependency on chemical plant protection and improved quality of the environment are measures of general influence. The NAP specifically mentions the criteria of the Water Framework Directive (WFD; EU 2000) for the quality of surface and ground waters as a measure for the quality of the aquatic environment, where a good state can be characterised by not exceeding environmental quality standards (EQS). The organisations involved can motivate themselves to utilise the evaluation to strategic planning and streamlining of processes, where evidence from an evaluation can be used as performance indicators for organisational management, for instance for monitoring the performance of the NAP actions.

Empowerment evaluation is a collaborative group activity, although a team or person in charge would be nominated for practical conduct of the evaluation. The evaluation team negotiates with the stakeholders on what relevant data is to be produced by each actor, who in turn understand how they could benefit the evaluation. Their organisations provide the evaluation team with adequate resources, data and assistance in order to make the evidence as representative as possible to tackle the multiple facets of the sustainable plant protection under the cross-pressure of simultaneous challenges and priorities set by the supervising and

sponsoring ministries. Extraordinary improvements are not to be expected in short time periods. As many stakeholders are enmeshed in implementing and producing evidence for the evaluation of the NAP, the expert panel members perceived that no one should be left outside. At a collective and organisational level, the expert panel members rely on traditional authorities, research institutes, universities and polytechnics as indispensable organisations providing multidisciplinary and multi-professional expertise and data for the evaluation. Ideas from other countries about implementing the IPM methodologies were also demanded. On the other hand, the experts tend to have rather restricted view on the involvement of stakeholders, as the stakeholder analysis in Chapter 6.1 illustrated. Plant protection practitioners, both commercial and public advisors, were highly appreciated as desirable and indispensable experts to be involved, while consumers and the uninformed general public were considered as impossible partners to provide expertise for the evaluation of the NAP. This is in contrast with the Netherlands, where Wijnands et al. (2014) argue for consumers having an important stakeholder role in the transition from a traditional regime in the crop protection system towards a new interpretation of sustainable practices.

The experts highlighted integrating the cognitive processes of knowledge production for separate research projects into a more systemic view on integrated crop protection:

> "The NAP is not only about IPM, but above all about sustainable use of pesticides. The influence of the three sustainability pillars on a farmer's economy has not been considered. […] Things should be analysed from this perspective. When we add here what happens to IPM and what is possible and necessary in relation to the future scenarios of our agriculture and on the crops and on geographical locations for which the development of IPM would be most important, we have pondered the development of plant protection and the implementation of the Directive at a really strategic level indeed, related to our scarce resources." (VII.C.3)

Because multidisciplinary science is integral to the implementation of IPM methods, the research and enquiry skills of multiple disciplines are relevant for understanding both quantitative and qualitative targets and outcomes. Participant teamwork skills and stress tolerance would help them reasonably organise their communication and data collection workload for the evaluation, although in parallel to their other responsibilities, probably within rather short timelines. Project management skills are necessary for the person(s) or team responsible for managing the implementation and leading the evaluation process (such as the stakeholder manager in the Netherlands, as described by Wijnands et al. 2014, p. 542-543). The organisations involved should recruit their best experts to ensure the appropriate knowledge is available to produce the relevant data required (e.g. statistics, performance reports, project descriptions, etc.) in the timely distribution of work for the evaluation process.

7.2. Proposal for evaluation procedures

One goal of my study was to support the collective learning of the Finnish NAP community (mainly consisting of people with natural scientific backgrounds) about the possibilities that social sciences and evaluation research can offer for evaluating the NAP. Because there are plentiful applicable models for programme evaluation available in the literature, I found it unnecessary to start developing another unique model just for the Finnish NAP, and decided to apply existing forms as much as possible. Different forms of practical programme evaluation can be distinguished on the basis of the purpose, state and timing of the programme continuum, where the evaluation is to be performed (Owen & Rogers 1999, p. 53-54). Boyd &. al. (2007) distinguished three types of

systemic evaluation forms: systemic stakeholder evaluation, systemic goal-based evaluation and systemic organizational evaluation. The authors offered step-by-step guides and flow diagrams on how to perform each type of evaluation in practice. Mickwitz (2003) suggested a framework and criteria for evaluating environmental policy instruments. However, because his criteria are more general and intended for global or national level use, additional questions need to be raised to highlight the achievements at lower conceptual levels, where the actual learning and behavioural change of PPP users takes place.

Combining the existing frameworks, I drafted five proposals for evaluation procedures for the Finnish NAP, focusing on different time points and aspects to be considered, in order to allow operating with different approaches. Specific characteristics of proactive, clarificative, interactive, monitoring and impact evaluations, the reasoning for choosing each form and examples of their uses in the context of the Finnish NAP are presented below. I also propose a few core orientating questions for each conceptual level and form of evaluation, adapted to fit the seven evaluation points of the theory-driven systemic programme logic model as presented in Chapter 6.8 above. I also suggested appropriate evaluation questions to be raised at different policy levels and systemic perspectives for those forms of evaluation. In order to ease the practical evaluation planning decisions of the NAP implementers, the proposed forms and questions are presented in detail in Tables 1.1 to 1.5 of Appendix 4, while the explanations of each form can be found below.

Proactive form of NAP evaluation

Prior to establishing a new policy instrument like an NAP, the policymakers have to ascertain the needs and priorities concerning its purpose via proactive evaluation. The orientation of this kind of enquiry is a synthesis or review of current knowledge, the research conducted and best practices focusing on the context of the policy area. A needs assessment is typically a proactive evaluation. The background study by Peltonen & Rajala (2009) served as a needs assessment for the preparation of the Finnish NAP, and can therefore be classified as a proactive evaluation. The study was ordered to explore the perceptions of the stakeholders on existing risk mitigation measures for plant protection products and possibilities for further means of risk reduction, in order to impose actions to implement the NAP as required in the SUD. Reviews of documents and databases, site visits and other interactive methods can be used as methods for data collection. Interactive methods such as focus groups, nominal groups and the Delphi technique can be useful for engaging stakeholders in the needs assessment. In the case of Peltonen & Rajala (2009), a semi-structured questionnaire was sent to stakeholders. Table 1.1 of Appendix 4 suggests relevant evaluation questions to conduct a proactive evaluation of the NAP.

Clarificative form of NAP evaluation

A clarificative evaluation guides the development of an existing programme, focuses on all elements of it and takes place during its implementation. Key approaches are evaluability assessment, logic/theory development and accreditation. A combination of document analysis, interview and observation, as well as interactive methods can be used as methods for assembling evidence. Findings include programme plans and implications for the organisation. A clarificative evaluation may have implications on participants' morale, such as improved commitment. This study contains elements of evaluability assessment and the development of the programme logic, and intends to engage stakeholders in the implementation of the NAP. Table 1.2 of Appendix 4 suggests relevant evaluation questions to conduct a clarificative evaluation of the NAP.

Interactive form of NAP evaluation

An interactive form of evaluation aims to improve an ongoing programme. Its major focus is on the delivery of services, as in the case of the NAP, on performance of defined actions, and therefore it takes place at the development stage of the NAP. Key approaches in interactive evaluation are responsive and developmental, qualitative and empowerment orientated. Interactive evaluation relies on intensive onsite studies, action research, quality review and observation as methods for gathering evidence. The degree of data structure depends on the approach. It is preferable to involve service providers and programme participants.

Experiences of the interactive form of evaluation include the interim evaluation of the National Programme on Dangerous Chemicals (YM 2013) as well as the currently ongoing interim evaluation of the NAP, with an emphasis on its outcomes. The interim report on the outcomes, to be produced by the NAP Steering Committee, will belong to the interactive and monitoring forms, because the stakeholders collectively report on the deliveries and services they are producing, and the final evaluation will presumably focus mainly on the impacts of the NAP at the end of the programme period. Characteristics of the interactive form are present in the ongoing interim evaluation, e.g. stakeholders provide evidence of their deliverables collectively. My study aims to increase the participative characteristics of an interactive evaluation of the NAP. Table 1.3 of Appendix 4 suggests relevant evaluation questions to conduct an interactive evaluation of the NAP.

Monitoring form of NAP evaluation

Programme monitoring is aimed at justifying and fine-tuning programme actions to make it more efficient and effective. Typical issues are assessing whether the implementation meets defined benchmarks, comparison between different sites, between different time points and in terms of costs during the programme period. Monitoring is typically timed at several moments during the continuum of an established programme, and at its final stage as minimum. Its major focus is on the delivery of services and outcomes. Key approaches in monitoring are for instance component analysis, devolved performance assessment and systems analysis. As a method for evidence gathering, hard systems analysis requires the availability of management information systems (MIS), the use of indicators and the meaningful use of performance information. Soft systems approaches could offer an alternative approach for evaluation, with an emphasis on qualitative data. Centralised performance monitoring of the NAP as a whole system might be problematic because of multiple independent stakeholder organisations, although each organisation undoubtedly monitors their own practices with their own management information systems. However, it may be possible to monitor the overall performance of the NAP by developing an environmental monitoring system and introducing risk indicators that are ongoing. Initial experiences in risk indicator calculation have been gained (Kruijne et al. 2014, Räsänen et al. 2013a). Table 1.4 of Appendix 4 suggests relevant evaluation questions to conduct a monitoring evaluation of the NAP.

Impact form of NAP evaluation

Impact evaluation is aimed at justification and accountability. This form of evaluation can be performed at a final stage, typically after the programme has been implemented. It mainly focuses on the deliverables and outcomes of the programme. Several key approaches can be identified: objectives based, process-outcome studies, needs based, goal free and performance audit. Traditionally, the assembling of evidence required the use of predetermined research designs, possibly with the use of treatment and control groups, and the use of tests and other quantitative data. These kinds of test designs are not, however, applicable to a programme like the Finnish NAP. Studies of implementation generally require observational data. Determining all the outcomes requires the use of more exploratory methods and the use of qualitative evidence. There is still a lack of experiences on impact evaluation with regard to policy programmes concerning PPP use in Finland. Barzman & Dachbrodt-Saaydeh (2011) evaluated the impacts of a range of different European NAPs, but this evaluation was limited to just a few

aspects. Experiences from other agri-environmental policy evaluations could also be utilised. Table 1.5 of Appendix 4 suggests relevant evaluation questions to conduct an impact evaluation of the NAP.

7.3. Process of selecting the heuristic tools to frame the evaluation

The evaluation of the NAP may be framed in many ways, due to its complexity, with multiple stakeholder views, depending on the values and views of those involved. Appropriate heuristic tools may be useful in this framing to properly address important boundary questions, and existing frameworks and tools are available in the literature for this purpose. Some of these were tested with my expert panel, as previously explained in Chapter 4, with the necessary adaptations to the context of the Finnish NAP. This chapter presents the results of the selection process and assessment of the applicability of the tools for the specific purpose of evaluating the NAP. Some of the expert panel participants will most likely be involved with the final evaluation of the NAP, and thus the expert panel reflections also provide opportunities for collective learning on the evaluation process to be performed. The process of selecting and proposing the heuristic tools is illustrated in Figure 7.1. below.

7.1

The process of selecting, assessing and proposing the heuristic tools

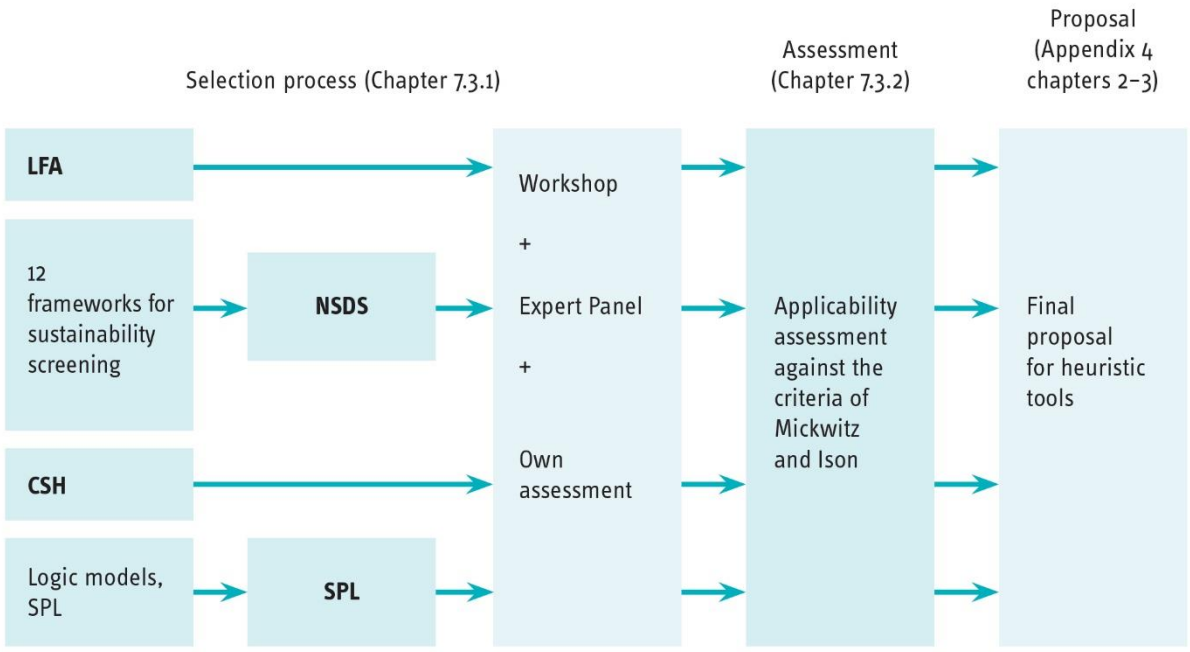

Figure 7.1. The process of selecting, assessing and proposing the heuristic tools.

As a result of the intensive examination of literature as described in Chapter 4.1, I selected a few of the most promising heuristic tools for further consideration and testing with the stakeholders. The selection process was explained in Chapter 4.5.6. Based on the experiences gained from the testing with experts, in the *first phase* I

settled on proposing *three heuristic tools* to enable the framing of the evaluation of the Finnish NAP. The three heuristic tools proposed are:

- Critical Systems Heuristics (CSH: Ulrich 1994, 2000; Ulrich & Reynolds 2010))
- Sustainability screening using the framework for evaluating National Sustainable Development Strategies (NSDS: Cherp et al. 2004)
- Limiting Factors Analysis (LFA: Gullison & Hardner 2009).

As described previously in Chapter 4.5.3, the framework of Critical Systems Heuristics was recommended to be used to enquire into the diversity of the expectations, perceptions, values and worldviews of the stakeholders regarding the boundary judgements for framing the NAP, and to explicitly formulate the programme theory of the NAP. Its applicability was confirmed by the expert panel.

Responses on the National Sustainable Development Strategy framework of Cherp et al. (2004) were received from individual experts, and a group of participants additionally volunteered to test and comment on it as a team, thus allowing for a general group discussion on sustainability criteria from their own perspectives. The method was clarified in Chapter 4.3.4 and the results of the exercise were presented in Chapter 6.6. It appeared that although the verbal comments on specific criteria indicated that the respondents basically had similar views, the scores given for them varied significantly. So it is not appropriate to use the scores as a quantitative measure of progress, but rather as a hint of areas that will require the most effort in the future.

Though the original scope was national-level analysis, the principles and criteria can be adapted for the purposes of lower level screening as well, or to cover particular issue-specific sectors only by simply omitting some of the criteria that are considered as not relevant for the sectors to be considered.

The procedure for finding and ranking the limiting factors was tested within the stakeholder workshop, as presented in detail in Chapter 4.3.3, and the results of the exercise were presented in Chapter 5.4.3. Limiting Factors Analysis (LFA by Gullison & Hardner 2009) appeared to be a promising practical device for rapidly assessing whether current conditions are likely to prevent or impede the actors from achieving the long-term objectives of the NAP. The process allows the stakeholders and participants to jointly identify the limiting factors, ranking them and understanding the responses needed to overcome the impediments. If the analysis is repeated periodically, changes in the rankings can illustrate the progress made in certain areas perceived as problematic, although new limiting factors may also emerge and be assessed during the course of operation.

The framework is partly opposite to the NSDS framework, which seeks to highlight the progress made, whereas the LFA tackles the areas where least progress is anticipated. Therefore, the two tools complement one other nicely. The LFA questionnaire with 16 limiting factors identified by the stakeholders and grouped by five themes is presented in Chapter 2.3 of Appendix 4.

Furthermore, the analysis of the Finnish NAP revealed the insufficient consideration of the programme theory, that is, laying down assumptions on how the NAP interventions are thought to work. It became necessary to start preparing the evaluation by making the programme theory evident, as explained previously in Chapter 6.8. In the *second* phase, the programme theory of the Finnish NAP system could be made explicit, based on boundary critiques using the three heuristic tools. Two frameworks for this exercise were proposed as:

- Logic model framework (W.K. Kellogg Foundation 2004; Chen 2005)
- Systemic Programme Logic (SPL) using the theory-driven model (Wasserman 2010).

Logic models for the specific intervention types included in the NAP were formulated, as presented in Tables 3.1 to 3.6 of Appendix 4. A logic model is a graphical presentation of the relationship between activities and the expected outcomes, to highlight the programme components. Logic models of NAP interventions are intermediate products in highlighting the assumptions of separate stakeholder groups regarding the programme theory, and therefore this tool was left out of the final recommendation. However, incorporating the logic models of separate interventions into a programme logic for the NAP as a whole made it possible to formulate the NAP programme theory in terms of systemic programme logic (SPL), where the framework of Wasserman (2010) provided a promising tool for addressing the expectations and motivations of programme participants (professional users of PPPs), service providers and their background communities. Collective learning is essential to achieve longer-term outcomes and impacts, and in this framework several evaluation points are expressed to consider collective learning. The SPL framework as an additional heuristic tool candidate was presented to the expert panel participants and the NAP Steering Committee for comments. The SPL framework is presented in Chapter 3.2 and Figure 3.2 of Appendix 4. As a conclusion, *four heuristic tools* were considered in the end. Finally, an applicability assessment was conducted on four frameworks, namely CSH, NSDS, LFA and SPL, as presented in Chapter 7.4.

7.4. Assessment of the applicability of heuristic tools for the NAP evaluation

As explained in the previous chapter, the three heuristic tools, CSH, LFA and NSDS, were first used to construct the fourth, SPL, to evaluate the Finnish NAP. To assess the applicability of these four candidate tools, I explored them in the light of the evaluative questions of Mickwitz (2003) and Ison (2010 p. 154). Mickwitz (2003) set out 10 criteria to assess whether the programme evaluation questions adequately consider the environmental sustainability issues in the form of 10 questions, which I modified below to assess the applicability and illustrate the different purposes of each of the four heuristic tools for analysing the process of implementing the Finnish NAP. My assessment is presented in Table 7.2.

1. Relevance: Do the goals of using these tools cover the key environmental problems of the NAP?
2. Impact: Is it possible to identify impacts that are clearly due to the NAP and its implementation using this tool?
3. Effectiveness: To what degree do the achieved outcomes correspond to the intended goals of the NAP or other public goals?
4. Persistence: Are the effects persistent in such a way that they have a lasting effect on the state of the environment?
5. Flexibility: Can the tool cope with the changing conditions of plant protection policy?
6. Predictability: Is it possible to foresee the administration, outputs and outcomes of the NAP? Is it thus possible for those regulated, as well as others, to prepare and take into account the NAP and its implications?
7. Efficiency: Do the results justify the resources used? Could the results have been achieved with fewer resources?
8. Legitimacy: To what degree do individuals and organisations, such as non-governmental organisations (NGO), interest organisations and firms accept the use these tools for evaluating the NAP?
9. Transparency: To what degree are the outputs and outcomes of the NAP, as well as the processes used in its implementation observable for outsiders?
10. Equity: How do the tools address the distribution of outcomes and costs of the NAP? Do all participants have equal opportunities to take part in and influence the processes used by the administration?

Table 7.2. Assessment of the applicability of the four heuristic tools in the evaluation of the Finnish NAP, according to the criteria laid down by Mickwitz (2003).

Criteria	Tools	Comments
1. Relevance	All	The goals of using all the tools cover the key environmental problems of the NAP, given that the stakeholders perceive the environmental issues as important.
	CSH: yes	The CSH aims to address legitimacy from the perspective of those affected, including the environmental compartments.
	NSDS: yes	The NSDS framework seeks to explicitly address the key environmental aspects of sustainability. It also considers the integration of socio-cultural and economic aspects in the evaluation.
	LFA: yes	The LFA is a tool for stakeholders to identify the obstacles to adequately address environmental / sustainability problems. It depends on their worldviews, which problems they perceive as core, although the joint deliberation permits seeking a common view.
	SPL: yes	The SPL reveals the relationships of service providers, participants and their community peers, and measurement points set at their intersection points allows for scrutinising the environmental issues in the evaluation.
2. Impact	CSH: yes	The 12 CSH questions explicitly guide users to reflect on the measures of success in terms of boundary critique.
	NSDS: yes	Depends on the users' priorities and perspectives.
	LFA: possibly yes	Depends on the users' priorities and perspectives.
	SPL: yes	Interventions are judged according to the expected outcomes. Impacts are assumed due to the actions of service providers, participants and their community peers. Exposure to PPPs in the environment is assumed mainly from their use by professional users.
3. Effectiveness	CSH: depends	CSH aim to reveal and articulate the assumptions and expectations of stakeholders about the intended goals. The extent depends on the level of detail the users dedicate to this tool.
	NSDS: scaling	The four-level NSDS scale allows the users to evaluate the extent. However, the ranking is approximate, and the views of stakeholders may deviate significantly.
	LFA: scaling	The five-level LFA scale allows users to evaluate the extent. The limited number of impediments allows for focusing on the most problematic areas in terms of achieving the outcomes. The approach considering limiting factors is the opposite of NSDS.
	SPL: depends	SPL aims to address the relationships between goals and outcomes. The extent depends on users' priorities and perspectives.
4. Persistence	CSH: depends	The persistence depends on users' priorities and perspectives.
	NSDS: depends	Users can assess the persistence; however, the views of the stakeholders can be variable. Repetition of the screening from time to time illustrates the progress.
	LFA: depends	Users can assess the persistence of the limiting factors identified. The extent of persistence depends on stakeholder views.

	SPL: depends	Depends on the users' perspectives. The causal links between inputs, perceived benefits and short- and long-term outcomes might help explain the (non-)persistence.
5. Flexi-bility	CSH: yes	CSH boundary critique can and is recommended to be repeated from time to time.
	NSDS: yes	NSDS can be repeated from time to time to illustrate the progress made.
	LFA: yes	LFA can be repeated from time to time. New factors potentially limiting the success may emerge in long run and may need to be included. The approach is opposite to NSDS.
	SPL: yes, but revision may be needed	The SPL model likely needs to be revised to portray the logic of changed assumptions.
6. Predict-ability	CSH: yes	The control and expertise aspects of CSH are intended to make the boundary discussions explicit. Two realities (how it is and how it ought to be) should be covered. If performed well, the boundary critique discourse should also address the legitimating of those affected but not involved.
	NSDS: yes	Progress is assessed in terms of ownership, commitment, coordination and level of political support.
	LFA: depends	Depends on stakeholder views. LFA does not explicitly require linking the limiting factors and their outcomes. If stakeholder participation is adequate, those to be regulated should be involved in the assessment.
	SPL: yes	SPL makes explicit the links between actions and their outcomes. SPL can be used as a collective learning tool for those to be regulated (professional users) and other stakeholders.
7. Effi-ciency	All	Using these tools does not generate any cost other than moderate working time allocated for participants. Monetary valuation beyond that will be difficult.
	CSH: yes	The resource issues are embedded in the boundary critique discussion of CSH.
	NSDS: yes	The resource and capacity issues are to be assessed using NSDS.
	LFA: depends	Depends on stakeholder views. Focus on obstacles might help finding issues, to rationalise the NAP implementation and thus allocate resources more effectively.
	SPL: depends	Depends on stakeholder views.
8. Legiti-macy	All likely acceptable	The tools were tested with stakeholders representing different groups; however, NGOs were missing. The feedback from participants was mainly positive. The NAP is also largely supported by different stakeholder groups. Therefore, no major objections are anticipated. The frameworks allow for the collective learning of stakeholders.
	CSH	CSH was developed to make the views of different stakeholders explicit.
	NSDS	In testing NSDS with stakeholders, their views deviated significantly.
	LFA	LFA is based on collective sense making between stakeholders.
	SPL	SPL allows for considering deviating views.

9. Trans-parency	CSH: depends	Depends on the views of participants. Variable impressions were presented by the experts who tested CSH. This might be an area for improvement, as many of the assumptions are implicit in the NAP. CSH was developed to make the implicit assumptions visible.
	NSDS: depends	The four-level NSDS scale allows users to evaluate the degree of transparency.
	LFA: depends	The five-level LFA scale allows users to evaluate the degree of transparency. The limited number of impediments identified allows for focusing on the most problematic areas, but it may leave the other outcomes and the processes unaddressed. The approach is opposite to NSDS.
	SPL: yes	Causal links between inputs, benefits and outcomes might help observe the expected outcomes. SPL can be used as a collective learning tool in terms of making the processes more transparent.
10. Equity	All	If stakeholder participation is adequate, those who bear the costs should be involved in implementing and assessing the NAP.
	CSH: yes	CSH aim to address the empowerment and legitimating of those affected, even if they are not able to be involved in the process.
	NSDS: depends	Targeting, resourcing and monitoring are included in NSDS. The four-level scale allows for assessment of the progress.
	LFA: depends	LFA does not require linking the distribution of outcomes and costs to limiting factors.
	SPL: depends	SPL does not explicitly require linking the distribution of outcomes and costs, although it is one possible approach.

Ison (2010, p. 154) emphasised the contextualisation of the practice to the situation where relevant systems thinking tools, techniques and methods are intended to be used. This can be assisted by considering four basic questions:

1. Is it the method, technique or tool, or how it is used that is important?
2. How are learning and action built in?
3. Who is or could be involved in the approach?
4. What could be said about the politics and practicalities of engaging in a real-world situation?

As responses to these questions, the following considerations were produced.

The aim of this study was to seek and test systemic enquiry methods that could be applicable for the evaluation of the achievements of the Finnish NAP. No new methods were developed from scratch; rather existing methods were adapted to this specific purpose. The selected tools are meant to complement one other, but it is perfectly acceptable to refer to only some of them.

It is important to provide the implementers and other stakeholders with insights of what kind of practical systemic inquiry methods are available to evaluate the successfulness of their practices. It is not important for the proposed evaluation tools to actually be followed exactly or approximately, but instead to offer the users heuristic ideas on how they could possibly be used. It must be recognised that evaluation needs may be different for the different actors involved, and hence the preferred tools may vary respectively. The expert panel work was intended to introduce the proposed systemic enquiry tools to those involved in implementing the NAP, and enable their reflections on practical applicability. As opinion leaders in their own organisations, the experts can

be proponents of the methods they find applicable to their own purposes. An example of this was the initiative of applying the NSDS sustainability screening framework in the development of the IPM research programme for Finland. As a result of this study, I produced practical guidance for prospective users on how to apply the proposed tools in a complex system situation like the evaluation of the NAP, summarised in Appendix 4. CSH is specifically intended to emancipate non-experts to equally participate in the discourse on complex issues with the experts. Using the tools does not require any specific skills or rigorous preparation in advance, and they can be learned in a practical situation either individually or jointly, which would make the threshold lower for testing them in practice.

Many responsible actors and other stakeholders who vested interest in it are involved in implementing the NAP. In addition, some stakeholders have been identified that are currently not involved but who could offer important knowledge and insights to the NAP. The NAP is considered as a collective effort and it would benefit from the widest conception of stakeholders. Evaluating the achievements of a national programme like the NAP is inherently a political interest, although not in the spotlight of political discourse today. Increasing the awareness of consumers and the general public is one of the programme's aims. Everyone could thus be involved, and the knowledge of citizens and NGOs about achieving sustainability in PPP use could be improved using these tools in particular. Although some of the tools were originally intended for national or international analysis, they also allow for consideration at lower hierarchical levels relevant to local and individual participation.

In order to successfully produce the results expected from the NAP, its evaluation would need to be bound to a larger context of visions about Finnish agricultural and environmental policies. The proposed tools are chosen based on their ability to make the issues of value, power, expertise and moral engagement explicit, in order to broaden the views of those involved to better understand the multiplicity of views, including marginalised groups. The aim is thus to turn the NAP programme logic from a top-down to a more bottom-up approach. As a conclusion, the heuristic tools to be proposed for framing the evaluation of the Finnish NAP have complementary properties for illustrating the views and values of stakeholders from different perspectives, and are thus appropriate tools for understanding the complexity of the pursuit of sustainable plant protection.

8. Gathering evidence of success

My fourth study question was about the measures for gathering evidence of goal achievement by the NAP. Evidence was obtained using multiple methods and data sources. How to obtain evidence was one of the key issues in the agenda of the stakeholder workshop, but the document analysis and the expert panel working with the Critical Systems Heuristics also produced suggestions for evidence collection. Some of the proposed measures and indicators had already been mentioned in the original NAP document (MMM 2011a), and some new measures and indicators have emerged during the expert panel working and consultations. However, practical means for collecting the data are discussed here in more detail than when the NAP was prepared. My fourth study question was about the means of gathering evidence of achieving the goals of the NAP. Gathering evidence was inquired using multiple methods and data sources. It was one of the key issues in the agenda of the stakeholder workshop, but also the document analysis and the expert panel working with the Critical Systems Heuristics produced suggestions for evidence collection. Some of the proposed measures and indicators were already mentioned in the original NAP document (MMM 2011a), and some new have emerged during the expert panel working and consultations, but practical means for collecting the data are discussed here in more detail than when the NAP was prepared.

A range of proposals for both quantitative and qualitative measures of evidence of goal achievement are discussed below in Chapters 8.1 to 8.7. As presented in Figure 8.1 below, the chapters are divided into six intervention areas, and compliance with legislation which has been highlighted in the FVO evaluation (2014b). In each chapter, the measures are classified as promoting human health, protecting the environment, implementation of good agricultural practices, and awareness-raising. Some of the measures cover more than one of the specific areas. In Chapter 8.8 tentative key performance indicators are proposed. Table 4.1 of Appendix 4 summarises the key measures of evidence and proposals to collect data for assessing the success of implementing the Finnish NAP.

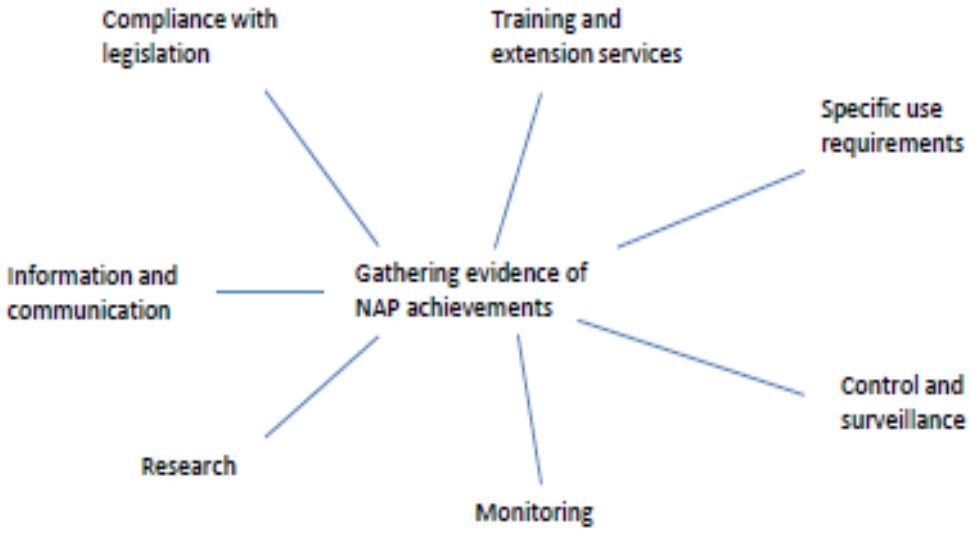

Figure 8.1. Gathering evidence of the achievements of the NAP interventions.

8.1. Measures and indicators of compliance with legislation

Compliance with legislative requirements within the required timescale can indeed be considered a pragmatic measure for achieving the NAP goals, as the FVO (2014b) has analysed. The timelines for different actions given in the SUD have been achieved in the implementation of the Finnish NAP. Additionally, the FVO highlighted examples of good practices of different actions (FVO 2014b). Although the targets were explicitly left non-quantitative in the Finnish NAP, several quantitative measures of improvement were proposed by the workshop and expert panel participants. For instance, total use rate of plant protection products per hectare was mentioned, although it was considered to be a less effective indicator of risk in the background report for preparing the NAP (Peltonen & Rajala 2009). Defined quantitative objectives, targets, measures and timetables are preferred as good practices. The FVO report does not at all consider the possibility of evaluating the qualitative achievements of the NAPs, although we are facing the novel situation in most Member States where the implementation of the first NAPs calls for collective learning of all stakeholders. Capri & Marchis (2011) also stick to the quantitative targets and indicators in their proposal. However, if the objectives of the NAPs are seen merely as to fulfil quantitative, numerical targets, then a range of important effects of the NAPs remain

unrecognised. Nevertheless, qualitatively evaluating the implicit, unintended and unexpected effects of implementing the NAPs require a lot of efforts from the Member States.

Due to the multitude of independent actors participating in the implementation of the NAP, each of them have their own goals and specific measures within their areas of expertise. Snapshots of the achievements of each organisation are regularly presented in the NAP Steering Committee meetings, although this does not enable any deeper discussions, however. The mid-term report (Tukes 2016) comprehensively listed the efforts of the actors so far. The stakeholder workshop proposed and discussed overall measures for the achievement of the NAP goals, and the participants highlighted the perspective of professional users in assessing if the goals of the NAP have been achieved, as:

> "[…] practical understanding about plant production: what works and what does not?" (V.B.1)

To address this perspective, the systemic programme logic was constructed for the Finnish NAP, as presented in Figure 6.6. While many of the responsibilities in the NAP oblige public institutions to provide the interventions, the programme logic contributes to the evaluation from the perspectives of service providers and participants as well as their background organisations. Furthermore, a concern was raised by some respondents, if the environmental perspective will be adequately present in the evaluation, because the causal change model of outcomes is complex and the actual impacts in the environment are likely difficult to quantify.

8.2. Measures and indicators of success in training and extension

The number of training events organised, participants in training events or certified professional users alone do not portray the effectiveness of the NAP according to its intervention theory, that is, the longer-term outcome of training as a change in the attitudes and practices of professional users towards more sustainable plant protection. However, some quantitative indicators are useful to help analyse the development of supply and demand of training and advice available for different production sectors. The availability of various advice and extension services, for individuals, groups, etc., and making the threshold for *seeking advisory services* as low as possible for the farmers, were all considered as measures for success in implementing the NAP. Reimbursing the use of extension services was considered important on the basis of the revised agri-environmental support system (EU 2013).

Analysing the demographical data of participants in training events and certified users, e.g. their age, gender, basic education, etc. might help to structure and target the training to best serve the participants. The length, depth and focus areas of basic and further training events in separate production sectors could be specified. Based on a regional needs survey, safe handling, hazards and risks of plant protection products, as well as use and maintenance of spray equipment are perceived as the most important areas where training is needed (Myllylä 2013). The same issues also emerged in the expert discussions, with citizens' references analysed as most topical. Frequent analysis of systematically-collected and centrally-filed data on training participants' expectations and feedback could serve as an evidence of the functionality of the training system. The Kirkpatrick model amended with its critiques offers a practical and widely used measure for evaluating the effectiveness of training (Kirkpatrick & Kirkpatrick 2006, Bates 2004). More in-depth inquiries into the *attitudinal change* of professional users could also be performed from time to time, for example on their implementation of safe working methods and environmental risk mitigation measures. Concerted sampling of this data could be carried out for instance during participation in training or extension, and collective ownership of the anonymised data

could probably rest with the NAP Steering Committee to allow all relevant stakeholders to use it for analysis and research.

Availability of attractive and interactive *training material* covering the issues specified in Annex I of the SUD for the disposal of training providers and agricultural schools and its online accessibility (Tukes 2014b) was regarded as an important measure of information success. The project for producing training material was discussed in Chapter 5.4.2. After the system for providing basic training and certifications for all professional users has been set up and is fully functioning by 2015, a further measure of success will also be to provide further training with specific focus areas, e.g. on IPM methods for professional users and the authorised training providers.

Implementing the NAP was essentially considered to be a learning process. The experts were simply trusting in the power of providing the professional users with training opportunities without revealing any theoretical perspectives in relation to expected learning and change (Blackmore et al. 2012). However, the need for a more systemic understanding about the *fundamentals of ecology* to interpret the functions and interactions of cultivated and natural environment as a basis for appropriate plant protection decisions was highlighted. Therefore, mainstreaming the content of training and extension on the basis of explicit agroecological principles, as proposed by Bellon & Hemptinne (2012), could be seen as a first-step measure of success in the realm of information. From a systemic perspective it is not adequate just to train the (professional) users in specific crop protection methods like spraying techniques or environmental restrictions, but to provide wider insights to weigh up how their choices are affecting the agroecosystem and its environments. To produce longer-lasting effects in environmentally significant behaviour, a broad range of causal factors, attitudinal, contextual, habitual and personal capabilities have to be considered in training (Stern 2000). The workshop participants highlighted the following issues to assess the achievements of the NAP from an agricultural standpoint: mapping of win-win situations mutually beneficial both to the environment and to the economy of the farmers, resulting from assimilation of new techniques and practices; participation of the farmers to change their experiences on IPM adoption; training opportunities and dissemination of knowledge; network of demonstration farms, and utilisation of extension services can portray the general willingness of improving the skills.

The perceived *knowledge gap* between top performers and average farmers on IPM practices could be one kind of indicator of the prevalence of IPM practices, as over half of Finnish farmers operate on the basis of practical working experience alone, whereas 38.5% have basic vocational education and 10.4% higher agricultural education (Agricultural Statistics of Finland 2014). Their motivation for constantly updating and obtaining new knowledge on plant protection is integral to the progress of IPM implementation, especially to the higher levels of IPM integration (Kogan 1998). The dissemination and implementation rate of new IPM methods and techniques to the farms was considered as a measure of success, but as it is lacking indicators for IPM adoption, this makes assessment of progress difficult (C-IPM 2015a-c). The workshop participants recognised disregard as being one obstacle that could limit the adoption of IPM methods, with the highest risk among those who essentially discount self-development of one's own professional skills and perceive the IPM methods complicated and difficult to understand. Therefore, the perceptions of IPM users on the applicability of these methods are important, and narratives of success stories of the top performing peers could dispel the suspicions, as was also seen in the media analysis in Chapter 6.4. Consequently, the potential agricultural indicators of success of adopting IPM essentially deal with the perceptions and attitudes of farmers.

The workshop participants specifically mentioned the importance of peer exchange of *IPM experiences* between the farmers. The traditional linear top-down model of technology transfer disseminating research findings to agricultural practice by advisors is considered no longer adequate to promote learning and innovation, but a more complex model is emerging, where the extension is refocusing as facilitator of innovation brokering between different actors from a range of independent interest groups such as farmers, scientists, policy-makers

and other stakeholders holding different and possibly even contradicting perspectives. Similarly, the evolving role of advisors and extension systems as knowledge brokers towards sustainability has been discussed in recent literature (e.g. Klerkx et al. 2012). Cristóvão et al. (2012) highlighted the risks of biased information and little space for collective learning, as a result of privatised extension services that primarily promote the technology transfer model and privilege large commercial farms as their customers.

In some of the participant responses the exemplariness of large, wealthy, progressive farms was mentioned as a desirable measure of IPM implementation. While it is obvious that these forerunners are important as emerging strategic niches of implementing novelties at a local scale (Schot & Geels 2008), mainstreaming the pursuit of sustainable plant protection requires a wider implementation to create the intended outcomes, and therefore the utilisation of extension services of greater masses of average farmers is probably a more realistic measure. In Finland the training and certification providers typically work as advisors in non-profit extension organisations or as teachers in educational institutions, which enables them to have an independent knowledge brokering role with understanding of public interests (Downs 1972) to be taken into account in their interventions. Obviously, facilitation skills of trainers and advisors (e.g. Taket 2002) is key to their success, and evidence of creating space for social learning by using facilitation techniques in advisory services and interactive training events could be used as qualitative indicator of NAP achievements. In this sense it would be helpful to study the attitudes of training providers, as proposed in the Systemic Programme Logic framework (Measurement point 5 in Figure 3.8 of Appendix 4).

8.3. Measures and indicators of success in specific use requirements

Crop rotation is widely recognised to maintain soil fertility, control the growth of pest populations and break the consecutive use of certain plant protection products on same fields, thus contributing to reduction of the environmental load from plant protection (e.g. Oerke et al. 1994). Although highly recommended by researchers and advisors (Ahvenniemi 2012), it has sometimes been traditionally difficult to arrange in Finland. However, analysis of the trend in total field area under crop rotation compared to whole arable land (Jauhiainen & Keskitalo 2012) could be used as an indicator of good plant protection practices, but this would presume amending the record-keeping requirements in order to enable reliable data collection on crop rotation practices for calculating and analysing the trends.

Qualitative aspects of improvement were proposed to assess using the *control threshold* values as a decision support system in IPM. Changes in pest control practices as a whole were considered a promising measure, however not defined in more detail. Learning of users and consumers was mentioned as an important outcome, but the experts did not recommend, how the learning could be assessed in practice. As a guarantor of success in the ideal world, the expert panel respondents identified the authentic common attitude of implementing the IPM as a state of will, where all parties agree on clear goals and clear rules.

The number of farms and the share of *area under organic farming* compared to total cultivated land divided by sectors of production were mentioned as examples of quantitative measures of the advancement of organic farming. Currently at around 8% of cultivation area, some stakeholders claimed for a target of 20%, and Koikkalainen et al. (2011) drafted two scenarios with 50% assessed as realistic by the year 2030. The availability of solutions to plant protection problems for all main crops appropriate to organic farming could enhance the transition. Therefore the selection of plant protection products authorised for organic farming, their sales and

use amounts and the environmental profile of these products belong to core indicators of organic farming as a means for achieving the NAP goals.

The call from consumers for organically cultivated food items and willingness to pay for it portray society's appreciation of organic agriculture. Some authors suggest a higher willingness to pay for organically produced food compared to conventional production, whereas IPM production is perceived more ambiguous (Florax et al. 2005; Marette et al. 2012; Yue et al. 2009). Although the market for organic food has recently increased, it is still small in Finland, with only 1% of food commodities produced organically in 2011, and small production volumes cause consumers uncertainty in the availability of many products (Koikkalainen et al. 2011).

Avoiding chemical plant protection in green areas is one of the targets of the NAP. As proposed measures for this target have been mentioned the identification of effective non-chemical pest management alternatives and the selection of plant varieties that sustain Finnish climate conditions and cover the ground densely in green areas. Local and municipal action plans appeared to be an effective tool for reducing pesticide use in public areas in Denmark (Kristoffersen et al. 2004). Systematic reporting of the innovations in this area has not been considered in the NAP, thus leaving the assessment of achieving the targets somewhat vague. Statistics on PPP uses in green areas by different actors within the greenery sector might improve the common knowledge base. The specific non-agricultural use of plant protection products could be analysed for instance by interviewing a group of experts (city and cemetery gardeners, advisors, greenery associations, traffic line maintainers and so on) about their plant protection challenges and practices, plant protection products used and estimated annual rates for specific uses. In addition, the need for appropriate risk mitigation measures in these uses could be considered, e.g. to implement terrestrial buffer zones for protecting bystanders, neighbours and vulnerable plantations and amenity areas in densely populated areas.

Aerial spraying of plant protection products is one issue where the Sustainable Use Directive requires Member States to take action. Derogations from the general prohibition of aerial spraying of plant protection products (MMM 2012c) have seldom been granted in Finland. Since 1981, the only three cases when permits were granted have been for the biological control of pine sawfly in forests. In the case of increasing exceptional permit applications in the future, the aerial spraying permits could be analysed for cases, acreage to be sprayed, reasons for granting the permit and the evidence of case-by-case risk assessment.

As the organisation responsible for conducting audit visitations in Member States, the Food and Veterinary Office of the European Commission has taken notice of storing of obsolete pesticides within farms and retailers in Finland (FVO 2006). Since the audit, the Finnish authorities have improved the control procedures e.g. by producing guidance (Tukes 2015h), but there is still no provision of keeping records on the collection of obsolete pesticides delivered to hazardous waste disposal. The goal for storing of this waste within the enterprises should be at zero, and a system for record keeping and collecting statistics on volumes of obsolete pesticides could help evaluate how well the disposal of obsolete pesticides is functioning at national level. Collecting reliable data for this measure would therefore require amending the waste legislation. Guidance for developing a survey and data collection system for obsolete pesticides is available from FAO (2010).

With regard to NAP, amateur uses of plant protection products have so far been considered as less important compared to professionals. However, there are examples in the literature that this perception may not necessarily be warranted (Adgate 2001; Ahmed et al. 2011; Grey et al. 2006). While the scope and actions of the NAP are mainly focusing to professional users, amateurs are instructed primarily to choose non-chemical methods for their plant protection problems. Following the divorced authorisation of plant protection products to professional and non-professional uses since 2015, the sales and uses of these two product groups could be analysed in more detail to find out the typical patterns of situations where amateurs resort to chemical plant

protection. In this context, amateur gardeners could be interviewed in garden fairs or courses in adult education centres, for instance, to inquire if specific interventions should be focused at amateur users in future.

8.4. Measures and indicators of success in PPP control and surveillance

Although increased control is one of the means for reducing the impacts of plant protection products on human health and the environment, the Finnish NAP does not explicitly mention how this intervention embedded in other legislations is assumed to be evaluated. This goal is also inconsistent with the recent target of the Finnish government to reduce and streamline official control measures in general. As separate legislations define frameworks for placing the plant protection products on the market, deciding on classification, labelling and packaging chemicals, controlling the residues in food and feed and for performing official checks to ensure compliance with legislation, the NAP does not give any measures of success for these actions. However, because advance control (risk assessment and authorisation before release on the market) is an integral part of reducing the risks and therefore dictates all the following actions, control measures cannot be separated from implementing the NAP. The risk assessments and authorisation decisions are performed according to the annual working schedules of Tukes and the northern zone authorities, but explicit targets for reducing environmental or health risks via authorisation decisions are not given. Likewise, residue control is performed according to the annual monitoring plan of Evira, and the control of market and use according to the control plans of Tukes and regional control authorities. Realisation of these control plans can be used for monitoring the performance.

The risk assessors have a key role in ensuring that only safe plant protection products will be authorised and their safety requirements are adequate to protect the users and consumers. Separating the risk assessors from the NAP implementation does not serve a smooth operation. It is essential that the professional users unequivocally understand and accept the personal protection requirements, use restrictions for protecting the environment and other usage instructions given for specific plant protection products.

A cumulative risk assessment on dietary exposure of Finns to plant protection products was produced by Laakso et al. 2010. The authorisation decisions are made on the basis of single product risk assessment, however. Evidence of implementing a cumulative risk assessment approach in PPP authorisations would therefore be a step forward. As a measure of correct use of plant protection products, the results from annual residue analyses from vegetable samples and the possible cases of MRL exceedances in food have been defined in the NAP (Kekki & Siivinen 2013).

Indicating the possible risks to operators, the sales and use patterns as well as reasons for withdrawals, restrictions and the precise safety instructions of specific products most severely classified as hazardous to human health, could all be analysed in detail. Practical applicability of instructions for choosing personal protective equipment was frequently highlighted by the respondents, e.g. to improve the intelligibility of standards for personal protection equipment in practical use situations as when using knapsack sprayers in greenhouses compared to tractor spraying in fields. Feedback from the users could be collected by surveying and interviewing.

Similarly, frequent *analysis of sales and use patterns* of products classified as hazardous to the environment and subject to environmental restrictions could illustrate the success in risk mitigation endeavours. The applicability of risk mitigation measures constantly afflicts the users, while from the environmental stakeholders' perspective it is questioned if the current use restrictions provide adequate conservation of all environmental compartments,

species and populations. Several projects aiming to amend environmental restrictions of plant protection products have already been achieved, but the resulting outcomes in terms of actual changes in environmental loads resulting from the changes in use instructions have not been evaluated so far. In addition, the cost effectiveness of project funding received for these projects has not been evaluated systematically, although a first attempt was made as presented in Chapter 5.4.2.

Following the implementation of comparative assessment of candidates for substitution, the list of plant protection products subject to comparative assessment (EU 2015), analysis of decisions made and reasons for and consequences of possible authorisations, withdrawals and restrictions of certain products could portray the effects of applying the substitution principle in authorisation of PPPs. In this analysis it would be important to also consider the available environmental monitoring data and risk indicator calculations.

The authorisation of plant protection products separately for professional and amateur use has not been entirely welcomed by the authorisation holders and retailers, who have so far considered it adequate to serve the needs of amateur users by marketing small package sizes of the same products intended for professional use. If the need to purchase hazardous products in small packages is constantly increasing among amateur users, it should be considered whether the training and certification system should be extended to also include amateur users. Further analysis of specific uses of amateur versus professional products would highlight evidence of this action.

Situational data gathered in control visitations to retailers, storages and farms could be further analysed for monitoring the performance of the controls (e.g. by FVO 2006, 2014a), but also for learning about the patterns of actual problem cases in the sales and uses of plant protection products. The annual plans for control visitations are focused on annual themes and the chosen locations are risk-based (Tukes 2015c). Evidence of and reasons for suspected non-compliance with risk mitigation measures should be collected and recorded during control visitations. Analysis of control events with illegal or improper use of plant protection products, violations of risk mitigation requirements, claims for misuse and compensation and claims for recovery of agri-environmental subsidies could reveal unwanted characteristics of improper attitudes towards PPP use. Although seldom verified in control visitations, this kind of suspicion can spoil the reputation of responsible agriculture. It is therefore important to keep records and analyse even the very rare cases in detail. The number of penalty cases in relation to total control visitations could indicate adherence to use instructions and the effectiveness of control and surveillance.

Data collection from the authorised inspectors and retailers on the types, purchase and turnover, condition, maintenance and repair of spray equipment in use in Finland could be used as indicators of spraying techniques of PPPs. Measures and data collection systems for the condition of spray equipment in Europe have been proposed e.g. by Wehmann (2012), Polvêche (2012) and Oggero et al. (2012). Manni (2014) investigated the existing types and possibilities of testing of spray equipment in use in Finland. An update of the testing guidance for spray equipment is currently under preparation at Tukes (Tukes 2015e). As record-keeping for these kind of issues is not designated to any specific actor, project-based surveys would be needed to gather the data for the analysis. However, any plans of this kind of action do not exist and the potential responsible actor for this task has not been discussed so far.

8.5. Measures and indicators of success in research

The expert panel participants are worried about the fragmentary nature and lack of *longer-term* planning and integration of research and development projects concerning the sustainable use of plant protection products. The national strategy for integrated pest management under preparation within the Natural Resources Institute Luke will obviously address this concern for its part in future. It is perceived that separate research projects may not adequately address the policy goals specified in the NAP, and short term funding available may not favour research questions that would contribute to a systemic transition towards sustainable plant protection practices. Strong interest in collaboration between production and protection inclined research traditions was articulated by researchers, but improved coordination was required to cover obvious knowledge gaps and avoid overlapping. Collaborative, regular discussion forum is desired to bring together the whole production chain (Vänninen 2016). The themes of environmental and human health risks and agricultural innovation systems are thus intertwined in the proposed measures of success within the NAP intervention of research.

To measure the NAP achievements within the realm of the environment, an idea has emerged of integrating multidisciplinary research to systemically study the effects of plant protection choices to the quality of the environment (cf. Bellon & Hemptinne 2012). Plant protection practices could be assessed against their pattern to increase or decrease the environmental load. A straight-forward status assessment approach was not considered adequate, but elements of participative methodologies could also be incorporated in order to address how the change is assumed (Stem et al. 2005). A proposal for a systemic research programme could be drafted to involve farmers, advisors, scientists and policy-makers to a co-innovation process of combining IPM practices, social learning and dynamic environmental monitoring, in order to establish the mutual benefit situations to agriculture and the environment. Preparation of a strategic research agenda for integrated pest management contains some elements of this kind of systemic research (C-IPM 2015b-c). Experimenting with usage instructions and risk mitigation measures of plant protection products would be key, as well as the selection of an appropriate study area to allocate the environmental monitoring. For intensive monitoring, a demarcated vulnerable area with the most intensive cultivation and thus high expected load would be required (cf. Mannio 2001). To increase the cost-effectiveness of environmental monitoring, this kind of targeted intensive study would offer data for designing criteria for the adequacy of spatio-temporal sampling and analysis schemes in environmental monitoring of PPPs. For instance, the involvement of local farmers, advisors, beekeepers and bystanders in local study groups, voluntary sampling and observation collection, record keeping exercises, opinion polls, consumer surveys on local food production, economic profitability studies and testing of the most applicable risk mitigation measures could all be areas to be incorporated in this comprehensive research, in order to cover the complexity of environmental impacts more systemically than simple monitoring of concentrations or non-target populations without assessing the effectiveness of interventions. An example of first attempts to involve the farmers in monitoring was the Vemmenhög project run in Sweden since the 1990s (Kreuger 1998; Kreuger & Nilsson 2012).

The impact of refining the environmental usage restrictions or intended substitution decisions could be assessed in particular situations by environmental modelling and using available monitoring data on these active substances. This kind of analysis would also require scrutinising the selection of plant protection products on the market, comparing their environmental use restrictions and hazard classifications, sales and usage. Excellent comparison material would be available from the project on amending the surface water buffer zones, when the adoption of the revised restriction will be obligatory from the growth season from 2015 onwards. Criteria for reducing the dependency on chemical plant protection (cf. Bürger et al. 2008) could also be developed to enhance the comparative assessment.

Statistics on occupational health situation (accidents, occupational diseases, other morbidities, poisonings, biomonitoring) were not perceived appropriate as quantitative indicators in Finland, although are relied on in certain Member States' NAPs (e.g. UK: Defra 2013). Further research is needed to produce better measures instead of quantitative health indicators. Surveys have been conducted to interview persons who contacted the poisoning information centre about suspected poisoning incidents and on agricultural workers' perceived symptoms linked with plant protection, and the preliminary results indicate very few cases related to professional uses (Koponen 2015a-b). Experimental studies have been proposed on the actual efficacy of personal protective equipment (PPE) in reducing operator exposure and on factors affecting the concentrations in tractor cabs, and the results could be utilised in the risk assessment and authorisation of plant protection products.

So far, various risk indicator approaches have focused less on human health issues, although some indicator developers have included elements of operator and bystander exposure in their indicators. There is less overall experience on using operator risk indicators in describing human health issues compared to environmental issues (OECD 2105), and further research is obviously needed in this sector. Concerning the consumer risks, residue data in food commodities can be considered as a risk indicator.

On the other hand, the development of environmental *risk indicators* for plant protection products has recently been under substantial research from many different offsets and configurations in numerous countries, and these risk indicators are considered a promising means for assessing the achievement of policy goals (OECD 2015). Countries with the most advanced experience on pesticide risk indicators have invested considerably in the research and development of indicators that particularly describe their conditions and use patterns. National visions on what will be pursued on the use of risk indicators as well as decisions on the implementation of most applicable indicators and on resources to be allocated to data collection and indicator calculation will be on the agenda in Finland soon, if evidence in the progress of risk mitigation work is anticipated to be gathered using risk indicator calculations. One question to be highlighted by research is how the risk indicators to be implemented can differentiate variable plant protection practices in transitions of cultivation techniques, like increased direct sowing or improved spray equipment, or in changing climate over time.

Although research and development of environmental risk indicators has been conducted since 1990s (cf. Reus et al. 1999), the progress in deployment of harmonised risk indicators within the EU has been slow since the adoption of the SUD, and national practices are variable. The development and experience in the implementation, use and reporting of risk indicators within EU and OECD countries have been followed (e.g. OECD 2015), and first attempts to produce Finnish indicator data with the proposed EU-wide HAIR2010/2014 indicator have also been piloted (Räsänen et al. 2013a, Kruijne et al. 2014). Another approach has been to assess the applicability of analysing the PPP load with life cycle analysis methods (Räsänen et al. 2015). Although a plethora of sustainability indicators are available, Lyytimäki et al. (2014) illustrated how in reality they are less used or not appropriately used in policy-making. In addition, the projects on Finnish indicator development have showed the large amount of high level of scientific expertise, workload and data needed for producing accurate indicator data. It can therefore be concluded that producing regular risk indicator data would require longer-term planning of the responsibilities between the NAP actors and more permanent resource allocation than temporary project funding can offer, risk indicators to become a commonplace policy tool. Facing the scarcity and priorities of research funding the NAP Steering Committee should soon frame the Finnish needs, goals and practical execution of risk indicator calculations.

Record keeping of plant protection decisions by field plots is a keystone of IPM and produces data for usage statistics to be used in risk indicator calculations. Although official sales statistics of plant protection products have been well developed in Finland since the 1950s (Savela 2015), collection of usage statistics started more recently (Mattila 2015; Luke 2014), and mandatory statistical purposes do not yet allow any deeper analysis of individual users' choices. As we currently live in a critical period of switching from conventional farming to IPM, we would likely be interested in analysing the plant protection records at farm level in more detail before and after the transition. This kind of research has not been published before. One option to analyse the effects of mandatory adoption of IPM as of 1 January 2014 is a case study on how farmers have actually recorded their considerations and plant protection decisions before and after the changeover. Explanatory factors like weather conditions, possible comparisons between different methods and products etc. might also be assessed from the data. Even a rather small sample of records from voluntary farmers could reveal how mandatory IPM has been perceived, put into practice and recorded in practical situations, and if material from several years were available, comparisons to earlier practices and longitudinal development of IPM thinking could arise. This kind of material should, however, be collected very soon, because it is likely that the records from years preceding the mandatory IPM uptake will gradually be destroyed. The results would give direction to future IPM research, help the policy-makers consider if the record-keeping obligation on PPP uses is adequately formulated in the legislation and provide information about the practical implementation of obligation to choose the plant protection methods that are the least hazardous to the environment.

A national strategic research agenda for IPM research in Finland is under development at the Natural Resources Institute. Simple measures of promoting IPM research are the development of numbers and funding received for research projects concerning IPM (Nissinen et al. 2015a-c). IPM impact indicators and IPM uptake indicators are two different things. Analysis of on-farm data on crop management and pesticide usage choices (c.f. Bürger et al. 2012) could be used for illustrating the IPM choices in IPM training. Indicators for the systemic level of IPM uptake are disputed and under development currently in the Europe (C-IPM 2015b-c). Therefore any targets or indicators for the depth of IPM implementation have not yet been set. Plant protection researchers call for participatory approaches to involve the professional farmers in the IPM development and to rest on their knowledge of newest cropping techniques, perfectly in line with the intervention of providing training and advisory services, as presented above in Chapter 8.2.

An indicator of such participation can be the number of ringside farmers committed actively to IPM development projects as co-producers and brokers of knowledge, as exemplified by the PesticideLife project at: https://portal.mtt.fi/portal/page/portal/mtt_en/projects/pesticidelife/Demonstration%20farms. In the context of sustainable intensification, future scenarios of Finnish agriculture and the policy-based implementation requirements of sustainable crop protection in the EU should be addressed by research.

The experts perceived that the research on IPM should specifically enhance the uptake of sustainable plant protection practices by agricultural and horticultural producers as well as in forestry and amenity areas, instead of looking for solutions for separate, specific pest control problems without connection to a wider systemic perspective on sustainable crop production. Transition to sustainable crop protection can ideally be seen as a combination of processes of both transition management and adaptive management (Pant et al. 2014; Voß & Bornemann 2011). Additionally, the higher societal impact of plant protection should be aimed for by connecting different stakeholders in the agricultural innovation system (AIS) through new boundary-crossing roles and knowledge creation practices to balance between the three pillars of sustainability: ecological, economic and social (cf. Klerkx et al. 2010).

The adaptive management perspective (Berkley 2013) to IPM research contributes to the socioecological knowledge production by integrating various kinds of epistemologies – scientific, professional and bystander views – into a co-evolutionary collective learning cycle, and builds on the prevailing institutional structures. The transition management perspective (Elzen et al. 2012) focuses on enabling and spurring the innovation processes and incremental structural transitions by facilitating a more long-term reflection on sociotechnical system dynamics and setting up transition pathways for active use of new technologies, first in small scale and later expected to become mainstream. There are already new IPM technologies such as forecasting models for pest infestations and global positioning system (GPS) based digital record-keeping programmes under development and increasingly available, but still not widely used, as Wijnands et al. (2014, p. 550) pointed out. The basic challenge for IPM research is essentially the same as that of other NAP interventions: how to combine these approaches to support the institutional change and get the stakeholders engaged to collaboratively contribute the transition towards a sustainable crop protection? As an outcome, suggestions for better policies to support sustainable crop protection uptake could be envisaged. This aspect will be further discussed in Chapter 9.

8.6. Measures and indicators of success in information and communication

The workshop participants and expert panel members mainly concentrated on information needs and training of professional users. Other communication, such as an increase in consumer awareness, did not intrigue the experts so much, although the general public's need to be given information came up in the frequently asked questions from citizens. It was questioned by the respondents:

"Has there been sufficient additional public discourse [on NAP issues]?" (V.E.7)

To balance the information needs and efforts to communicate effectively on sustainable plant protection, a comprehensive communication plan and a network for communicating the efforts of individual organisations was considered necessary. Currently, the NAP relies on every actor independently providing details about their own tasks and achievements to the best of their ability, as has been regularly evidenced in the minutes of NAP Steering Committee.

Tukes follows its annual communication plan in its information. The actors report informally about their efforts in the NAP Steering Committee meetings, but any written reports apart from the meeting minutes are not produced collectively as evidence of achieving the NAP goals. However, perceived lack of coordination in the communication efforts between the stakeholders was mentioned as bewildering by some of the respondents. Improving the communication plans and maintaining the communication network between different actors was considered an important measure of success. Frequent analysis of media publicity of NAP issues could provide evidence of awareness-rising efforts and help improving the coordination of communication between different actors.

The responsibility of trade and industry has been highlighted to serve the buyers by providing guidance on the use of appropriate personal protection equipment. Contrary to what was perceived as inappropriate for the authorities, it was proposed that the authorisation holders and retailers could more actively recommend specific brands and models of personal protective equipment (PPE) associated with their specific plant protection products during the sale events. In addition to sales statistics of plant protection products, an analysis of the sales of personal protective equipment associated with the sales of plant protection products could indicate a tendency to operator protection.

A comprehensive list of different actors providing information is presented in the NAP. However, the perspective is completely that of information providers and there has been no further analysis on how the information available is expected to be received or actually affect the receivers. The numbers of information providers, organised information campaigns, press releases and leaflets produced may therefore not be such adequate indicators for acceptance of the information, but feedback from the target groups is more relevant in the evaluation. For instance the National communications plan for dangerous chemicals (Tukes 2013a) intends to survey the consumers' awareness as a consequence of investing in information campaigns. This survey could be extended to also cover plant protection issues. Stratified sampling could, for instance, focus on visitors of agricultural exhibitions, gardening fairs and culinary events in order to reach different consumer groups likely to be interested in plant protection issues.The success of communication might benefit from more systematic and continuous recording and analysis of citicens' references. The feedback received by different actors could also be reported regularly to the NAP Steering Committee in order to maintain the mutual communication climate.

Availability of Plant Protection Product Register and other information material in both official languages in Finland (Finnish and Swedish) was specifically mentioned as an important information channel for professional users. Additionally, the availability of detailed education material on, for example, guidance for adequate personal protection and selecting personal protective equipment was prioritised by the experts as an awareness-raising effort. Similarly, improving the guidance for control of safe storing and statistics on storages of obsolete PPPs was perceived as a top priority. Feedback from the self-directed interactive training material available at the website of Tukes (Tukes 2014b) has been largely positive.

The importance of learning and knowledge brokering of research results and innovative IPM practices from researchers and advisors to a wider scale of professional users was emphasised by the experts both nationally and internationally. Multidisciplinary and multi-professional competence of and collaboration between the stakeholders involved are seen to guarantee the success. Active dissemination and utilisation of research findings benefits all stakeholders in the implementation of the NAP that explicitly aims to refine its goals on the basis of cumulating scientific knowledge. The experts appreciated the mutual expertise, adequate funding, facilities and tools that are needed for the collaboration**.** However, the uncertainty of temporary project funding may cause that instead of actively communicating the results of their finalised projects the researchers involved may have to start immediately focusing on new projects with all their might. A shared *information platform*, such as the IPM portal under development (Vänninen et al. 2014), would greatly improve the mutual exchange of information, if new data were to be uploaded regularly by all actors producing and dissipating it.

Although cost-effectiveness considerations of NAP implementation projects may not be of interest to general public, policy-makers and administrators would make use of this data to evaluate the overall accountability of NAP actions, like amending the risk mitigation measures (as presented in Chapter 5.4.2) or utilisation of individual extension services, for instance. It is therefore proposed that the costs of separate actions to participating organisations during the whole programme period would be calculated and analysed in more detail than during the preparation of the NAP.

8.7. Measures and indicators of success in monitoring

As a specific dimension of evaluation forms, monitoring the implementation process of the NAP can be considered as a distinguished intervention type to oversee the deliverables of the process (see Chapter 7.2). For this purpose, general management information like work contributions and other resources allocated to NAP actions or other measurable indicators of interventions as presented above, are considered appropriate. Because of the involvement of multiple actors in different phases of the NAP system, each organisation follows its own budgetary cycles and monitoring processes separately, and any concerted action may be troublesome, if at all necessary. However, this kind of data would contribute to evaluating the accountability of organisations involved.

Monitoring the residues of plant protection products in food commodities and the environment is a special type of programme evaluation, but has a core role in evidence-based evaluation of interventions that aim to reduce the risks from their use to human health and the environment. Residue analysis from food commodities and environmental samples was perceived as the most effective indicator to illustrate the risks from the use of plant protection products in Peltonen & Rajala (2009). Consequently, the organisation and maintenance of the two monitoring systems was incorporated as core actions in the Finnish NAP. The environmental monitoring currently depends on separate funding to be realised, and requires further research to adapt Finnish conditions, as previously presented. The resources available for developing and maintaining the monitoring systems are therefore one indicator of the success of this intervention.

Monitoring of pesticide residue in food commodities is regulated by European legislation, and the system of sampling and analysis is operating well in Finland, as concluded by the FVO (2006 and 2014). Results of residue monitoring in food commodities are reported yearly (Kekki & Siivinen 2013), and it can be concluded that consumers are exposed to a mixture of residues at low levels from different foodstuffs, but the lifelong overall exposure of Finns is at a safe level. In addition, the acute exposure does not cause a risk in general. However, for toddlers consuming plenty of fruit and vegetables produced outside the Europe, there is a risk of exceeding the safe level of residue intake, because their food consumption related to their weight is higher than in other population fractions. The risk can be reduced by choosing preferably domestic products for consumption. Residue monitoring in food has a well-established organisation with multiple actors involved in the system, due to the community level legislation in this sector.

The continuity of the monitoring of plant protection products in the environment is integral for evaluating the risk reduction outcomes of the NAP. The Finnish monitoring system has so far been based on project funding where continuation is uncertain, as Karjalainen et al. (2014, p. 7-8) described. Although faced with an increased scarcity of public funding available for implementing environmental policy programmes, the ministerial working group preparing the NAP did not consider appropriate to apply the Polluter Pays Principle in obligating the plant protection industry and agriculture to participate in the cost of organising the environmental monitoring system by taxation, for instance; contrary to several other Nordic countries. The environmental monitoring is therefore organised in Finland within the strict limits of temporary public funding and is consequently grappling with the challenge of defining the boundaries for adequacy. The Finnish system of environmental monitoring of plant protection products therefore still seeks the most cost-effective design and lacks a longer time frame, compared to other Nordic countries, where pesticide taxes have traditionally been allocated to monitoring, allowing abundant sampling at several sites as well as active communication of monitoring results to the general public and the stakeholders (Nordic Council of Ministers 2007).

As a measure of success, the good chemical and ecological status of natural waters as defined in the Water Framework Directive (EU 2000) is stated in the NAP. This can be assessed by comparing the monitoring results

with the Environmental Quality Standards (EQS) for specific active substances. Although official standards have only been set to specific priority substances at the EU level (EU 2008c), one of the first deliverables of the NAP was the proposal for all plant protection products on the market in Finland (Kontiokari & Mattsoff 2011). The proposed values can be used as surrogates to official reference values, thus observed exceeding values over time illustrating the overall trends of aquatic load from PPP usage. Based on the results of surface water monitoring projects, Siimes (2012) and Karjalainen et al. (2014) concluded that plant protection products did not cause broad environmental problems in Finnish surface waters during the monitoring period of 2007-2012. Although up to 68 substances were detected, the concentrations remained usually well below the proposed EQS values. However, up to ten substances exceeded the reference values occasionally in certain sites, four of them being sulfonylurea herbicides. The numbers of sampling sites and times are low compared to the area of Finnish surface waters. Surface water monitoring will be continued within the framework of funding available, and further research is targeted to focus the monitoring on sites with most vulnerable conditions and highest expected loads (Siimes 2014). The substances with highest concentrations observed would require more detailed further analysis of usage patterns that cause the highest environmental loads. Criteria for sampling density and adequacy of monitoring need to be developed. Monitoring results could be better integrated to the emerging IPM research to improve understanding of how plant protection practices could be transformed to be more sustainable.

A more close connection between monitoring and applying the risk mitigation measures would be beneficial. For instance, the aquatic risk mitigation measures were changed as an outcome of NAP activities (Tukes 2015d) as explained earlier in Chapters 5.4.2 and 6.4, adopting narrower buffer zones (the basic level being 3 m) in association with spray drift reducing techniques, but the reform only considered surface water exposure by spray drift. Recent research in different countries suggests, however, that much wider vegetative buffer zones would be required to adequately protect the surface water ecosystems from pesticide exposure via runoff and drainage pathways, as discussed in Chapter 2.8.3. The effects of this NAP action should therefore be carefully evaluated by using surface water monitoring data after the implementation of the modified risk mitigation measures from the year 2015 onwards.

8.8. Summary on gathering evidence of success in implementing the NAP

To allow online communication about the achievements of the NAP, the key evidence proposed in previous chapters could be organised to a digital dashboard. In management information systems, real-time user interfaces that show the current status and historical trends of key performance indicators at a glance in an easy to read format are called dashboards. For the NAP, the IPM portal to be developed could possibly be the platform where the dashboard could be located. In Table 8.1 below, some core measures are condensed from the chapters above as tentative key performance indicators for the NAP. A more complete summary with proposals for collecting the data is presented in Chapter 4 of Annex 4.

In an example from programmes aiming to promote human health through raising awareness, education and skill development, Peersman (1999) illustrated the importance of appropriate target-setting and measures of evidence by systematically reviewing the outcomes of almost 6800 study reports, where only a few programmes included a range of measures necessary to assess whether or not an intervention works, and how it works or why it does not. In the majority of the studies the target setting was incomplete in a way that it appeared impossible to evaluate if the programme targets were met or not. The programmes may be designated ‘not effective’ due to being assessed with inappropriate tools. In its evaluation the FVO highlighted examples of good

practices of different actions required by the SUD and presented in the NAPs (FVO 2014b). Defined quantitative objectives, targets, measures and timetables were preferred as good practices. The report did not at all consider the possibility to evaluate the qualitative achievements of the NAPs, although we are facing the novel situation in the most Member States where the implementation of the first NAPs calls for collective learning by all stakeholders. If the objectives of the NAPs are seen merely as to fulfil quantitative, numerical targets, then a range of important effects of the NAPs remain unrecognised. Nevertheless, qualitatively evaluating the implicit, unintended and unexpected effects of implementing the NAPs requires significant effort from the Member States.

Table 8.1. Tentative key performance indicators for the Finnish NAP. Intervention areas refer to Figure 8.1.

Intervention area	Measures and indicators
Compliance with legislation	• Legislative requirements fulfilled and timelines adhered
Training and extension	• Supply and demand of training and advice in each sector • Feasibility of training and advice with regard to facilitation and creating space for social learning • Knowledge gaps between top performers and average users
Specific use requirements	• Crop rotation in use, reasons and bottlenecks of not implementing • Deployment of organic farming • Sales and uses of professional vs. non-professional PPPs
Control and surveillance	• Evidence of risk reduction in PPP authorisation • Evidence of using substitution in PPP authorisation • Condition of spray equipment
Research	• Combining farming practices, social learning and dynamic monitoring of exposure to a wider societal impact of IPM • Improving the implementation of human exposure indicators • Improving the implementation of environmental risk indicators • Longitudinal evidence of introducing IPM practices in field
Information and communication	• Centralised platform for PPP information • Availability of NAP information material in both official languages • Active dissipation of research findings
Monitoring	• Monitoring of pesticide residues in food • Monitoring of PPP exposure in the environment • Good chemical and ecological status of natural waters (Directive 2000/60/EC)

9. Engaging the stakeholders in striving for risk reduction: empowerment evaluation

My last research question was about how the stakeholders could be engaged to strive for the NAP goal of reducing the risks from the use of plant protection products. In this chapter the issues of stakeholder participation in the implementation and evaluation of the NAP are discussed. First, current efforts to stakeholder participation in the NAP are analysed in Chapter 9.1. Power issues are dealt with in Chapter 9.2. Aspects of empowerment evaluation are discussed from the perspectives of three main stakeholder groups in the next chapters: the general public and the NGOs (9.3), users (9.4) and the trainers and advisors (9.5). The balance between socio-cultural, economic and ecological sustainability issues is discussed in Chapter 9.6, and finally, good practices are discussed in Chapter 9.7.

9.1. Analysis of current stakeholder participation efforts in the implementation of the NAP

Stakeholder participation in the Finnish NAP implementation was repeatedly highlighted and appreciated by the experts, but participation was in general expected to be institutionally driven and – among those professionally involved – as mainly between researchers, advisory services, authorities, industry and farmers. Organisational capacity-building was mentioned as an important outcome of participation. Although producer organisations were involved in the preparation of the NAP document, the NAP was largely perceived as an authority-driven programme with less involvement of grass-root commitment and local activity. Analysis of the modes of stakeholder engagement in the NAP actions confirm this view, as presented below.

Different modes of engaging stakeholders in knowledge-based action for sustainable development were analysed by van Kerkhoff & Lebel (2006). Following traditional modes of translation and consulting style knowledge transfer, recently participatory approaches have become more common with an increasing level of engagement and power sharing between experts and practitioners in action. Characteristics of all these processes are today present in the involvement of stakeholders in the NAP implementation and knowledge production on IPM issues in Finland. Representative examples of key tasks listed in the NAP document (as summarised in Appendix 1) are presented in Table 9.1. in the light of increasing stakeholder engagement and power sharing.

So far the focus has traditionally been at lower levels of engagement characterised by one-way knowledge transfer from experts to practitioners, as illustrated in lower rows of the table, but the first efforts of more developed engagement approaches are also emerging. Although the collective learning type of engagement was not present during the preparation of the NAP document, one later example of this type project is included to illustrate the gradual shift to higher levels of stakeholder participation in research projects on IPM development (by Vänninen 2012).

Table 9.1. Examples of recent Finnish NAP implementation actions representing various modes of stakeholder engagement and power sharing as characterised by van Kerkhoff & Lebel (2006). ↑ indicates increasing level of engagement and power sharing.

Modes of engagement and power sharing	Typical characteristics	Representative examples of Finnish NAP implementing actions
Collective learning	Practitioners and experts are engaged to iterative processes of research and action for working together to clarify and solve problems defined together. Facilitators may enhance the process.	- Implementation of system-level IPM strategies require longer-term mutual learning relationships, as emerged in particular IPM development projects e.g. in change laboratories for greenhouse sector.
↑ Negotiation	Stakeholders seek influential experts and practitioners to support and further controversial contested action agendas in political arenas. Lobby groups involved. Outcomes are usually trade-offs.	- Modifying the environmental risk mitigation measures of PPPs and spraying technique to reduce spray drift in actual Finnish conditions of use required hearing and negotiations between users, industry, authorities and NGOs. - Preparation of guidelines for notification of the use of PPPs to neighbours, beekeepers and bystanders.
↑ Integration	Shared accountability. Research funders require specified interactions between researchers and practitioners representing different disciplines.	- Ministerial funding of research projects requires nominating stakeholders as steering committee members for research projects, with research agendas defined collectively: - advancing research and development of plant protection methods for organic production - introduction and implementation of EU-wide risk indicators.
↑ Participation	Practitioners consult experts directly for advice, experts gather and consider input from practitioners.	Multiple expert organisations are involved in - production of training material - organising training courses - developing extension services for PPP users to better grasp the needs of the farmers.
↑ Translation of science for laypersons	Researchers and specialists engage in science communication. Knowledge brokers may translate scientific data to easily understandable form. Direct participation of practitioners is not expected.	- Experts producing awareness-raising material and leaflets for laypersons, e.g. on IPM, safe handling of PPPs. - Traditional agricultural extension services.
↑ Trickle down of knowledge	Researchers produce scientific studies to be published, practitioners consult the studies where appropriate.	- Monitoring data on residues in food and in the environment are published by responsible research organisations. - Inclusion of exposure scenarios for amateur users in the risk assessment.

Figure 9.1 illustrates the numbers of key tasks listed in the NAP document as categorised according to the expected level of stakeholder engagement along the three phases of programme continuum in the first, second and third phase of implementation (2011-2014, 2015-2017, and 2018-2020).

9.1

Numbers of implementation tasks (actions) listed in the NAP

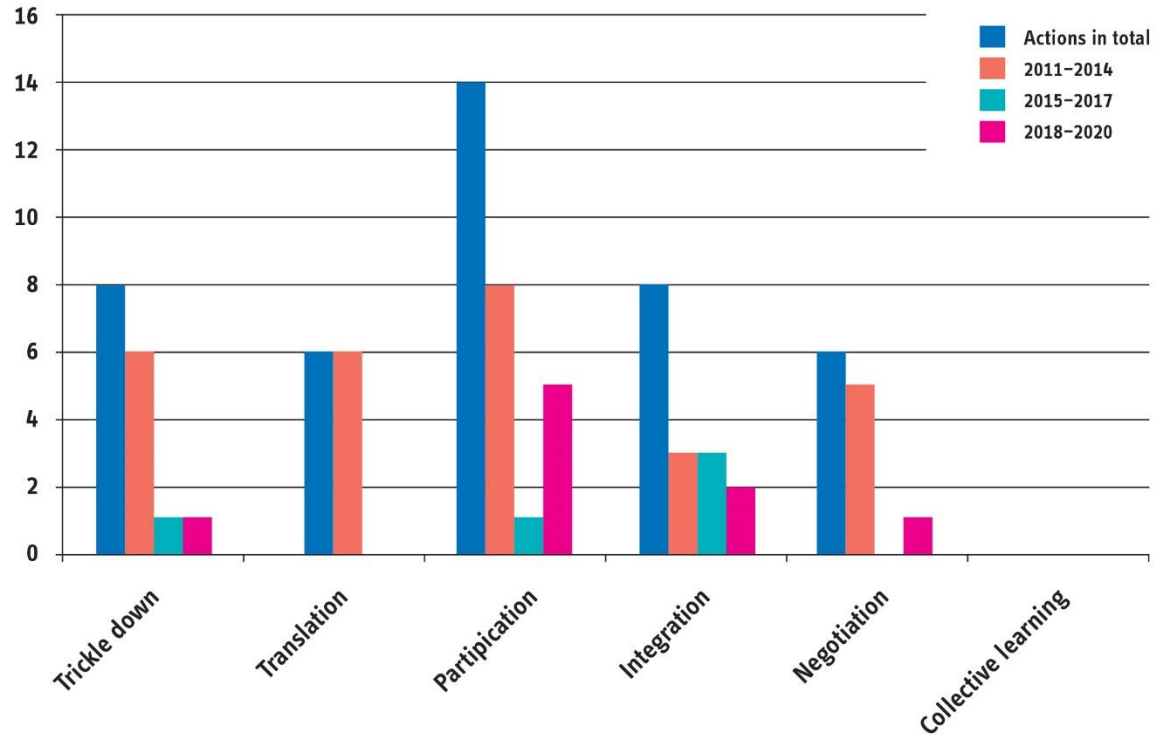

Figure 9.1. Numbers of implementation tasks (actions) listed in the NAP document, explicitly characterised by each mode of engagement in the first, second and third phase of implementation (2011-2014, 2015-2017, and 2018-2020). A summary of the tasks is presented in Appendix 1.

One interpretation for the relatively high amount of lower level participation (trickle down, translation) is that several background studies were committed at the starting phase, whereas the emphasis was expected to turn to more participatory designs at later phases of the programme. However, although stakeholder participation was considered important, only limited experience in the highest level modes of engagement was available during the preparation of the NAP document, rather resigning to moderate modes of participatory activities (participation, integration). Interestingly, attempts to potentially increase the highest level participation appear to fade out along the programme continuum, with negotiation type actions concentrated in the first phase of the NAP. The request for collective learning engagement was not emerged yet, but interest in it was later seen along the course of the NAP implementation, implying that negotiation and collective learning will presumably become more attractive approaches in the future. In order to increase the engagement of stakeholders in action towards more sustainable plant protection, the more developed processes of stakeholder participation described above could be considered whenever appropriate.

The tasks and roles of the NAP Steering Committee came into question in expert consultations. Some of the participants found the role of the committee was unclear. Indeed, the NAP document does not assign any defined tasks or even mention the establishment of a steering group; hence the process of assigning it may not appear very transparent to those who were not involved at the start. A range of relevant tasks to the Steering Committee

were proposed: participation in report writing, general guidance in implementation and information exchange between organisations. Some characteristics of the Finnish NAP implementation were evaluated according to the criteria of Walls et al. (2011) for the effectiveness of such stakeholder engagement efforts. The criteria can be used either quantitatively in surveys with participants, or qualitatively, collecting verbal descriptions and views of the participants and observations during and after events where stakeholders are engaged in the evaluation. The analysis of stakeholder engagement in the Finnish NAP is presented in Table 9.2.

Table 9.2. Descriptive evaluation of stakeholder engagement in the implementation of the Finnish NAP in the light of criteria established by Walls et al. (2011).

Criteria	Characteristic evidence in the NAP implementation work
1. Representativeness of affected stakeholders	Most stakeholder groups are invited and are participating in the Steering Committee working and usually almost all present in the meetings, with an exemption that NGOs have not appointed their representatives, a few of them gave their excuses.
2. Influence of participation procedure on the outcome	As the main stakeholder groups are actively involved in the implementation of the NAP, they can be considered as influential. For deviating insights on influence of different groups, see the results of the stakeholder analysis in Chapter 6.1. The lack of NGO insights may therefore cause an obvious bias in the evaluation.
3. Transparency of decision-making process	This is an area for improvement. Minutes of the NAP Steering Committee meetings and other materials are circulated to all participants, but the flow of information from Steering Committee representatives to their other colleagues within each organisation has to be ensured. Some experts were doubtful if the NAP communication between stakeholders has reached adequate transparency.
4. Resource accessibility to participants	This is an area for improvement. Adequate resources for implementing the tasks designated to separate organisations need to be ensured in long term. Filing the data produced by separate stakeholders and organisations should be organised so as to ensure the accessibility to everyone interested, including those not able to participate the steering group working and the general public. Websites and portals where the data is uploaded must be regularly updated.
5. Task definition	Each actor promotes their own interests in the implementation of the NAP. The tasks of the NAP Steering Committee could be defined in more detail. The tasks of authorities have been defined in the legislation. The actors define their current tasks and report on the achievements to the others in Steering Group meetings. Structured, collective decision-making on specific tasks, including hearing of stakeholders, is important for mutual commitment.

9.2. Power of stakeholder participation in implementing and evaluating the NAP

As depicted in the sustainability screening of the Finnish NAP in Chapter 6.6, broad-based ownership and commitment was clearly the area where the overall progress was perceived as most advanced. There is also evidence from European studies that various framings of stakeholders alter the problem definition and seeking solutions for transforming the plant protection practices to be more sustainable. The importance of stakeholder participation in agricultural programme evaluation (e.g. Pinxterhuis & Caron-Flinterman 2010) and in the implementation of IPM is emphasised in stimulating the process towards the goals of the NAP. However, though improving communication was considered as one of the main purposes of the NAP, its intended audience was

felt as only vaguely defined. It was felt to be speculative, whether it is the users who ought to resolve perceived problems by getting certified, or if it is expected that the goals will be reached if the research community fills the data gaps through their research and reports. Or are the legal aspects regulated by the authorities the core of the NAP, or merely the Commission and other Member States that should be convinced? When the message is not clearly addressed to any presumed audience, it remains rather weak. Preferably the proposed NAP actions should not be challenged by any audiences. As summarised in Table 5.1, the majority of the actions are directed at the authorities and other public organisations within the agricultural sector. Only a few of the actions are directed to the actual users of plant protection products, who in reality are primarily in charge of applying the IPM criteria in their plant protection decisions. The official expert language used suggests that the NAP is mainly directed to European Commission and other Member States for explaining how the Finnish authorities use their executive power to implement the SUD, as articulated by one of the respondents:

> 'The NAP is a load of hot air – and who knows whether it will come true. Performing a task given from our superiors, so that we can report to the EU that we have sat in on meetings […]' (VII.C.3)

The parties not involved were hardly mentioned explicitly, but were considered merely as bystanders and faceless objects for information campaigns, and would better be kept at a distance for not stepping in with their controversial demands. So the NAP appears to be a top-down policy-level programme speaking a specialised expert language, with less interest in local action or direct involvement of the general public or the NGOs.

In the stakeholder analysis in Chapter 6.1, the focus group of experts considered that most powerful stakeholders are authorities with a coercive influence, entitled to imposing sanctions for infringements of legislation. Hence the Agency for Rural Affairs (Mavi) was considered as most influential, with the power of paying the agri-environmental subsidies. The Ministry of Agriculture and Forestry was perceived to have a greater economic influence compared to other authorities, due to its financial steering. Other authorities were perceived as less influential in the implementation of the NAP, in terms of coercive or economic influence. In addition to authorities, other stakeholders, like grower and advisory organisations, training and education institutions and NGOs, were also perceived to hold a strong cultural influence.

In addition, the focus group of residents perceived authorities to be the most powerful actors, but they also highlighted the influence of food and chemical industries, retailers and research institutes. Parties perceived as most affected, as represented by NGOs, included different consumer groups, non-target organisms and environmental compartments, being viewed as least powerful but having a high interest level. However, the experts specifically mentioned bees as having a high level of coercive influence on farming, thus recognising the offering of the unique ecosystem service of pollination to the benefit of plant production and the whole society. Consequently, the most apparent influential stakeholders are well represented in the implementation of the NAP, whereas the less influential stakeholders are missing. Hence it can be justly suspected if the less influential stakeholder groups consider the participation in the implementation of the NAP and its evaluation as meaningless and not allowing their actual impact.

If we compare the situation with other countries' NAPs, Barzman & Dachbrodt-Saaydeh (2011) found out that a wide stakeholder participation was a prerequisite of a successful implementation of the NAP in all countries studied. In some cases the NGOs were not fully satisfied either with the preparation process of the NAP or the targets set, but the closer involvement was offered, the higher level buy-in was achieved, thus defending the idea of wide participation in the process. As a conclusion, stakeholder involvement in policy-making and evaluation processes needs to be taken seriously to avoid rejection, which obviously is also our challenge with the Finnish NAP.

The next three chapters address the perspectives of empowering three stakeholder groups in evaluating the outcomes of the NAP. Empowerment evaluation is specifically aimed to help people in evaluating their own performance, as its developers had defined (Fetterman et al. 1996). Therefore, stakeholder participation is the core of an empowerment evaluation to bring forward an insider view and a personal commitment to the implementation of the NAP. Firstly, the opinions of the general public and the perspectives of NGOs are considered in Chapter 9.3. Secondly, personal commitment and participation of the users of plant protection products is discussed in Chapter 9.4. Thirdly, the implications of participatory approaches in extension services, training and user certification are presented in Chapter 9.5.

9.3. Considering the public opinion and NGOs

Traditionally, a gap between the production and protection inclined perspectives has been discernible in the discourse on crop protection, as presented in Figure 6.5 in Chapter 6.7. However, contrary to some other Western societies (e.g. Wijnands et al. 2014), the general public has not been much encouraged to explicitly bring forward their stakes and participate in the discourse on the risk reduction of plant protection practices, as illustrated in a recent newspaper column in Helsingin Sanomat (Ruukki 2015). It has rather been presumed that calming down the discourse alleviates the potential concerns of stakeholders and enhances the effective implementation of the planned NAP actions without inevitable conflicts of interests.

In general, the Finnish administrative culture is traditionally based on wide and well-organised co-operation between various interest groups and stakeholders, striving for a consensus to satisfy most participants (Reunanen et al. 2010). The Finnish NAP was prepared in consensus by the ministerial working group broadly covering various stakeholders, and the draft was circulated for comments. However, a limiting, instrumental view of those involved framed the actions to follow a top-down rather than a bottom-up approach. Although awareness-raising among the consumers and general public is one of the objectives explicitly mentioned in the NAP, active participation of those groups in knowledge-making is not expected by the experts. As Downs (1972) highlighted, societies are less willing to invest in environmental protection during periods of economic depression, which has also been obvious in Finland; for instance, considering the scarce funding for environmental monitoring of plant protection products in recent years. The future shows how long the current consensus will stand if budgetary limitations continuously affect the implementation of the NAP. During the preparation of the NAP document, the identification of stakeholders affecting and affected by the use of plant protection products was not systematic, thus potentially excluding some marginalised groups. It was not even clear for the experts, how to identify the potentially marginalised groups. The awareness-raising efforts therefore become unidirectional, from experts to the general public, thus predicting a lukewarm response.

The capacity of researchers and authorities to actively provide different stakeholders with information was discussed by the expert panel participants. Public engagement in environmental policy implementation is more successful if participants' feeling of being able and capable to do something is developed at the same time as their awareness (Sleenhoff & Osseweijer 2015). Deliberate redirecting of the communication about the NAP to less influential interest groups affected by the use of plant protection products could possibly strengthen their equal opportunities for participating in the discourse on sustainable crop protection and empower consumers and the general public to assess and analyse the content of communication, thus increasing the multiplicity of views on the sustainability of plant protection (cf. Latour 2005, p. 43-62). Recent communication attempts in respect of general chemical safety to adolescents and children through age-appropriate means (social media,

plays) are examples of this development, although communication on plant protection is still mainly targeted at professionals.

The residents living adjacent to agricultural fields highlighted the importance of making rural bystanders more aware and conscious of the nature of the fields that they use and live close to and of the cultivation practices, where plant protection products might be applied at regular intervals with different application methods. Information about specific mitigation measures to reduce the risks of exposure should also be communicated to neighbours and residents. These opinions are in line with the results of Sacchettini et al. (2012). The local and individual perspectives as presented in Chapter 7.1 could be introduced as complementary to the organisational views prevailing in the NAP implementation currently. Questions that individual consumers could ask themselves: Do my consumer habits contribute to sustainable agriculture and plant protection? Do I require my food to have been produced according to sustainable agricultural practices? And environmentalists could ask themselves: Do I require the farmers to introduce adequate risk mitigation measures to protect the biodiversity, non-target species, soil, waters and the air? Are my ecological requirements reasonable to ensure the socio-cultural and economic sustainability of Finnish agriculture? The heuristic tools presented in Chapter 7 also help find answers to these questions at an individual level.

As explained earlier in Chapter 6.2, the participation of NGOs in the target-setting and implementation of the NAP has been limited, and the situation has been even considered as desirable by the experts. Concern was raised as to whether the expected outputs really do indicate the timely changes of the state in the environment. In addition to the local and individual level assessment of achievements, a broader perspective is also required for the of NAP interventions (Brewer & Goodell 2012). Implementation of more advanced approaches to produce public environmental protection goods on a wider scale is more challenging than applying IPM at an individual field level, and requires societal acceptance, community cooperation and different forms of incentives within the entire food chain, as also highlighted by Nuutila & Kurppa for organic food chain (2016b).

The ideal of unpolitical and consensus-seeking systems of stakeholder participation substituting the traditional corporative model of governance may actually exclude a great deal of the general public, thus narrowing the discussion in favour of powerful stakeholders with the greatest interests and the loudest voice (Keränen 2014). Midgley's description (2000, p. 208) on how, in coercive situations, debate is easily closed out by those with authority in the name of consensus, could explain also why the NGOs have not shown further interest in participating in the process of evaluation of the NAP. Greater citizen participation is considered important in principle, but those considered as less knowledgeable may be easily ignored and excluded from the discourse between experts aiming to achieve a consensus. Consequently, as particular NGOs criticised in their statements, the draft NAP document has a modest target setting for reducing the risks, but their comments did not change the final proposal – they have not considered further participation to be meaningful and have renounced any further influence in its implementation. During the course of the implementation of the NAP, further attempts to explore the views of NGOs have not been made outside of this study so far. Within the NAP community climate there is therefore a risk of mutual path-dependency to a situation, where consumers and NGOs are excluded from the expert discussion, and simultaneously the producers and plant protection experts barricade themselves with a 'business as usual' mentality. Without trying to win the wider support of society, the NAP can hardly reach its ultimate goals, but remains with a reputation of bureaucratic bustle between experts, instead of building trust in risk management institutions, as highlighted by Renn (2008, pp. 222-223).

9.4. Participation of professional PPP users

The implicit pre-assumption of the NAP is that the Finnish farmers already behave responsibly and use plant protection products according to good practice in general. As the responsibility of learning has turned from authorities to individual users, implementing the IPM at farm level is still considered very challenging (Nissinen et al. 2015a; Peltonen & Rajala 2009), likewise reported from other countries (e.g. Hillocks 2012; Hillocks & Cooper 2012; Jess et al. 2014). Therefore it was considered inappropriate to burden the farmers with fundamentally new requirements resulting from the NAP interventions, apart from the obligation to certify the professional users. Because the authorisation of plant protection products presumes that the risks have been assessed as acceptable before releasing the products on the market, it means that no unacceptable risks should be caused provided that the products are used according to good agricultural practice. It was also considered impossible to introduce any new administrative actions, e.g. incentives to reduce the frequency of treatments with chemical plant protection products. A potential inconsistency was recognised as the actions listed in the NAP document are mainly authoritative actions, but achieving the targets actually depend on the choices of individual users of plant protection products.

Similarly to Finland, the voices brought out in the NAPs are typically those of the authorities also elsewhere. By contrast, in addition to authority-driven activities, a few Member States (e.g. the UK: see Defra 2013) implement their NAPs on a voluntary basis with private sector stakeholder initiatives. It is noted that many NAPs specifically refer to the efforts made to involve all stakeholders in the development of the plan. However, some of the weaknesses observed by the FVO (2014) suggest a lack of input from key stakeholders in specific expertise areas.

Despite their explicit wish to participate, my attempts were not successful to invite farmers' associations to organise a third focus group for the stakeholder analysis for this study. It can be speculated if the ignorance was due to perceived inconvenience for the participants although important to general welfare, which did not serve as adequate incentive for their personal participation according to the social learning theory of Bandura (1977, p. 114). The challenge of convincing farmers about the importance of sustainable plant protection practices in their real farming situation has been highlighted in other studies as well (Sacchettini et al. 2012). So it is necessary to focus on awareness, knowledge, skills, sensibility and concern to make farmers eager to learn, thus bringing out also the affective aspects of the commitment to more sustainable practices, as discussed in Chapter 6.9. Barzman et al. (2014) summarised a range of studies to explain how the engagement of farmers in professional networks encourages them to adopt IPM innovations. In Finland, Nissinen et al. (2015b) reported that learning and evaluation of own performance were perceived as difficult or impossible by vegetable growers, thus warranting the focus on empowerment of the farmers as a source of motivation to collective learning at local conditions.

Decentralising the targets and measures of the NAP to a more local level might increase the commitment of the actual users of PPPs. The role of PPP users should be changed from objects of interventions to active participants and NAP implementers, as Wijnands et al. (2014) suggested. Similarly, a reflection from one of the workshop participants expressed clearly the wish of closer farmer participation in knowledge making:

> "Professional farmers should be included in the development of IPM methods. They have knowledge of the newest cultivation techniques, because they rely on it themselves!" (IV.A.2)

Individual user perspectives to the NAP implementation as presented in Chapter 7.1 could be introduced for instance with following questions that individual users of plant protection products could pose themselves: Do I strive for sustainable crop production? Do the plant protection decisions I take promote IPM and sustainable use crop protection? The heuristic tools presented in Chapter 7 also help find answers to these questions at an

individual level. In the end, the first NAP describes the current status quo of the prevailing plant protection practice in Finland rather than expects a gradual change in PPP uses in general. For the time being therefore, its summative evaluation will most likely not reveal any significant measurable changes in terms of reduced use rates, treatment frequencies or dependency on chemical plant protection at a national level. Neither have such outcomes been observed so far in countries that have fixed risk reduction targets in their NAPs (FVO 2014b).

However, the expert panel members consulted stated also that in order to achieve more environmentally-sustainable practices, a more holistic, systemic view about crop protection would be necessary to achieve higher levels of IPM adoption. This would require a paradigmatic shift in agriculture in general, from a natural resource utilisation perspective towards an ecosystem services approach. It was appreciated that in this process the ecological and economic sustainability would be intertwined between the economic profitability and benefit for the environment both at farm level and in general, as illustrated by the following quotation:

> "The NAP pattern will very likely be successful if we do not forget the practical view of the farmers and impede their operational conditions unreasonably. It is important that we always assess the consequences of different decisions at farm level, therefore win-win solutions are desired if we want to cherish domestic agriculture and food production." (VII.C.2)

9.5. Participatory approaches in extension services, training and user certification

In the stakeholder workshop, a *disregarding* attitude was found as one of the potentially limiting factors for successful implementation of the NAP. The experts identified a risk of disregarding the development of professional knowledge and uptake of IPM practices by farmers. A challenge for research and extension services is to make the training attractive and IPM knowledge easily understandable, dealing with up-to-date specific pest control problems on one hand, but then also broader systems-level issues such as the significance of crop rotation and soil fertility, also covering the interactions between the actors through tutorial group exercises, demonstration farms and collective learning, for instance. Users' own communities are responsible for creating a supportive climate that fosters collective learning and attitudes of everyone's personal responsibility.

Similarly to the challenge of producers to change their productivity paradigm, the extension service advisors are also facing a request of changing their professional identity. To be able to respond to requirements of a more systemic approach on IPM issues entails intensive training and regular updating of the training skills of the advisors and training providers. According to the experts consulted, the role of advisors in adoption of IPM and non-chemical pest control methods has not been adequately emphasised in Finland, although effective and professional knowledge brokering has proven to be a necessary condition of dissemination of research findings into practice (Ward et al. 2009) and in transition to sustainable farming systems and IPM adoption in particular (Elzen et al. 2012, Nissinen et al. 2015a-c).

Focus on the training of extension service advisors should support their paradigmatic shift from former productivist modes of thinking towards facilitating collective action and more participatory learning of practitioners, for instance via strengthening their conceptions of learning and ability of co-innovation based on partnerships of multiple actors in the long term. The role of extension advisors in facilitating the farmers' participation in knowledge production along the modes of participation is significant with the potential for sustaining local action and ownership of the transformation process. The modes of participation (Gibbon 2012)

gradually change from technology transfer to adaptive management, and the transformation not only involves a change of the farm but also change of people, institutions and policies, as noted by Röling & Jiggins (1998, p. 290). The NAP community climate is important in supporting the development of training and extension suppliers in this aspect. Important changes in pest-management strategies cannot be expected by only strengthening regulations and upgrading knowledge without a broader perspective and support from society, as also stated by other authors (e.g. Blackmore 2010b; Blanc et al. 2010; Vänninen et al. 2014).

The role of IPM research in changing the prevailing modus operandi of plant protection practices has been recognised in the evolving operational environment. A challenge for the agricultural research is to build up a dynamic IPM research agenda for Finland to tackle the right problems in a timely way, and to create an extensive contact network to improve the communication channels supporting the collective learning of scientists and practitioners in practical implementation of the co-produced knowledge. For instance, demonstration farms are regarded as a promising means for a holistic demonstration of the ecological and economic benefits of ecosystem services in plant production, but the responsibility of organising demonstration farm activities has not been explicitly addressed to anybody. The demonstration farm approach was tested in practice in the PesticideLife project (Alanko et al. 2013 b).

Whilst the demand of independent extension services is increasing to significantly contribute to the sustainability of crop protection practices, it is noteworthy that the highest academic level of education for agricultural extension services in Finland is run-down, and funding of extension services is expected to be increasingly market-based. The recent agri-environmental support system (EU 2013) allows compensating farmers for the costs of purchasing extension services on plant protection, and there are about 200 advisors registered to provide the farmers with plant protection advice. However, separate roles of publicly funded and private extension was observed as potentially problematic, as the following was wondered:

> "Are there two different actors within the advisory sector in Finland - one partly publicly funded and another produced by chemicals industry and inputs producers? What comes of it?" (V.E.7)

As a contribution to the requirement to further engage the extension sector in the risk reduction goals defined in the NAP, it is proposed that the NAP Steering Committee and Tukes could consider organising refresher courses and networking and discussion events for the advisors, training and certification providers and spray equipment inspectors regularly. Those events could enable networking and improve and maintain the knowledge and counselling skills of training and certification providers, advisors, spray equipment inspectors and researchers, and thereby increase their social capital and advance innovativeness (Iivonen et al. 2011). In addition to strengthening and updating the latest substantial knowledge in plant protection, also improving the communication and counselling skills as well as the understanding of professional learning of social and collective learning theories could be the core of these events. Feedback from a training participant:

> "Networking happened in the training. IPM issues are the best in training events, but then the farmers often know more about many topics than the trainers. The purpose of training should be that the participants discuss and the trainer acts as sparring partner. The participants should be encouraged to interact, discussing their own experiences. There should be a farmers' address in training events, which could be an excellent learning opportunity for the authorities. Hopefully the trainers also acquire knowledge as widely as possible from abroad, and foreign lecturers could also be invited to disseminate the latest knowledge to Finland." (III.E.2)

9.6. Balancing between the three pillars of socio-cultural, economic and ecological sustainability

Although sustainable development in fact requires integration of the dimensions of socio-cultural, economic and ecological sustainability, these pillars are often considered separately, especially in practical governance. The dimensions also intrigued the expert panel participants differently, with an emphasis on economic sustainability of farmers. I therefore first discuss the economic sustainability issues, and then the socio-cultural and ecological dimensions of the NAP. Cohesion and search of a balance between the three pillars of sustainability ideally occurs in fruitful policy programmes aiming to sustainable development.

The stakeholders involved mainly emphasised the farmers' economic sustainability as the basis for implementing the Finnish NAP. The paradigm of economic growth both at private farm and national levels was taken as implicit pre-assumption of economic sustainability. Without achieving economically sustainable plant protection, actions to strive for ecological sustainability are deemed not attractive. This was also highlighted in the Limiting Factors Analysis, where three of the five factors perceived to limit most severely achieving the goals of the Finnish NAP considered economic aspects (as presented in Chapter 5.4.3 in more detail). Similarly, in the media analysis on amending the aquatic restrictions of plant protection products, the main concern of the farmers was that the environmental restrictions should not cause impediments to their livelihood (see Chapter 6.4). Explicit economic targets to be set for the NAP in addition to the current ecological and social targets were viewed as beneficial, but the experts recognised the current limited progress in development of indicators that consider the economic sustainability properly:

> "Environmental [targets and indicators] - yes, and partly also health [ones] from the social side, but where are the economic [ones] lingering?" (VII.C.3)

At its best the IPM was perceived to promote the public relations of agriculture, but the values it was expected to support in the face of the society were essentially economic, highlighting the importance of food security. Respondents' views on the economic sustainability concern primarily maintaining the livelihood of Finnish farmers and ensuring the performance of food chain. Ensuring the availability of agricultural inputs and reducing the impediments of production are main concerns of the production-inclined stakeholders within the Finnish NAP community, just in agreement with the path dependence theory of Arthur (1989; see also Cowan & Gunby 1996; Wilson & Tisdell 2001). Adequate selection of plant protection products on the market at affordable prices and harmonising the authorisation for instance on environmental restrictions of use appeared to be means for seeking the economic sustainability the participants highlighted.

Similarly to our results, motivation for behavioural change towards more sustainable agricultural practices was driven by economic consideration and legislative requirements, even when combined with a strongly negative attitude to highlight its coercive nature (Marchand et al. 2010). Although Hildén et al. (2012) observed the diversification of sustainability discourse in agriculture during the 2000s, economy and profitability of farmers is still considered the main driver for implementing new innovative IPM techniques, and thus the economic sustainability plays a fundamental role in the implementation of the NAP, as demonstrated elsewhere by Lefebvre et al. (2015), van Eerdt et al. (2014) and Wijnands et al. (2014), respectively. For instance in Germany the economic sustainability is mentioned as one of the main elements of the NAP, with significant research funding allocated to this theme (Barzman & Dachbrodt-Saaydeh 2011). Within the public consultation of the draft European strategic research agenda for IPM (C-IPM 2015b-c), most of the comments received highlighted the socio-economic aspects of IPM.

The need for developing appropriate plant protection practices for organic farming was highlighted in the NAP document as an important field of exploration both in the expert opinions and farmer responses of my study. However, initiatives or commitments to organise systematic and longer-term funding for research and development projects to resolve plant protection problems of organic farming did not emerge in the expert discussion. Organic farming was perceived economically more risky compared to conventional farming, thus contributing to its slow expansion. New innovations depend solely on the enthusiasm of a few individual growers willing to take on the economic risk and burden for the functionality and the solutions to emerging problems (Koikkalainen et al. 2011, p. 54). FVO (2014) pointed out that the assumption that organic farming or adoption of IPM principles automatically leads to reduced or zero PPP use and residues is not necessarily true.

The socio-cultural and environmental aspects are less highlighted in the NAP discourse. Although reducing the exposure of vulnerable populations was one of the targets of the European thematic strategy (EU 2006), this aspect raised less interest when the NAP was prepared, and did not emerge during the workshop and expert panel working of my study. Reason to this may be the narrow view on stakeholder groups involved by the experts, as revealed in the stakeholder analysis in Chapter 6.1. While the social, historical and cultural time scale has been emphasised in the transition expected for sustainable agriculture as not a deterministic process but remaining conditioned by different discourses on sustainability (Acselrad 1999, p. 40-41), the lack of discourse on socio-cultural sustainability, like poverty eradication, gender issues and needs of disadvantaged and marginalized groups was recognized in the implementation of the Finnish NAP. The social aspect of sustainability was perceived as least interesting by the stakeholders in the context of crop protection. It was even questioned by some of the respondents, if the socio-cultural questions should not at all be furthered with a policy instrument like the NAP on the sustainable use of pesticides. Although Buttel & Goldberger (2002) showed that gender is unimportant in explaining differences in agronomists' commitment to sustainability and environmental issues, they found that male agronomists tend to have more links with private agricultural industry compared to females, thus potentially framing their performance in education and extension consultancy differently.

Gender issues and the role of women as one facet of the social sustainability are completely implicit in the Finnish NAP, although several authors have argued for taking intersectionality into account in all sustainability programmes (e.g. Elliott 2006, p. 175-177; Reid & Frisby 2008), and the governmental equality programme (STM 2015) is calling for mainstreaming of gender issues in the implementation of all governmental programmes. Circa one third of the labour force in Finnish farms were female in 2013 (Agricultural Statistics of Finland 2014). According to the internal registers of Tukes, one third of the training and certification providers authorised by Tukes were female by the end of 2015. Neither the specific needs of female professional users (e.g. occupational health provisions of female workers in fertile age) nor female amateur gardening enthusiasts (e.g. as buyers of non-professional use products) were actively mentioned in the expert panel working. Limited usability of amenity areas to vulnerable populations exposed to the use of plant protection products in those areas was briefly mentioned as a social issue, but no concrete actions to alleviate this theoretical problem were proposed.

In addition, the short and long-term needs of consumers and the environmental compartments were less highlighted in the discourse on plant protection. The experts did not pay much attention to mentioning separate voices of those affected by plant protection practices, like consumer groups or the environment. Apart from some individual citizens' contacts, the materials did not deal with the stakeholder status of the environment explicitly, and therefore the discussion about the NAP can be characterised more or less anthropocentric. One reason to this may be the absence of environmental NGOs in my expert panel working, and in the social discourse about the PPP use in Finland in general. However, narrow boundary judgements to exclude the social aspects from the systemic intervention of implementing the NAP will lead to an authority-driven top-down approach with ostensible improvement of actual plant protection practices, if the needs of vulnerable stakeholder groups are omitted. Hence the NAP rather becomes a tool for watching the interests of production sector instead of

aiming to protect those affected. It can be interpreted that powerful participants largely support a view that the NAP as a policy programme should preferably not change the status quo of current plant protection practice. Despite increased control being mentioned as a specific type of NAP intervention, the wish to intensify surveillance activities on the use of plant protection products, as expressed in the citizens' communications, is fairly contradictory to the aim of the current government policy of reducing regulatory burden and requirements for the producers that was explicitly mentioned by the professionals.

The experts typically brought out the *innovation champion* perspective (Hildén 2014), meaning the perspectives of prosperous, progressive, skilled ringside farmers, who actively explore and test innovative new plant protection practices and thus act as role models for their peers (in micro-level technological niches before a wider transition is anticipated, as presented by Geels (2002, 2005). However, the participants of the Limiting Factors Analysis workshop (Chapter 5.4.3) found disinterested attitude as an important impediment, which may take root within the farmers' community, if the lower-level performers find the NAP requirements too difficult, complicated and impossible to live out, and therefore feel outsiders. Hence it is a real challenge for the service providers to make the training and advice so attractive, particularly for the lower-performing and less-educated users with less readiness for change, who would probably benefit from it more than the innovative and already high-performers who are able to seek the knowledge by themselves.

Although the goals of ecological and economic sustainability were generally perceived as somewhat contradicting, the potential for mutual benefits was also recognised:

> "[It is proposed to] survey the win-win situations that could bring benefits both for the environment and the economy of the farmers." (IV.A.2)

Despite the ecological sustainability being considered as the main purpose of the NAP, less concern was expressed at the current state of the environment. Apparently the ecological sustainability of plant protection is experienced as generally adequate in Finland, because environmental risks of plant protection have not arisen as a topical concern to the extent to which it is at issue in many other Western countries. The main topics in Finnish discussion about environmental load of agriculture have been the nutrient imbalance and eutrophication (e.g. Hildén et al. 2012) with minimal concern on pesticides, lulling us into a false sense of security that the ecological sustainability of plant protection has already been achieved. So far, weak signals of discovering environmental residues of plant protection products in monitoring studies (Karjalainen et al. 2014) or effects to non-target organisms as bee colony deaths (e.g. Koistinen 2015) have still been very rare and difficult to prove that they have been caused from the use of plant protection products.

9.7. Proposed good practices

During the expert consultations a number of good practices were recognized and proposed to increase the stakeholder engagement in the implementation of the NAP. Table 9.3 summarises the proposed good practices, which are further discussed in this chapter.

Table 9.3. Proposed good practices to improve the NAP implementation

Practice	Description, justification, use	Responsible organisers
Systematic record-keeping, filing and analysis of citizens' communications.	- Analysis of situations where general public seeks advice. - Customer service training. - Organisational learning from actual communication situations.	Tukes All implementing organisations involved. Extension services.
Concerted filing and public availability of all deliverables produced by NAP actors.	- All information produced is available online to all interested parties. - Improves the data exchange. - Requires regular updating to become a reliable data source.	Tukes websites? NAP Steering Committee? IPM portal to be developed?
Concerted communication plan	- Improves internal information exchange and shared commitment of the organisations involved.	Tukes NAP Steering Committee All implementing organisations involved.
Interim evaluation of the NAP	- Listing of tasks completed and outcomes. - Transparent reporting of costs incurred from implementation tasks and projects. - Guides the re-focusing of the NAP, if necessary.	Tukes coordinates. All organisations involved report their own outcomes and preferably also costs.
Introducing quantitative objectives, targets, measures and timetables	- Enables monitoring of outcomes. - Recommended by the FVO and the SUD. - Easy to measure, where possible to set quantitative targets. - Requires policy-level negotiations, e.g. taking a stand on the level of IPM to be desired.	NAP Steering Committee All involved organisations.
Gathering expertise on processes of collaborative learning and co-production of knowledge	- Enables enhanced self-driven change. - Promotes local networking of farmers and extension services. - Improved co-production of knowledge, e.g. producing guidance on notifying the bystanders of PPP sprayings.	Local actors Farmers' organisations Trainers and advisors Research and authorities
Record-keeping on plant protection decisions	- Demonstrates the level of IPM to be applied. - Enables accurate statistics on actual uses.	Local actors, professional users Trainers and advisors

The experts considered important that consumer communication covers both informing amateur users and general public about why plant protection products are used and about the benefits they provide. Systematic filing and record-keeping of citizens' communications would enable a more detailed analysis of typical and problematic situations where the general public seeks advice, information and measures from Tukes. Frequent analysis of topical themes and numbers of references could illustrate the issues intrigued by general public, as indicators of topical talking points of public discourse on PPP use in the society in general. Furthermore, because the officials often considered answering the citizens' references as demanding and tiresome, the files could be

used for customer service training, internal supervision of the officials and development of operations, thus contributing to organisational learning from actual communication situations. In addition to the competent authority Tukes, also other actors involved in the NAP implementation, could benefit of filing and analysis of their citizens' references, and learn from sharing the experiences for instance within the NAP Steering Committee or specific joint training events.

The collaboration of stakeholders in the evaluation was considered essential, in order to increase the effectiveness of the interim evaluation. Arranging the interim evaluation of the NAP was considered useful by the NAP Steering Committee, but preferably with a lighter level of detail compared to the recent interim assessment of National Programme on Dangerous Chemicals (YM 2013): just listing completed and timely tasks as well as a revision of focus areas would be sufficient so far. However, it was perceived that preparation of the interim evaluation should not be assigned to Tukes alone, but the whole network of stakeholders should be involved with different perspectives taken into account. When writing this, the mid-term interim evaluation is in drafting phase (Laitinen 2015b). Transparent reporting of realisation of costs and expected outcomes during the performance and at the ending of completed actions like explorations and research and development projects embedded in the NAP would enable the assessment of resource allocation on competing projects to produce most benefit for society. The starting level of the actors involved should be considered, for instance in evaluating how the deployment of drift reducing sprayer technology has evolved during the programme period.

Concerted filing and public online availability of all deliverables, data, research reports, publications, information materials, leaflets and guidance documents produced as outcomes of the NAP by any of the organisations involved would enhance the communication and evaluation of the progress made collectively. This kind of concerted forum could be for instance at the website of Tukes or the IPM portal under way by the Finnish Plant Protection Association (Vänninen et al. 2014, p. 89). However, to become a functional and attractive tool for knowledge users, resources for the regular updating of data content of the IPM portal should be available. In the currently critical public economy situation, stakeholders worry in general about safeguarding adequate resources for implementation of the NAP actions according to their goals.

The experts urged that the NAP should take a stand on the target level of IPM to be desired, in other words, on which level it is expected to solve the most topical problems (Bellon et al. 2010; Kogan 1998) and to set IPM targets in terms of ecological, social and economic sustainability. For this purpose it is important to follow the international development of indicators for IPM.

In the NAP communication, the collaboration between the independent organisations and actors is essential. Although every organisation is individually responsible for providing information and communicating the achievements of the actions they are involved in, the experts highlighted that collaborative efforts in specific information campaigns could add weight to the messages to be spread. Therefore a shared communication plan between the involved organisations is perceived as a core tool for the NAP Steering Committee. The communication plan is also linked with the interim evaluation of the NAP, and communication to general public should have a role in it. Communication should be planned in collaboration with professional public relation officers of the organisations involved. Improvement of the internal information exchange between the NAP actors was demanded. For instance e-mailing of press releases on plant protection issues could be routinely distributed to all NAP Steering Committee members in advance, and they could in turn forward the material received to their colleagues in each organisation.

Farmers' personal information search strategies are based on the perceived usefulness and usability of information in practical situations and build their information resources in long term (Magne & Cerf 2009).

Modelling of collective processes of sense-making and knowing could be used for supporting practical interventions like IPM uptake or other NAP actions. Knowledge about the methodologies for promoting collaborative learning processes for self-driven change in complex situations (Restrepo et al. 2014) could be useful in this task. Local solutions are core especially in organic farming, thus presuming farmers' networking and new operational models of extension services facilitating collective learning.

One practical example of potentially increasing the stakeholder participation in implementing the Finnish NAP is the action to prepare guidance for notification procedure on how the users should inform neighbours and beekeepers about the spraying events. It was recognised that informing bystanders is a sensitive issue for farmers, while beekeepers are increasingly demanding the information. Therefore bilateral local collaboration between farmers and beekeepers in this issue is necessary, if it is anticipated that the notification procedure is followed in practice to avoid cases of bee poisoning.

The importance of farmers as data providers for use statistics was highlighted. The quality of aggregated statistics depends essentially on the detail and quality of data recorded and reported by individual farmers. Although the likelihood of an individual being sampled for usage data survey is not great, meticulousness of previous record-keeping alleviates the burdensome reporting in case this occurs. The farmers' community could therefore collectively emphasise the accuracy of use record-keeping to portray the whole community's actual knowledge and phase of IPM uptake, and train their members in appropriate record-keeping techniques.

10. Conclusions and discussion

In this final chapter, firstly a synopsis of my key results as presented in Chapters 5-9 is provided in Chapter 10.1. Then a short comparison to other environmental policy programme evaluations and NAPs is made in Chapter 10.2. In Chapter 10.3 I will reflect on conducting participatory research and on my parallel roles as implementer and researcher of the NAP. Limitations and possible sources of error in this study will be discussed in Chapter 10.4, and issues to be considered in conducting practical evaluations are raised in Chapter 10.5. Further research activities will be proposed in Chapter 10.6, and finally, a few concluding remarks are made in Chapter 10.7.

10.1. Synopsis of key results

The practical part of my results is presented in a pragmatic 'cookbook' format as the last Appendix of this monograph. The reason for this approach is to provide those practitioners who prefer a straightforward guidance with practical tools for conducting an evaluation instead of ploughing through the theoretical part of this study (cf. Raunio 1988). Because various stakeholders may identify multiple evaluation needs, one procedure does not fit all purposes and users, and different evaluation forms are proposed for different needs and levels to consider different perspectives, and a range of basic evaluation questions for proactive, clarificative, interactive, monitoring and impact evaluation forms are suggested to cover each of these purposes in Chapter 1 of Appendix 4.

In order to engage the stakeholders and assist in determining their values, expectations and assessments on implementing and evaluating the NAP, a few existing heuristic tools were tested within the expert panel. Four tools are intended to frame the evaluation and assess the achievements of the NAP. The heuristic tools suggested

have slightly different scopes and therefore they can complement each other in practical evaluation situations, but can also be used independently. I propose the twelve questions of Critical Systems Heuristics (CSH), sustainability screening with the National Sustainable Development Strategy (NSDS) framework, Limiting Factors Analysis (LFA) to assess the potential impediments of implementing the NAP, and Systemic Programme Logic (SPL) for explicitly clarifying the programme theory. The heuristic tools are summarised in Chapters 2 and 3 of Appendix 4.

Stating the assumptions of the programme theory explicitly helps the evaluators to consider what is expected to happen within the NAP during its implementation. What are the drivers and causal links that are expected to produce the intended outcomes, the reduced risks as stated as the goal of the NAP? The intervention theory behind the NAP is the (implicit) assumption of the Thematic Strategy on the sustainable use of pesticides (EU 2006), that increasing the knowledge of the users causes change in their behaviour and leads in turn to a reduction of the risks and impacts. Therefore the outcomes of the NAP should capture the evidence of reduced risks and impacts to demonstrate its success, just as the theory-driven programme evaluation literature suggests to base the evaluation on the assumptions about how the programme works. However, different and possibly conflicting expectations of stakeholders and the long time frames needed make it difficult to bring out the outcomes of the NAP. Additionally, the NAP lacks explicit target setting on how much and what kind of reductions in risks and impacts are presumed. So, instead of simply calculating the deliverables, the evaluation tools aim to making the goals explicit, sharpening the programme theory and exploring the data needs based on the realistic expectations of the stakeholders and the resources available during the ten year time frame of the NAP. The programme theory of the NAP community can be inquired by logic models to build the programme logic for the NAP. Tools for this process are given in Chapter 3 of Appendix 4. The final construction of the Systemic Programme Logic (SPL) can then be used as the fourth heuristic tool, as explained above. The SPL framework has specific evaluation points to cover the perspectives of interveners (service providers), participants (users of plant protection products) and their background communities who support the collective learning of stakeholders throughout the system. The evaluation questions presented above are targeted to gather appropriate data at each of these evaluation points.

Providing training and extension services for professional users of plant protection products is the core intervention that is assumed to produce the intended outcomes of the Finnish NAP. As can be seen from the Systemic Programme Logic, training has a focal role to contribute the collective learning of the NAP community. Supportive and pleasant programme climate maintains the positive attitude of both training providers and participants as a key for longer-term impact of participating in training. The pedagogical and facilitation skills of training providers and advisors are thus important in producing services that are perceived as meaningful by the participants and contribute to long-lasting learning outcomes at all four levels of Kirkpatrick (Kirkpatrick & Kirkpatrick 2006). Mog (2004) highlighted sustainable development as an unending process instead of achieving fixed goals, a continuous learning process of participants long after the programme itself has ended. Implementation of Integrated Pest Management (IPM) practices is a topical issue where continuous collective learning and knowledge-exchange is essential to enhance the more systemic view on crop protection. The interventionist individual learning paradigm of conventional one-way classroom lecturing should be challenged by implementing more participatory teaching methods with shared knowledge production and collective learning to make the participation in training attractive for the professional users (Röling & Wagemakers 1998). As the NAP does not place any specific requirements on the pedagogic skills of the training providers, variation is anticipated within the actors. To improve this situation, further training of the trainers could consider also the pedagogic aspects in effective knowledge brokering to allow collective learning for the whole NAP community.

The stakeholders proposed a wide range of measures and indicators of evidence for the specific intervention areas of the NAP (training and extension, specific use requirements, control and surveillance activities, research activities, information and communication, and monitoring). Some of the measures are quantitative and others qualitative, and also practical proposals are given on how the data should be collected for these measures. A few most illustrative measures could be organised as a dashboard of key performance indicators for the NAP. Table 4.1 of Appendix 4 summarises the key measures and data collection proposals. Quantitative indicators alone are not appropriate to measure the goal achievement, as no quantitative targets for risk reduction from the use of plant protection products were set for the Finnish NAP. Therefore qualitative assessment methods may more rigorously portray the transformation process towards more sustainable plant protection practices, provided that adequate resources are available for producing the analysis. Once quantitative indicators on the SUD have been agreed within the EU, they can complete the picture of the evidence.

Several good practices could be identified to enable more deliberate stakeholder participation and communication about the NAP issues. Some of the good practices are already in use and several could be introduced relatively easily. As effective communication about the achievements of the NAP was identified as one core activity, the dissemination of all deliverables produced by different actors to all interested parties would become easier if a concerted forum for this purpose would be available, for instance the planned IPM portal by the Finnish Plant Protection Association (Rajala 2013; Vänninen et al. 2014, p. 89).

10.2. Comparison with evaluation studies about other sustainability programmes and NAPs

The general challenges of policy programmes for furthering sustainability discussed by Mickwitz et al. (2011) also resonate with the NAP. Radical changes in consumption and production take time and require constant and active learning, rather than simply waiting for a miracle to occur. Transformations towards greater sustainability need to be documented and assessed in order to maintain credibility and transparency, and to provide input for the learning process.

Several countries have organised their national programmes for sustainable consumption and production (SCP). The programmes of Finland, Sweden and the United Kingdom are rather collections of diverse proposals for deliberative power-sharing actions than transparent strategies of systemic change, sharing the problem of inadequate governmental commitment with lack of clarity and resources (Berg 2011). Although the Finnish NAP on the sustainable use of plant protection products is only a narrow subsystem of the national consumption and production system, similar patterns occur in both programmes. According to Berg (2012), the Finnish SCP programme has had quite scarce outputs compared to the challenges and visions presented. The programme has been a tool to raise awareness among major actors, with unprompted effects. Its ritual function has been key in renewing policy-making traditions, and key discursive conflicts between efficiency and sufficiency issues and regulation-inclined versus new policy instrument-based governance were revealed. Compared to both Finland and the UK, the Swedish programme has largest percentage share of traditional governmental regulation. As the legally binding requirements are given separately in legislation, the NAP mainly covers actions of ‘new policy instruments’ (Jordan et al. 2005), as was also the case with the SCP. The acceptance and agreement of stakeholders on the NAP actions is therefore crucial for their actual engagement in the implementation of the NAP and for creating a supportive programme climate for the transformation. Honkasalo (2011) described the preparation phases and implementation of the Finnish SCP. The conditions of agreement, strengths and weaknesses are quite similar to what we faced in the preparation of the National Action Plan on the sustainable use of plant protection products. A wide stakeholder participation in preparation ensured a broad acceptance of

the strategies, but made it impossible to agree on any quantitative targets; so the question about evaluating the achievements arose from both programmes. It is vital to provide reliable and easily comprehensible information on environmental impacts, but this alone is not enough to cause a transition towards more sustainable practices. Cost is almost always the overriding factor in decision-making.

An analysis of elements included in the NAPs of a few European Member States is given in Appendix 3. Following the implementation of the SUD in the EU, the Food and Veterinary Office of the European Commission conducted an evaluation of the implementation status of the NAPs of all 28 Member States (FVO 2014b). The NAPs vary greatly in terms of details and take specific national, regional and local conditions into account. The NAPs satisfactorily cover the requirements set in the Sustainable Use Directive, given that this is a new area of legislation. However, there are certain weaknesses that need to be improved during the following revisions of the NAPs. Establishing quantitative objectives, targets, measures and timetables for the risk reduction are areas where the European Commission specifically wishes Member States to improve their NAPs. These issues appear to be consistently among those which the evaluations of various environmental policy programmes and action plans have highlighted as challenging. Barzman & Dachbrodt-Saaydeh (2011) compared the NAPs of five European countries, which had established national plans prior to the requirement of the SUD. Denmark, Germany, the Netherlands, France and the United Kingdom have each developed pesticide action plans as their policy tools, thus representing a model for other countries that just recently started to develop their policies towards sustainable practices in plant protection. The authors specifically assessed the goal setting, stakeholder involvement and the role of research and extension in their study. I have used this study as a basis for my comparison of the Finnish NAP with the five countries. Because the latest revisions of the NAPs were not included in their analysis I have combined data from their study and the current NAPs of the countries in Appendix 3. For the latest versions of the NAPs a reference is made to the Website of the European Commission where the NAP documents of each 28 EU Member States are publicly available in English (European Commission 2015b).

A few Member States already used National Action Plans as a policy tool prior to the implementation of the SUD, whereas for most of the Member States this is the first NAP relating to plant protection products. Some elements of the NAPs have already existed in the practices of several Member States before officially adopting the NAP. It is appreciated that the social, agricultural, climate and soil conditions vary a lot and therefore sustainable use of PPPs cannot be unequivocally defined throughout the EU. The primary goal and aim of the NAP is perceived differently by different Member States, thus reflecting the very different views about what is understood as a sustainable use of pesticides. While certain Member States highlight the protection of human health and the environment against unnecessary load of toxic substances, some others emphasise the need and benefit of adequate chemical plant protection. There are inconsistencies both within and between NAPs in terms of establishing quantitative objectives, targets, measures and timetables. The majority take the view that use reduction does not correlate with risk reduction, and therefore propose risk reduction rather than use reduction targets. Only four Member States give defined targets and timetables for measures to protect the aquatic environment from PPPs. In addition, the resources for implementing the NAPs vary significantly. While some Member States invest considerably to research supporting the NAP targets, others rely mainly on administrative actions without any additional inputs.

Annex III of the FVO evaluation (2014b) lists risk indicators mentioned in European NAPs. Typically, the indicators are activity or outcome indicators calculating numbers or percentages associated to the actions like training, monitoring or IPM introduction, but also more complex indexes are in use in several Member States. The applicability of these indicators and indexes has not been evaluated by the FVO. In some Member States the legally binding provisions of the SUD have been incorporated into the national legislation, and therefore the NAP covers mainly additional, voluntary or optional actions.

Sundgren (2014) explained the policy programmes of Sweden since the 1980s to reduce the risks to human health and the environment from the use of pesticides. In the first programmes, policy goals were set for reducing the use of pesticides by 50-75%, while the target of the later programmes was modified from use reduction to risk reduction, along with the development of appropriate national risk indicators during the 2000s. Adoption of IPM strategies as well as providing educational and advisory services are the core efforts to implement the current NAP in Sweden.

Blackstock et al. (2007) highlighted the focus, purpose and timing of an evaluation in selecting the most appropriate transparent and reflexive evaluation methodologies, when sustainability projects as subjects for evaluation are generally too complex to be captured by one variable, measure or method. Multiple methods and data sources are therefore particularly effective in shedding light on different aspects of empirical reality thus increasing the probability of an in-depth understanding, whereas single method data collection can oversimplify and distort information, and often fail to identify underlying dynamic processes. They concluded that a 'cookbook' approach is inappropriate in the context of participative research evaluation. In Australia, Hajkowicz (2009) highlighted how the initial increase of stakeholder engagement turned to burnout in a voluntary awareness raising programme on sustainable agriculture and consequently led to institutionalised government funded natural resource management organisations, and subsequently to market-based instruments compensating the landholders for the provision of environmental and social services related to agricultural landscapes. According to Jacobs et al. (2012), the likelihood is low that longer-term transformation from awareness to an actual change of behaviour would occur in the participants of environmental information and education programmes without enforceable behavioural consequences for norm adherence. Consciousness of the legal or social sanctions motivates the participants to adopt the intended pro-environmental practices. It can therefore be anticipated that mere information campaigns are not adequate means for reducing the risks from the use of plant protection products, but should be accompanied by appropriate norms and control in order to be effective. Thus, in general, the pursuit of breaking off the environmental regulations is not in line with the goals of programmes that intend to reduce the risks from the use of plant protection products.

Sustainability research benefits from the reflexive scientific practice of co-generation of multiple forms of knowledge between scientists and lay participants jointly. The importance of stakeholder engagement in aiming for the goals of the NAP was proven in this study, similarly to many other studies on sustainability projects and programmes (e.g. Sleenhoff & Osseweijer 2015; Wijnands et al. 2014). The normative implications of participatory research imply ongoing social learning that ought to lead to personal and institutional transformation. Despite my efforts to invite representatives from all main stakeholder groups in the workshop and expert panel working, the NGOs did not participate. A similar pattern was observed by Valve (2002) in her study of implementing European rural policy. My results can therefore be seen as biased in terms of underrepresentation of those affected by plant protection practices but not involved in implementation or evaluation of the NAP. However, other means for data collection were used to catch up the perspectives of the NGOs, so this sector was not left completely aside.

Van Woerkum & Aarts (1998, p. 274) distinguished three patterns of reactions of farmers on environmental policy plans: those not accepting it as a meaningful reality, those who are willing to deal if getting compensated well enough, and those who accept it as an inevitable development of society. Although environmental policy has become mainstream in agriculture in almost twenty years since their results, similar patterns can still be observed in the NAP implementation today. Despite the general emphasis on common cooperation and consensus between the participants involved, the different perspectives of the production sector and protection-inclined actors were distinguishable down the line in this study. The Advocacy Coalition Theory (Sabatier 1998; Sabatier & Jenkins-Smith 1999; Weible et al. 2009) can be applied to explain why these core policy beliefs are still so permanently maintained in framing the discourse on plant protection, while a need for a paradigm shift

is largely demanded to cope with the current sustainability challenge of agriculture. Deliberate and repeated invitation of non-experts to participate in the NAP process by the experts currently involved would probably lead to a more inclusive perception of the stakeholders, and enhance building a climate of mutual understanding of what a sustainable use of plant protection products actually means to different audiences. Different and possibly contradictory opinions between the stakeholders should not be silenced but there should be exploration of whether and to what extent the differences are negotiable, and thus increase the collective learning.

10.3. Reflections on participatory research and on my role as implementer and researcher of the NAP

In this chapter I reflect to my twofold role as a researcher and a participant in the NAP stakeholder community (cf. Cerf 2011). Participatory research should fulfil four conditions as a scientific practice. Firstly, the engagement of participants is based on their expression of the need for change and willingness to clarify it with researchers. Secondly, the scientific interest and care ethic towards those involved and the whole process is the responsibility of researchers. Thirdly, the non-academic participants will be the ones who really take charge of the implementation of the solutions to be developed, and finally addressing the learning process in terms of different forms of conceptualisation by practical and scientific knowledge.

To address these conditions, my research questions emerged from practice and interactions with stakeholders involved. The invited workshop participants and expert panel members are colleagues participating in the implementation of the NAP, and it is in our common interest to collectively learn about how to further the risk reduction endeavours and to find out appropriate means for evaluating these attempts. For the majority of the colleagues this is rather administrative and managerial interests, and therefore the scientific quality of this research is solely my own responsibility. Consequently, this study can be characterised as one type of involved research as defined by Klaedke et al. (2014).

Issues of power are often regarded with some discomfort by researchers because of an implicit assumption of research as a neutral, disinterested application of scientific method (van Kerkhoff & Lebel 2006, p. 466). However, as soon as researchers become concerned with action, decision making and change, power can no longer be ignored as it is intimately entwined with the ability to act. Thus, the issue of power is evidently present in this study. As being involved in the development of the legislation behind the NAP and committed to promote its goals by improving the current practices, I cannot pretend to be neutral. My research tasks included a commitment to find heuristic tools for engaging the stakeholders to the goal of reducing the risks from the use of plant protection products. Essentially I consider the outcome of this study as collectively produced, although being alone fully responsible for writing the monograph.

The participatory approach I chose for conducting this study included several opportunities for the stakeholders to involve in knowledge production and reflection (Heikkinen & Syrjälä 2010). Participation in the stakeholder focus groups and workshop, including the opportunities to comment on the outcomes, attempted to engage multiple perspectives in framing the evaluation of the NAP. Similarly, the targeted communications and inquiries with specific experts and the expert panel working with the voluntary experts in general produced a variety of valuable views to enrich the assessment. The NAP Steering Committee has been informed during the study process, and finally, peer review of the study results with the expert panel produced valuable comments which shaped this report remarkably. However, it must be recognised that the community that actively participates in

the implementation of the NAP in Finland is relatively small and people are well-known to each other. In order to protect their possibility of also expressing critical views without being stigmatised, I handled their responses confidentially to ensure their anonymity. Therefore only a limited number of direct quotations were included in the report, and some were slightly rephrased to make them unrecognisable, for instance by excluding references to their employers. The purpose of exploring boundary judgements with the expert panel participants was to surface between the perceptions about an ideal world (how things ought to be) and a realistic situation (how they really are and what is possible) in line with the Critical Theory of Habermas (1987; Huttunen 2010; Huttunen & Heikkinen 1999) and Galtung's trilateral science (1977). The non-participation of NGOs in the workshop and expert panel working may possibly be explained by how we as experts unconsciously can patronise the non-experts by leading the discourse to happen between practitioners, where those affected but not involved can easily feel not being heard and withdraw from the discourse or not even wanting to participate at all.

Reid & Frisby (2008) requested researchers to be explicit in how gender and other intersectionality issues are taken into account when deciding on research questions, collecting and analysing data, and deciding upon action plans. Although the NAP does not mention any specific intersectional needs in plant protection, the topic was touched on in a few responses from the stakeholders. For instance the rural laypersons living in the neighbourhood of agricultural fields recognised pregnant women and future generations as important stakeholder groups that have specific interests in evaluating the sustainability of plant protection practices, whereas we still have a prevailing conception of male farmers as professional users. It is also notable how the gender of agronomists may frame their performance in education and extension consultancy differently, as concluded by Buttel & Goldberger (2002). We should consider what collaborative processes are in place and could be created to build relations and work across genders in the implementation of the NAP.

Sulkunen (2006b) claimed that the expansion of a project evaluation management complex has caused a re-emergence of research in politics, where the scientist's role as an expert has shifted from planning activities to evaluating projects and programmes financed by public administration and public funds, thus requiring accountability evaluation. The expectation is that ideas that can later be established as best practices are sieved out from among all the new ideas. However, evaluation researchers are usually called in too late, when the project or programme already is ongoing and consequently not planned in a way that opens it up for a proper evaluation of its results (p. 39). Contrary to this view, our collective effort of knowledge making and collective learning on the NAP at this stage may help us to introduce best practices we identified during this study already when the programme is still ongoing.

10.4. Credibility, limitations and possible sources of error

There is limited consensus about the criteria for assessing the quality of qualitative research among different researchers, and therefore a range of variable approaches and criteria have been proposed. Creswell & Miller (2000) summarised validity procedures for assessing the credibility of qualitative research from the perspectives of researcher, study participant and external reviewer. In Table 10.1. I explain how these criteria were considered in this study, in the light of other authors' views on specific aspects of the scientific rigour of qualitative research.

Table 10.1. Fulfilment of credibility criteria of qualitative research in this study.

Criteria	Source	Details of criteria	Evidence in this study
Triangulation	Flick 2007, p. 37-53; Patton 1987, p. 161; Royse et al. 2010, p. 95-96	Triangulation of data	I gathered more than one type of data from a range of sources for qualitative analysis: NAP preparatory documents, workshop outcomes, external sources like media, and expert consultations, as explained in Chapter 4.
	Isaac & Michael 1990, p. 92; Saini & Shlonsky 2012, p. 126-127	Triangulation of methods	I used several methods of classical qualitative research to analyse the data: argumentative and discursive content analysis, as well as several soft systems methodologies for making the synthesis of the results, as explained in Chapter 4.
	Hermans & Thissen 2009	Policy analysis methods that differ in focus but are similar in terms of information needs and sources are combined.	To cover more than one dimension of the actor context, argumentative analysis was used to focus on perceptions, and stakeholder analysis to focus on resources and values.
	Shapiro & Markoff 1997	Content analysis results are related to other measures.	The thematic framework for the content analysis used throughout the study helped to put the results of different analysis into the context.
Disconfirming evidence	Finfgeld-Connett 2010	Systematic sampling Disconfirming evidence	Systematic sampling was used to grasp the opinions of different stakeholder groups. Stakeholder analysis with different stakeholder groups and discourse analysis aimed to provide possibly disconfirming evidence from those affected in addition to those involved.
Researcher reflexivity	Cerf 2011; Heikkinen & Syrjälä 2010; Newton & Parfitt 2011	A reflective, reciprocal and collaborative relationship between researcher, the field and the researched	I have clearly justified all choices made. My twofold role as researcher and implementer of the NAP was reflected throughout the study and detailed in Chapter 10.3.
Member checking, peer debriefing	Flick 2007, p. 33-35	Member checking, peer debriefing	My suspected one-sided view was moderated with involving the expert panel participants into the process of reflective practice, where the stakeholders were involved to critic, comment and discuss the choices we made by member checking, as described in Chapter 4.3.
Prolonged engage-ment	Patton 1987, p. 16-17	Personal and prolonged engagement, persistent observation and collaboration in the field	My professional career as an implementer of the NAP confirms my personal and prolonged (or actually continuous) engagement in the field, as reflected in Chapter 10.3.

Audit trail	Finfgeld-Connett 2010; Flick 2007, p. 135	Maintenance of well-documented data.	Archiving my working files systematically would enable a possible audit trail.
Thick rich description	Gibbs 2007, p. 90-93	Thick and rich in-depth description	The methods were described in such a detail to allow step-by-step learning and facilitating communication of experts and stakeholders and derivation of logically undisputable statements
Further criteria	Finfgeld-Connett 2010	Development of multidimensional theory	The multidimensionality was highlighted with the systems orientation: Soft Systems Methodologies were used.
	Reid & Gouch 2000	Existence of a wide variety of types, genres and forms of qualitative research. Defining view on what research is and should be.	Triangulation of data and methods was used, as explained above. I have reflected on the goals and aspirations of this study to define clearly my own and the NAP community's expectations.
	Geurts & Joldersma 2001, p. 305	Analytic and process criteria for participatory methods of policy analysis	The study is decision-oriented and stimulates broad framing of the evaluation. Broad overview of insights was brought out to allow the integration of scientific data and judgements of experts and stakeholders. Evaluation tools proposed are creatively different, relevant, and internally consistent.

Considering the limitations, compromising between the scientific rigour and administrative pragmatism was necessary in this study. For instance, my work could be criticised on the limited sampling for gathering the material for this study. The number of individuals who actually participated in workshops, focus groups and expert panel working was rather limited and reflected on the population of the implementers of the NAP, and therefore it was necessary to adjust the method of data collection to gather also the perceptions of those affected. It was my conscious decision to rely on working with a smaller number of participants who volunteered to be actively involved in the study process, instead of organising more time consuming interview and survey methods for collecting material from wider populations. The complementary data sources gave me additional insights and allowed the triangulation between data sources and study methods, in line with the methodological pluralism of Systemic Intervention (Midgley 2003). In future, if further research projects are established for evaluating the NAP, larger sampling on the opinions and attitudes of more individuals might be considered using interviewing and survey techniques, depending on the resources available for the studies. My choice of research methods was therefore a compromise based on two points, namely the rather short time period in which I had to conduct this study, and the hypothesis that engaging the stakeholders as much as possible to the development of evaluation tools would already empower the NAP community to collective learning during the first programme period, which would have been unlikely with study methods that alienate the researcher from the community to be studied.

Royse et al. (2010, p. 67) pointed out that for using focus groups in the evaluation the goal is not to have the participants arrive at consensus but to identify and delineate their particular and sometimes divergent needs, which may lead to difficulties in assessing the accuracy of the obtained data, if the views are atypical and biased. Both the variety of insights of participants and their ability to deliberate mutually appreciated outcomes were demonstrated in this study. As the participants were experts in their specific areas of the NAP, they represented the most deeply involved and passionate experts having up-to-date knowledge on plant protection in Finland

and acting as opinion leaders and role models, thus having the power to create and support the vision on how the NAP goals could be promoted in their own organisations. Thus the representation can be seen as somewhat biased, as the disadvantaged groups were missing. However, emancipation could be expected by enabling collective learning of these key persons via systems thinking. The use of Critical Systems Heuristics (Ulrich & Reynolds 2010) in expert panel work explicitly targeted in consideration of the disadvantaged groups even when not necessarily present. Consequently, the expert panel working thereby aimed to enhance building the common understanding of the interdisciplinary, longer-term vision of NAP and delivering it to the peers and colleagues in their own organisations, as highlighted by Senge (2006). Evaluation theorists debate a lot on the superiority of the outsider/insider roles of programme evaluators (e.g. Royse et al. 2010 vs. Fetterman 2003). So, although I take full responsibility for the report, I also consider this study to be a shared effort to provide jointly identified tools for those who will actually take on the task of evaluating the achievements of the Finnish NAP, having either an outsider or insider view on the sustainable use of plant protection products in Finland.

Lacking a baseline of survey data with the users of plant protection products on their attitudes on the risks and impacts prior to the NAP, it is no longer possible to gather comparative information about the possible attitudinal change as a consequence of implementing the NAP. This will limit the weight of evidence of evaluating its outcomes (e.g. Donaldson & Lipsey 2006). Participation in training or passing the examination alone does not mean that the users have permanently changed their plant protection practices towards reducing the risks or better listening to the earthworms and other populations affected. If the baseline is therefore set on the first round of obligatory certifications from 2015 onwards, the attitudinal change could possibly not be observed before the next programme period is introduced. Chen (2005, p. 27) highlighted that people may more likely participate seriously if they receive encouragement and support from their immediate social units as family, peer group, and neighbourhood. Therefore, achieving the intended NAP outcomes presumes a wider stakeholder participation than only the imminent professional users of plant protection products. Martin (2008) recommended making participatory evaluation part of the project from its inception so that participants expect ongoing evaluation. Thus the volume of the research material is rather limited but focused, and allow the analysis within the given time frame.

The NAP is a system explicitly orienting to pre-defined goals and problem-solving via specifically defined actions, which would warrant hard systems problem methodologies to be applied. Based on Flood & Carson (1988, p. 135-136), I grounded the justification of deliberately choosing rather soft systems methodologies in three facts. First, soft systems methodologies are able to better portray the complex nature of the NAP where multiple independent stakeholders may perceive the reality of plant protection differently, thus making the situation more ambiguous to be handled straightforward with the problem-solving tools of first wave systems analysis. Second, measuring and scaling the programme outcomes simply in terms of calculable factors would also be inadequate as an evidence of reduced risks, as illustrated in Chapter 8. Finally, the scales tipped in favour of soft systems methodologies on the basis of my researcher position as an involved participant in implementing the NAP, instead of being an outsider observer. A boundary critique was made in terms of stakeholder analysis, limiting factors analysis and critical systems heuristics, and reflected on with the expert panel. The values of the stakeholders have been investigated using stakeholder analysis, discourse analysis and expert consultations as well as own observations and reflection. Constructing the logic models based on the SSM root definitions made the values of the stakeholders explicit to formulate the programme theory for the NAP.

Participatory action research entails action for improvement of an actual situation. My research problem was to provide the NAP community with applicable tools for the evaluation that fulfil the utility, feasibility and propriety criteria. Based on the feedback from the expert panel participants during the testing phase, the tools presented in Appendix 4 tentatively fulfil the above mentioned criteria until the practical evaluation will confirm the final

judgement. As pointed out by Mickwitz (2003; 2006), complementary use of several methods not only has advantages but is also demanding and resource intensive, and often the necessary competence can only be ensured by having a multidisciplinary evaluation team. As a conclusion, a final assessment on the quality of this study can only be taken once the tools have proven their usefulness in practical evaluation of the Finnish NAP. A long-term commitment on self-reflection and collective learning, preferably using participatory inquiry methods, leads more likely to permanent change and promotes the achievement of the targets at the level of attitudes and values. Castillo-Burguete et al. (2008) highlighted that the hope on a permanent progress in participatory research needs a longer term to flourish, whereas there is uncertainty of achieving the targets in the medium-term and even strong anti-participation in the short-term, which would lead to bias in evaluation if conducted too early in the process.

10.5. Issues to be considered in conducting future evaluations of the NAP

Crano (2003, p. 146) emphasised the consequences of appropriate framing and choice of the form of evaluation to be conducted. Making use of wrong evaluation model often results in a mismatch of research resources and research aims, and can result in evaluations that, at best, are useless, and at worst, misleading. Therefore, collective learning of the NAP community about the evaluation forms and continuous mapping of the expectations of the stakeholders' build capacity for the appropriate use of the evaluation tools in due course. Donaldson & Lipsey (2006, p. 69) defined the standards for an effective evaluation. The utility of an evaluation comes true if it serves the information needs of intended users. The criteria for feasibility are fulfilled if the evaluation is realistic, prudent, diplomatic, and frugal. Propriety criteria include behaving legally, ethically, and with due regard for the welfare of those involved and affected, and the accuracy of an evaluation includes revealing and conveying of technically accurate information.

The possibilities of using both quantitative and qualitative methods should also be considered when appropriate. For instance the Sustainable Use Directive presumes using risk indicators. Despite the recent prolific development and research on the field of risk indicators, there are still fundamental problems with their practical applications in policy-making, and no jointly accepted and harmonised risk indicators are available within the EU that could solve the problem of commensurable measurement of overall goal-achievement in all Member States. All indicators available so far have their specific limitations, and the problems in collecting data (e.g. the resource-intensiveness required for calculating them) have been identified in several countries (e.g. Lyytimäki 2012b; OECD 2015; Räsänen et al. 2013a).

Emmelin & Lerman (2008, p. 481) discussed the applicability of Environmental Quality Standards (EQS) as measures of environmental policy objectives. An important tool in ecological modernisation is environmental policy integration and thus the use of management by objectives (MBO). The role of action programmes is complicated in relation to MBO. The central idea of MBO is to allow actors at lower levels to choose both their strategies and programmes of application and the tools and methods of doing so. The problem with EQSs is that they are aimed at no specific actors but merely signal demands for environmental quality, be it desirable or minimum acceptable quality. In other words: by being aimed at everybody they are in fact aimed at nobody in particular, and thus blurs the accountability questions.

Taken the resource limitations the participants have brought out in the Limiting Factors Analysis (Chapter 5.4.3.) and demonstrated by the case studies of cost-effectiveness calculations in Chapter 5.4.2, only a limited number of projects and actions are realistic to carry out at any one time. Hence the NAP Steering Committee might

benefit from longer-term planning of strategic target-setting and selection of most topical issues to be promoted beyond the programme period, instead of simply listing various research needs without any links to a greater picture. A lack of links to longer-term visions has been recognised to consolidate the development of Finnish agricultural system with preconditions of environmental policies directing the agricultural and environmental research to create a solid knowledge basis for the NAP. Transition management requires long-term thinking over generations (at least 25 years) to focus on collective learning processes to bring about systems innovation alongside system improvement in society (Rotmans et al. 2001). The results of research are not available and the innovative IPM solutions are not adopted in practice in the short-term, and the effects of the transition to be visible as improvements of environmental quality require long time frames. It is therefore not considered adequate to measure the NAP actions on a yearly basis or even in terms of the whole programme period, but longer time frames, if a technological transition towards more sustainable plant protection practices is anticipated as the general outcome of the NAP.

10.6. Proposed further research activities

In order to gain scientific evidence of the achievements of the NAP, further research is required. As demonstrated in Chapter 8, the study area is so multifaceted that it is impossible to gather evidence by using research methods from solely natural or social sciences, but multidisciplinary, integrative research approach is necessary. Several proposals for further studies are drafted below. These proposals are not meant to be extensive, but rather as examples of research needs discovered. Taken that funding for integrative environmental and agricultural research is limited, it is not anticipated that everything could be studied at once, but the projects could build an integrative research programme for creating evidence in the longer term.

To gain empirical data on how certain NAP interventions actually influence the behaviour of PPP users, research in experimental setting could be drafted for inquiring the influence of received training and extension on crop protection decisions of particular users in terms of the quality of their adjacent environment. In spirit of the findings of Kreuger & Nilsson (2012), such study project could test the significance of personal advice on cautious working practices adjusted to site-specific conditions as a key to reducing the aquatic load of plant protection products, which could be measured by intensive monitoring *in situ*. The impacts of particular risk mitigation measures, drift reducing spray equipment, personal protective equipment and alternative crop protection methods introduced at local farm scale could be studied with regard to local environmental quality. For instance aquatic concentrations and development of biodiversity in a specified study area could be linked to the practical crop protection choices and IPM practices under actual conditions, if voluntary farmers would be available for this kind of experimenting, willing to share their experiences with researchers. Even the sampling could possibly be organised by the farmers and local residents, in order to engage them to the research.

Several data gaps in IPM knowledge have been recognised in the NAP implementation. To cover these gaps, the Finnish IPM research programme is under way to be created along with the EU wide C-IPM-Eranet project (C-IPM 2015a-c). One of its aims is to turn to more holistic grower-friendly research design for direct participation and added value for the farmers. There is a need to a paradigm shift. In addition to producing biology-based solutions to specific plant protection problems, a demand for social scientific research is recognised, thus setting the experts and other stakeholders and their practices as research objectives as to study linkages between knowledge production system and operations models for dissemination of research findings to extension, that contributes to or impedes the sustainability change of farming practices (e.g. Lamine et al. 2010; Hubert et al.

2012). A need for research on training and participatory co-production of knowledge is widely recognised. For instance the *turn from conventional to IPM practices* could be analysed using the on-farm record-keeping before and after the date of obligation to implement the IPM practices in 1.1.2014. The sampling for this kind of study should, however, be done urgently before the previous recordings will be disposed.

In the development of new innovative IPM methods, econometric cost-effectiveness analyses of alternative plant protection choices and lines of production take increasingly into account the externalities to the environment and society to discover means for breaking out from the path dependency of chemical plant protection paradigm. Such studies have been published internationally (e.g. Wilson & Tisdell 2001), but comparative cost-effectiveness calculations of alternative plant protection choices in Finnish conditions are less abundant. This is therefore clearly an area where further research is welcomed to build a solid ground for assessing the level of IPM intake readiness and achievements of the NAP goals.

By now the studies on *risk indicator development* in Finland have mainly served rather general policy assessment purposes than learning about individual choices at farm level. As first steps for developing such assessment tools for Finnish conditions, Räsänen et al. (2013a, 2015) recently tested the EU-wide HAIR2010 indicator and a Life Cycle Assessment (LCA) tool to estimate the aquatic ecotoxicity from PPPs in Finland. Their tools appear to be promising for a nation-wide or regional analysis, but since they are using quite complicated calculations, they may not be applicable to assess individual decisions at a local farm scale. Because the indicators developed so far require quite a lot of scientific data and knowledge, their applicability in practical use situations is limited. Therefore further exertions are proposed to develop simple farm-scale indicators for Finnish conditions to be used by farmers and advisors in assessing and comparing IPM decisions and PPP choices. In addition to the environmental performance of plant protection solutions, the benefits from ecosystem services to the farmers could also potentially be included in the indicators. Further research efforts for developing farm-scale indicators to assess the environmental performance of the plant protection decisions would benefit farmers' and advisors' collective learning on IPM solutions. In addition to a higher level conceptual use of risk indicators as a tool for assessing the effectiveness of policy options (e.g. OECD 2015), the sustainability of on-farm crop protection practices could be assessed with indicators that allow for comparisons of individual plant protection decisions under local conditions. In projects on indicator development, the participation of stakeholders could be considered in the selection process and adoption of appropriate indicators to foster knowledge acquirement and social learning that leads to changes in attitudes within users' communities (cf. Wustenberghs et al. 2012). In the process it is important to apply the indicators to local conditions (Calliera et al. 2013a). In any case, development and application of appropriate indicators would require persevering research contributions and adequate resources to materialise.

There is still room for increasing the knowledge base on the *fate and behaviour* of plant protection products in the cold northern environment. Specific properties of different chemical types are variable and our northern climate and soil conditions (including the consequences of climate change) make it usually impossible to extrapolate the data from other chemicals or other regions (Stenrød et al. 2016). In addition to the evolving northern zone research cooperation, investing in this kind of research is also our own national responsibility.

Although the agricultural research has mainly focused on conventional farming so far, organic farming has a reputation for pioneering innovations, and it just goes to show how it is possible to survive without chemical plant protection. Research projects to compare and learn from the two branches of farming would mutually benefit the knowledge system on ecologically sound farming practices. Besides IPM, there is a need to cover organic farming explicitly in the research efforts (C-IPM 2015a-c). Significant funding investments on organic farming research would also benefit conventional farming enabling the two branches to learn from each other.

10.7. Concluding remarks

The purposes of this study were twofold. I have exposed myself and hopefully also the rest of the NAP community to a learning process on building capacity for evaluating the outcomes of the Finnish NAP on the sustainable use of plant protection products, by searching for appropriate qualitative tools for conducting such evaluations, and testing them in concert with the expert panel volunteers. The engagement of grassroots level individuals was highlighted, as actually producing the outcomes and impacts in their plant protection practices and as perceiving the risks. While administrative decisions are taken at higher levels, the skills and responsibility of users is the key of reducing the risks. As pointed out by Ehrlich et al. (1999), increased knowledge production and awareness-raising as such do not alleviate the environmental problems, unless the stakeholders explicitly commit themselves to transformative policy interventions as the NAP. Taken that there are no quantitative targets set in the Finnish NAP, my research problem was how to evaluate if the sustainability of plant protection is achieved overall. The research problem was approached with seeking answers to five more specific research questions along the evaluation cycle, the first of which describing the Finnish NAP in terms of systems thinking methodologies and the second inquiring the expectations of the stakeholders on the goals and implementation of the Finnish NAP. Thirdly, practical evaluation procedures and heuristic tools were tested and proposed for conducting the evaluation, and fourthly, possible measures and indicators for evidence of the achievements were discovered. Finally, the means for stakeholder engagement to strive for the goal of reducing the risks from the use of plant protection products were analysed to answer the fifth research question.

Because I participated in the Finnish delegation during the preparations of the Sustainable Use Directive and the Finnish National Action Plan, my role as researcher was not an outsider observer's but guided by my own interest in the transformation. Divergent purposes and aims of different stakeholders were revealed, illustrating the NAP as a complex societal system. Therefore a systemic view was generated, resulting to a proposal for appropriate evaluation forms, evaluation questions and heuristic tools to assist the practical evaluation of the national action plan. Collecting and analysing the evidence in different sectors calls for applying methods of a range of disciplines, and understanding the whole requires an integrating approach. Participation of the stakeholders in the evaluation process should allow the empowerment of the NAP community to state their expectations and to take into account also those affected but not involved more explicitly in developing strategies for achieving the risk reduction targets more consciously.

The heuristic tools fulfil the scientific criteria embedded in the framework of environmental policy analysis, sustainability research, systems thinking and evaluation research. I hope that using these evaluation tools would be applicable to assist the NAP community to explore the values and perceptions of different stakeholders and to frame their evaluations according to different purposes and uses identified and depending on the resources and time frames available for evaluating if the general sustainability goal of the NAP to reduce the risks from the use of plant protection products will be achieved. If the scope of the framework directive will be extended to biocides in future, the procedures and heuristic tools might be adjusted for setting the national targets for biocidal uses as well.

Finally, I am grateful for the opportunity for conducting this study and would like to emphasise the pleasant and supportive NAP programme climate that made my personal learning experience so enjoyable. I hope that a similar programme climate will prevail within the whole systemic programme logic of the NAP to support all implementers and participants to make their collective learning experience as pleasant as I perceived it during this process.

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Appendix 1.

Priority areas, timetables and responsibilities for the measures and key tasks of the Finnish National Action Plan on the Sustainable Use of Plant Protection Products

(Working Group Memorandum MMM 2011:4, pp. 31-35)

Phase 1, 2011-2014

Priority Area	Measures/Key tasks	Responsible parties
IPM	Preparation of crop group-specific IPM guidelines by updating the current 'balanced plant protection' guidelines, and awareness-raising among farmers regarding the new guidelines. Investigation of non-chemical pest management alternatives. In particular, knowledge of natural enemies of pests is to be improved and suitable conditions created to promote their use. Promotion of research projects targeted at biological pest management. Development of farming methods and systems that minimise pest occurrence, e.g. use of natural enemies. Determination of threshold values (action thresholds) for pest control, the viability of forecasting systems, and decision criteria for weed control. Ensuring the continuation of national IPM information services as an integral part of the performance guidance of expert institutions.	Finnish Safety and Chemicals Agency Tukes, Natural Resources Institute Finland Luke, Finnish Plant Protection Society KSS
Training	Preparation of a training programme and training material for users, retailers and advisors of plant protection products, taking into account the subjects listed in Annex I of the Sustainable Use Directive. Account shall be taken of the following: - Training is required for a wider group than at present and must be differentiated for different production sectors. - Training of sales personnel: · Personnel must be available at the time of sale to provide adequate information to customers as regards use, risks and safety instructions to manage those risks. · Sufficient information and/or guidance should be provided to all buyers of plant protection products. Retailers play a key role. In the sales situation, it should be possible to clarify for	Tukes in cooperation with other authorities, industrial organisations, retailers, NGOs and advisory organisations within the sector.

	home gardeners the risks of using plant protection products and to steer consumer choices towards safe products or alternative methods. The above also applies to online sales. - Development of tailored training for landscape workers. - Adequate trainer competency is to be ensured. Demonstration of competence by means of training/educational background or qualifications, or by means of online training resources followed by a competence-based examination (e.g. online examination). - Inclusion of IPM in the training. - Training supervision. - Inclusion of occupational health and safety in training aimed at users, retailers and advisors of plant protection products. - Control/auditing of inspections by spraying inspectors. Addition of this measure to the TUKES monitoring plan.	
Spraying technique	Determination of how spraying techniques can be used to reduce spray drift, so that restrictions can be adapted according to the technique employed. Determination of alternative washing methods for different sprayers (e.g. biobed, wash tower). As agri-environmental support only covers tractor-mounted sprayers and self-propelled sprayers, an investigation of other existing sprayer types and test methods should be conducted, and an inspection programme/procedures should be developed for sprayers and for test methods.	Tukes, Luke
Information	Preparation of an action plan for the provision of information, guidance, advice and training on plant protection products. Monitoring and control and provision of information on counterfeit products and other illegal plant protection products. Improved monitoring and control and provision of information on origin labelling of plant protection products. Organisation by retailers and Tukes of the collection of plant protection products that have been removed from use and from the Plant Protection Product Register. Regular information campaigns on the storage and disposal of plant protection products are to be implemented. (An awareness-raising campaign on responsible disposal of plant protection products removed from use was launched by Evira in spring 2008. Information on the campaign is available at the Evira/Tukes websites and in brochure format.) Preparation of plant protection product storage guidelines for farms. Information campaign: more effective use of residue monitoring results in communications.	Tukes, Finnish Food Safety Authority Evira, cooperation partners

	Determination and preparation of guidelines for farmers on procedures for notification to their neighbours, for example to beekeepers, of the use of plant protection products.	
Worker and user protection	Inclusion of home gardener exposure in operator exposure assessments. Only products requiring minimal personal protective equipment are to be approved for non-professional use.	Tukes
Environ-mental protection	Adequate environmental monitoring of plant protection products. Setting of environmental quality standards (EQS) for all plant protection products on the market. Investigation of the potential for a transition to a risk-based approach in the determination of product-specific water body restrictions.	Finnish Environment Institute SYKE Tukes, SYKE Tukes, SYKE
Agri-Environ-mental support	Investigation of the potential for the use of conditions for agri-environmental support to encourage farmers to adopt the use of buffer zones with permanent plant cover near water bodies in order to reduce the risks of plant protection products. In addition, investigation during preparations for the new programme period beginning in 2014 of the potential of agri-environmental support to encourage farmers to protect groundwater more extensively and in different ways. Investigation of the feasibility of the use of permanent plant cover and buffer zones of sufficient width in reducing the risk to aquatic organisms of plant protection products. Promotion of diverse crop rotation to be investigated during preparations for the new programme period beginning in 2014.	Tukes, SYKE, Ministry of Agriculture and Forestry

Phase 2, 2015-2017

Priority area	Measures/Key tasks	Responsible parties
Organic production	The advancement of national basic and applied research into organic production in order to develop sufficiently reliable organic protection methods to address more challenging plant protection problems and to advance current knowledge of preventive methods in organic production. Determination of the potential for better harmonisation within the Baltic Sea region of substances covered by Annex II (Pesticides — plant protection products) of the Organic Regulation and of substances included in the Finnish Plant Protection Product Register.	Research organisations, advisory organisations, Finnish Association for Organic Farming (Luomuliitto ry)

Environ-mental protection	Adequate environmental monitoring of plant protection products. Identification of possible nationally problematic plant protection products. Application of comparative assessment to these products as far as possible, with the objective of future replacement of certain environmentally problematic substances. Investigation of the effects of changing cultivation techniques (e.g. direct sowing) on the use and rates of application of plant protection products.	SYKE Tukes Luke

Phase 3, 2018-2020

Priority area	Measures/Key tasks	Responsible parties
Indicators	Development of means for transferring parcel-specific data on the use of plant protection products by holdings to a common database, and clarification of right of use principles concerning holding-specific information. Analysis and preparation for implementation of EU risk indicators. Implementation of Community-level indicators once an agreement is reached on the most viable indicators for use. Until this, existing national indicators will be used. Monitoring of plant protection product residues in domestic foods will be continued.	Luke Tukes, Luke Evira
Worker and user protection	Investigation of means of gathering information on acute poisoning incidents and, as far as possible, chronic poisoning incidents related to plant protection products. Investigation of the development potential of current techniques of plant protection product use (product dilution, sprayer filling and product application).	Tukes Tukes, Luke
Green areas	Assessment of viable biological pest management methods for the eradication of invasive species such as hogweed. Identification of effective weed control methods for green areas, e.g. assessment of alternative ground cover materials.	Luke
Environ-mental protection	Adequate environmental monitoring of plant protection products. Clarification of the criteria used by other EU countries for the determination of groundwater restrictions; plant protection product use vs. groundwater areas.	SYKE Tukes, SYKE

Appendix 2.

Calculations of the total expenditures of two implementation projects of the NAP

Table 1. Total expenditures of the NAP implementation project on development of aquatic buffer zones based on the risk assessment of separate plant protection products in 2011-2014. The details of the project are discussed in Chapter 5.4.2. Two different methods for calculating the salary costs were used, as explained in the text. The final figures are rounded for conveniently illustrate the level but not the exact total costs.

Item of expenditure	**Calculation basis**	
Working hours	total allocated to the project 111KSM008 in the working hour recording system of Tukes equivalent to ca. 1.6 man-year	2540 h
Monthly salary Day salary Hourly salary Direct salary costs	mean salary with obligatory social charges in 2011-2013 4940 € per month average of 21 working days per month: 235 € per day average of 7.25 working hours per day: 32.40 € per day 2540 h x 32.40 €/h	 82 000 €
Indirect costs	2540 h x 62.50 €/h	159 000 €
Other direct costs	meeting costs etc. and miscellaneous	600 €
Total costs		242 000 €
Hourly salary based on absorption cost pricing	Tukes fees under public law: indirect costs incorporated	95 €/h
Salary costs	2540 h x 95.00 €/h	241 000 €
Other direct costs	meeting costs etc. and miscellaneous	600 €
Total costs		242 000 €
Authorisation decisions amended	all PPPs on the market in Finland, where outdoor uses and hence exposure of surface waters are assumed	261 products
Workload per product		10 hours
Cost per product		900 €

Table 2. Total expenditures of the NAP implementation project on preparation of a training and certification system for professional users, distributors and advisors of plant protection products in 2013-2014. The details of the project are discussed in Chapter 5.4.2. Two different methods for calculating the salary costs were used, as explained in the text. The final figures are rounded for conveniently illustrate the level but not the exact total costs.

Item of expenditure	**Calculation basis**	
Working hours	total allocated to the project 132KE013 in the working hour recording system of Tukes equivalent to ca. 0.61 man-year	977 h
Monthly salary Day salary Hourly salary Direct salary costs	mean salary with obligatory social charges in 2013 5090 € per month average of 21 working days per month: 242 € per day average of 7.25 working hours per day: 33.40 €/h € per day 977 h x 33.40 €/h	 32 600 €
Indirect costs	977 h x 61.60 €/h	60 200 €
Other direct costs	preparation of educational video material ordered from a consultant	50 800 €
Total costs		143 600 €
Hourly salary based on absorption cost pricing	Tukes fees under public law: indirect costs incorporated	95 €/h
Salary costs	977 h x 95.00 €/h	92 800 €
Other direct costs	educational video material ordered from the consultant	50 800 €
Total costs		143 600 €
Authorisations of training and certification providers	117 training organisers including 102 certification providers trained and authorised by end 2014	117
Workload per training provider		8 hours
Cost per training provider		1200 €
Workload per training participant (by end 2014)	4500 training participants by end 2014 (number increasing from 2015 onwards, when the certificate becomes mandatory to all professional users)	0.2 hours
Cost per training participant (by end 2014)		32 €

Appendix 3.

Key elements of the NAPs in five countries compared to Finland

The data refers to Barzman & Dachbrodt-Saaydeh (2011) and the current NAPs of the Member States, available at http://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/national_action_plans_en.htm

	DK	DE	FR	NL	UK	FI
Overall target	40% reduction in Pesticide Load by 2015.	30% reduction of risks by 2023; MRL exceedings <1% by 2021.	50% reduction in pesticide use in 2008-2018. Use reduction of 53 particular active substances by 2010.	No specified overall target. WFD objectives met: no EQS and drinking water limit exceedings by 2027.	No specified overall target. Six separate action plan groups define their own targets.	No specified overall target.
Indicator	Treatment Frequency Indicator (TFI) 2007-2011, Pesticide Load Indicator (PLI), Area Load (AL)	Set of 28 indicators, including SYNOPS + treatment index + PIX (=plant protection index)	Number Of Dosage Units (NODU)	HAIR2010 National environment indicator NMI-3	Regulatory: PIAP + WIIS. Set of 36 sector-specific indicators under develop-ment.	Sales and use statistics according to Regulation 1185/2009/EC. MRL exceedance statistics. National environmental risk indicator.
Stakeholders in process	Enlisted voluntary farmers, experts from different stakeholder groups involved.	"Relevant groups of stakehol-ders" not explicitly mentioned.	Building partnership between stakeholders. Farmer survey.	“Polder model” (Schreuder 2001) with remarkably diverse set of stakeholders.	Public consul-tation, Voluntary Initiative	Stakeholder organisations invited to ministerial task force and consulted before finalizing the draft.

Responsible actors	Steering group comprising of representa-tives of ministries and agencies. Multi-stake-holder committees for local and technical issues.	Federal government, federal states, stakeholders	National committee with represen-tatives from government, research, farming, training and extension, industry, two NGOs. Expert committees for technical issues. Regional monitoring committees.	Government, private sector, civil society organisations, regional networks.	Government, Pesticides Forum is a multi-stakeholder group with separate standing working groups. Stakeholders independent from govern-ment have significant responsi-bilities in imple-mentation.	Competent authority, other authorities, research institutes and farmers' organisations have specific tasks. Steering group comprising of representatives of stakeholders.
Agreement	Joint political agreement with govern-ment and opposition parties.	Agreement following consulta-tion. Certain NGOs disagree.	Presidential commission. Expert institutions involved.	National Agreement incorporates recommen-dations from NGOs and the private sector. Public consultation. Certain NGOs disagree.	Agreement following public consultation.	Consensus of the ministerial task force following consultation of the stakeholders. No explicit disagreement.
Main elements	To protect the general public and nature against unneces-sary toxic substances.	"Necessary minimum" PPP use provides benefit to the society as a whole.	Reducing the dependence of cropping systems on chemical plant protection products.	Supply chain approach comprising actions throughout the plant production chain.	Six separate action plan groups. Regulatory burden on businesses kept to a minimum: stakeholder organizations responsible for non-regulatory initiatives.	Reducing risks to human health and the environment, raising awareness, promotion of IPM, introduction to comparative assessment.

Main actions	Cross-sectorial initiatives: strict approval of pesticides, ground-water protection initiatives, food safety, increased control, research. Areas of specific interests: IPM, uses on amenity areas, home gardens	Research, IPM, organic farming, ensuring availability of PPP, risk mitigation, monitoring	Develop-ment of indicators, knowledge transfer, IPM, training, surveillance, Overseas Departe-ments, non-agricultural areas.	According to the articles of SUD: training and certificates, awareness-raising, inspection of equipment, drift reducing techniques, closed water systems in glasshouse horticulture, monitoring, promoting IPM.	Regulatory measures + non-regulatory, voluntary measures: financial, industry standard schemes, training, advice, monitoring.	Monitoring of residues in food and in the environment, training and certification of professional users, inspection of spray equipment, risk mitigation measures to protect the environment, promoting IPM, information campaigns.
Role of research	Focus on economic sustaina-bility.	Long-term field experi-ments provide evidence for the policy-making.	Focus on economic sustainability. Long-term field experi-ments provide evidence for the policy-making.	Boosting entrepre-neurship and innovation in general. Research proposals not explicitly specified.	Govern-mental research funding programme (Defra). Focus on Biopesticides Scheme since 2006.	Focus on IPM methods and techniques. Several R & D proposals depend on external funding.
Role of extension	Farmer-funded experience groups, collective learning	State advisory services in collabo-ration with farmers.	50 experi-mental sites, 800 partici-pating farms.	Regional networks of stakeholders disseminate practical solutions.	Advisory services offered by non-govern-mental sectors, support from the govern-ment.	Advisory services offered by non-govern-mental, but farmers not obliged to utilise. Incentives to the use of advisory services.

Evaluation / reporting	Yearly evaluation. Stakeholder committee is responsible for joint assess-ment.	Yearly PIX. Reporting every 4 years. Scientific Advisory Board.	Yearly calculation of NODU.	At the end? No explicit reference to reporting.	Yearly report by Pesticides Forum.	Mid-term evaluation in 2015-16, final evaluation in 2020.
Timescale	1990-1997-2000-2009-2012-2018	2008-2011 2012-2015-2018-2023	2008-2018	1990-2000 2001-2010 2011-2013-2018	1996-2010-2013-	2011-2020.
Achievements	Reduction of the TFI from 2.45 to 2.0 and further to 1.7 was achieved in 10 years. Introductio n of pesticide tax.	Extensive research basis via long-term experiments.	Mobilising local actors.	85% reduction in surface water impacts from 2004 to 2010.	Effective information distribution and reporting. Periodic public consultations. 10 new biopesticides registered since 2006.	Training and certification system set up. All tractor-mounted spray equipment tested at least once since 1996. Crop-specific IPM principles under development.
Financing	11 M €/year, revenues from the tax.	Not specified.	Not specified.	Not specified.	Total not specified. 200 000 €/ year on Biopesticides Scheme alone.	Estimated 8 M € / 10 year period, within the government spending limits.

Appendix 4.

Summary on proposed tools and guidance for the NAP evaluation

1. Evaluation questions

Based on three types of systemic evaluation forms distinguished by Boyd et al. (2007) and the criteria for evaluating environmental policy instruments by Mickwitz (2003), evaluation questions for the Finnish NAP are proposed to be used in five practical forms of programme evaluation to be conducted at different states and times of the programme continuum, as outlined by Owen & Rogers (1999). The evaluation questions to these purposes are presented in Tables 1.1 - 1.5.

1.1. Proactive form of the NAP evaluation

Proactive form of evaluation will be used, when a programme is in a planning phase, and it is orientated to inform policy-makers of the current knowledge, priorities and needs of potential beneficiaries and best practices within the policy area in question. Proactive evaluation questions for the Finnish NAP are presented in Table 1.1.

Table 1.1. Proactive evaluation: suggested evaluation questions for the Finnish NAP

Policy level	Suggested evaluation questions	Focus of the evaluation	Clients of the evaluation
National	Stakeholder evaluation perspective: • What do we know about the risks of PPPs and the risk mitigation measures in use that the NAP intends to address? • Who is / should be involved in the risk reduction efforts concerning PPP use? Goal-based evaluation perspective: • What will be the links of the NAP to larger environmental and agricultural policy objectives and sustainability goals? • What do the relevant research and other knowledge tell us about the risks of PPPs and the applicability of risk mitigation measures in general in Finland? • What is recognised as best practice in PPP use? Organisational evaluation perspective: • Have there been other attempts to find solutions to this problem? • What could we find out from external sources to rejuvenate an existing NAP? • Is there a need for a NAP? • Is it possible to foresee the administration, outputs and outcomes of the planned NAP?	Current situation and contexts, policy and goals. Existing infrastructure, skill levels, present and future needs.	Ministries, Competent authority, participating institutions, NAP Steering Committee
Regional / sectorial	Stakeholder evaluation perspective: • What do we know about the risks of PPPs and applicability of risk mitigation measures that the NAP intends to address in specific use conditions? Goal-based evaluation perspective:	Current situation, contexts, policies and goals.	Funding agencies, regional and sectorial planning groups

	• What are the needs and abilities of specific areas and production sectors to participate in risk reduction? • What is recognised as best practice in PPP use in our area / conditions? Organisational evaluation perspective: • Who will be in charge of providing the training, certifications and advisory services in practice? • Where should we see new innovative provisions?	Existing NAP provision, regional / sectorial infrastructure, present and future needs.	
Local	Stakeholder evaluation perspective: • What do we know about the risks of PPPs to us and our environment that the training and certification intends to address? Goal-based evaluation perspective: • What are the needs of individual farmers, production sectors and locations, their perceived benefits and presumed willingness to participate? Organisational evaluation perspective: • How will it be made sure that participants all over the country have equal opportunities to take part?	Current situation, contexts, policies and goals. Existing service design, present and future needs at local / individual level.	Funding agencies, local policy makers, NAP implementers and service deliverers, training and certification providers, advisors, spray equipment inspectors

1.2. Clarificative form of the NAP evaluation

A clarificative form of evaluation concentrates on clarifying the internal structure and functioning of an existing programme or policy, and focuses therefore on its theory or logic, aims to its development and is conducted during its implementation. Clarificative evaluation questions for the Finnish NAP are presented in Table 1.2.

Table 1.2. Clarificative evaluation: suggested evaluation questions for the Finnish NAP

Policy level	Suggested evaluation questions	Focus of the evaluation	Clients of the evaluation
National	Stakeholder evaluation perspective: • What is our underlying rationale (programme logic) for the NAP? • Do our policies provide support for the implementation of the NAP? Goal-based evaluation perspective: • What are the links of the NAP to larger environmental and agricultural policy objectives? • Do the goals of the NAP cover key environmental and health problems caused by the use of PPPs? • What are the intended outcomes and how is the NAP designed to achieve them? Organisational evaluation perspective:	Policy statements Programme information and support	Ministries, Competent authority, participating institutions, NAP Steering Committee

	• What elements need to be modified in order to maximise the intended outcomes? • How does the national infrastructure support the implementation of the NAP in line with the policies? • Does resource allocation reflect our stated objectives and priorities?		
Regional / sectorial	Stakeholder evaluation perspective: • To what degree do stakeholders (individuals and organisations, including the NGOs) accept the NAP as an environmental and health policy instrument? Goal-based evaluation perspective: • What are the intended outcomes within specific production sectors and how is the training and advice designed to achieve them? • How do we disseminate the knowledge on NAP implementation? Organisational evaluation perspective: • Which aspects of the NAP are amenable to a subsequent monitoring or impact assessment?	Programme statements Programme information and support	Regional staff / advisory groups, advisors, training and certification providers, spray equipment inspectors
Local	Stakeholder evaluation perspective: • How do the professional users of PPPs value the expected changes in their attitudes, behaviours and skills following participation in training and/or receiving advisory services? • Is the NAP perceived as plausible and realistic? Goal-based evaluation perspective: • How useful and beneficial do the professional users perceive the training, certification and advice is to them? Organisational evaluation perspective: • Do all participants have equal opportunities to take part?	Programme design Programme design	Programme planners, service providers and administration

1.3. Interactive form of the NAP evaluation

Interactive form of evaluation is used when the purpose is to gather information about the implementation of the NAP or selected activities within it, in order to improve the programme during its implementation. In case the evaluator is insider, the evaluator may also be involved in facilitating change in cooperation with the implementers. Interactive evaluation questions for the Finnish NAP are presented in Table 1.3.

Table 1.3. Interactive evaluation: suggested evaluation questions for the Finnish NAP

Policy level	Suggested evaluation questions	Focus of the evaluation	Clients of the evaluation
National	Stakeholder evaluation perspective: • How could the implementation of the NAP be improved to make it more effective? • What are the strengths and weaknesses of the professional delivery strategies? Goal-based evaluation perspective: • What are we trying to achieve with the NAP? • What are the links of the NAP to larger environmental and agricultural policy objectives? Organisational evaluation perspective: • How could the NAP organisation be improved to make it more effective? • How does the national infrastructure support the NAP implementation?	Processes	Ministries, Competent authority, participating institutions, NAP Steering Committee
Regional / sectorial	Stakeholder evaluation perspective: • Is it possible for those regulated to prepare and take into account the NAP and its implications? • How can we improve the support for the NAP? Goal-based evaluation perspective: • To what degree do the achieved outcomes correspond to the intended goals of the NAP? Organisational evaluation perspective: • Is delivery of training and advice consistent with the NAP?	Processes	Regional staff / advisory groups, advisors, training and certification providers, spray equipment inspectors
Local	Stakeholder evaluation perspective: • Is the delivery of training and advice working? Am I satisfied with training and advisory services I received? What are practitioners doing that is working well? What is not working so well? • Is the training and extension adequately tailored to meet individual needs and expectations? Goal-based evaluation perspective: • From the professional users' view, to what degree do the achieved outcomes correspond to the intended goals of the NAP? Did the participation change my attitudes and plant protection practices as expected? Organisational evaluation perspective:	Processes	Service providers and participants

	• Do all participants have equal opportunities to take part and influence the content of the training and advisory services?		

1.4. Monitoring form of the NAP evaluation

Monitoring form of evaluation is conducted when the management wants to assess if a settled programme is performing successfully, efficiently and effectively in the light of performance indicators. However, there is a growing recognition that quantitative indicators do not in themselves provide adequate evidence on programme effectiveness, but indicator information needs to be combined with contextual knowledge. Evaluation questions for monitoring of the Finnish NAP are suggested in Table 1.4.

Table 1.4. Monitoring evaluation: suggested evaluation questions for the Finnish NAP

Policy level	Suggested evaluation questions	Focus of the evaluation	Clients of the evaluation
National	Stakeholder evaluation perspective: • How well does the NAP reach its target population? Goal-based evaluation perspective: • Does the implementation of the NAP meet the benchmarks of good plant protection practice? • How can we refine the NAP to make it more efficient and effective? Organisational evaluation perspective: • How is implementation going between sites / between production sectors?	Existing policy and related programmes	Ministries, Competent authority, participating institutions, funding institutions, NAP Steering Committee
Regional / sectorial	Stakeholder evaluation perspective: • How are the NAP activities (e.g. training and advisory services, spray equipment inspections) going now compared to previous times? • Are the learning outcomes translated into improved IPM practices? Goal-based evaluation perspective: • Are our costs on providing NAP activities rising or falling? • How are the trends of indicators (e.g. EQS exceedances in surface waters, numbers of tested sprayers etc.) developing in our region / sector? Organisational evaluation perspective: • How do the farmers' organisations and local communities support the social learning of their members who participate the training and receive advisory services? • Are there programme sites or production sectors which need attention to ensure more effective delivery?	Existing policy and related programmes	Regional staff, advisory groups, service providers
Local	Stakeholder evaluation perspective:	Existing programmes	Managers and staff of the

	• How are the outcomes and costs distributed among the local residents and farmers? Goal-based evaluation perspective: • How is participants' economical sustainability developing as a consequence of participation in training and receiving advisory services? Organisational evaluation perspective: • How well does the NAP reach the target population of professional users?		service providers, coordinators

1.5. Impact form of the NAP evaluation

Impact form of evaluation is typically used at the final stage or after a programme has been implemented. The purpose is to assess if its intended outcomes were achieved or not. If the intention of the evaluation is to make a decision about the merit or worth of the programme, this type of evaluation is described as summative evaluation. Evaluation questions for impact evaluation of the Finnish NAP are presented in Table 1.5.

Table 1.5. Impact evaluation: suggested evaluation questions for the Finnish NAP

Policy level	Suggested evaluation questions	Focus of the evaluation	Clients of the evaluation
National	Stakeholder evaluation perspective: • Has the NAP been implemented as planned? • Can the NAP cope with changing conditions of the environment and the society? Goal-based evaluation perspective: • Have the stated goals of the NAP been achieved? • Have the larger environmental and agricultural policy objectives been addressed? • What are the unintended outcomes? • Does the implementation strategy lead to intended outcomes? • Has the NAP been cost-effective? Organisational evaluation perspective: • Do the results justify the resources used?	Existing policy and related programmes	Ministries, Competent authority, participating institutions, funding institutions, NAP Steering Committee
Regional / sectorial	Stakeholder evaluation perspective: • Is it possible to identify impacts that are clearly due to the participation in NAP activities like training and certification? • Have the needs of those served by the NAP been achieved? Goal-based evaluation perspective: • Have there been any unanticipated outcomes, desirable or undesirable, as a result of the NAP? Organisational evaluation perspective: • How do differences in implementation between different sites, service providers or production sectors affect the outcomes?	Existing programme	Policy makers and planners, funding bodies
Local	Stakeholder evaluation perspective: • Are the benefits for participants worth the costs?	Existing programme	Managers and staff of the service providers,

	• How do the residents' and bystanders' risk perceptions develop when the professional users are obliged to certification? Goal-based evaluation perspective: • Did the participants actually change their plant protection practices following the learning in training courses and personal advice? • How does the level of IPM intake develop as a result of participating in NAP activities? Organisational evaluation perspective: • Does the organisation of training and certification and advisory services benefit the users?		clients, NGOs, participants

2. Heuristic tools for framing the NAP evaluation

Because the NAP and its implementation is a complex system, some heuristic tools are proposed to deal with the boundary questions of framing its evaluation properly. Based on the experiences gained from the testing with experts, following heuristic tools are proposed:

- Critical Systems Heuristics (CSH: Ulrich 1994, 2000; Ulrich & Reynolds 2010))
- Sustainability screening using the framework for evaluating National Sustainable Development Strategies (NSDS: Cherp et al. 2004)
- Limiting Factors Analysis (LFA: Gullison & Hardner 2009).

2.1. Critical Systems Heuristics: 12 questions on the implementation of the NAP

Critical Systems Heuristics (CSH) consists of 12 questions which are designed to identify, visualise and critically reflect, and allowing experts and non-experts to discuss the assumptions and normative content underlying a specific solution to a problem. The recent version of the set of questions by Ulrich & Reynolds (2010) was modified for the purpose of evaluating the Finnish NAP and tested with the expert panel. The modified CSH questions proposed to assist the NAP evaluation are as follows:

<u>Boundary issues as the source of motivation</u>: What are the motivating factors to implement the NAP?

1. Whom do we want to serve?

    - Primary clients?
    - Secondary clients?
    - Whom are we unable to realistically serve although ideally we would?

2. What do we want to achieve?

    - Primary aims?
    - Secondary aims?
    - Unrealistic aims?

3. What should be our measure of improvement?
    - Quantitative measure(s) of improvement?
    - Qualitative aspects of improvement?

Boundary issues as the source of control: Who is in control of implementing the NAP?

4. Whom do we want to decide?
    - Those able to stop the implementation of the NAP?
    - Those able to change or redefine our measures of improvement?

5. What resources do we aim to have available?
    - Financial
    - Material
    - Political
    - Social

6. What conditions of success should rightly be controlled by third parties?
    - Public sector authorities
    - Private sector organisations
    - Individual stakeholders not involved
    - Nature
    - Change

Boundary issues as the source of knowledge: What information and skills are relevant for the implementation of the NAP?

7. Whom do we want to contribute their experience and expertise?
    - Indispensable experts
    - Desirable experts
    - Impossible experts
    - Undesirable experts

8. What information and skills do we want them to contribute?
    - Peer experience
    - Professional know-how
    - Professional skills
    - Other

9. Where should we look for some guarantee of success?
    - True guarantors
    - False guarantors
    - Doubtful / potential guarantors

Boundary issues as the source of legitimacy: What stakeholders should be considered in the implementation of the NAP?

10. Whom do we want to voice the concerns of those not involved?

    - Those affected but not involved?
    - Those concerned but not directly affected?
    - Those normally without voice (future generations, non-human environment etc.)?

11. What do we want to do to emancipate stakeholders from our premises and promises?

    - In terms of rights
    - In terms of compensation
    - Other

12. What worldview do we want to rely on /give preference to?

    - Privileged view
    - Clashing views

2.2. Sustainability screening framework (NSDS)

The sustainability screening framework consists of five principles of sustainability to be reflected, with their criteria and explanations as well as ranking. The framework was originally developed to screen the national sustainable development strategies (NSDs), but was modified for the specific purpose of evaluating the NAP and tested with the expert panel. To follow up the progress in implementing a sustainability strategy, its ranking can be repeated from time to time. Please note that the opinions of different experts may vary considerably on the ranking of particular criteria, as shown in the right-hand column of the Table 2.2, where the extremities of current ranking given by the expert panel participants is presented. The ranking is:

- A = all of the requirements of the criterion are fully met;
- B = all the requirements of the criterion are satisfactorily met, although some further improvements are desirable;
- C = some requirements of the criterion have been satisfactorily or fully met, but others have not yet been satisfactorily met;
- D = few of the requirements of the criterion have, as yet, been satisfactorily met.

Table 2.2. Five principles of NSDS sustainability screening, with their criteria and explanations, and the current assessment of the ranking by the experts.

	Criteria and their explanation		Current ranking by the experts
Principle 1. Integration of economic, social, and environmental objectives			**A B C D**
1.	Criterion 1.1 Integration	The NAP is based on a comprehensive and integrated analysis of economic, social, and environmental issues, which clarifies links between the three spheres, resolves conflicts between them where practicable, and negotiates appropriate trade-offs where conflicts remain.	B - D
	Criterion 1.2 Social and poverty issues	The NAP integrates poverty eradication, gender issues, and the short-term and long-term needs of disadvantaged and marginalised groups into economic policy.	C - D
	Criterion 1.3 Environment and resource issues	The NAP integrates the maintenance of sustainable levels of resource use and the control of pollution to maintain a healthy environment into economic policy.	B - D
	Criterion 1.4 International commitments	Measures are in place to ensure compliance with international agreements on environmental and social issues.	A - B
Principle 2. Participation and consensus			**A B C D**
2.	Criterion 2.1 Involvement of stakeholders	The NAP processes of strategic planning, implementation, monitoring, and review include the participation of stakeholders, including government, decentralised authorities, elected bodies, nongovernmental and private sector institutions, and marginalised groups.	B - B
	Criterion 2.2 Transparency and accountability	The management of the NAP processes is transparent, with accountability for decisions made.	C - C
	Criterion 2.3 Communication and public awareness	Measures are taken to increase public awareness of sustainable development, to communicate relevant information, and to encourage the development of stakeholder involvement in the NAP process.	B - C
	Criterion 2.4 Long-term vision and consensus	The NAP processes are based on a long-term vision for the development of Finnish agriculture, which is consistent with our capabilities, allows for short-term and medium-term necessities, and has wide political and stakeholder support.	B - D
Principle 3. Ownership and commitment			**A B C D**
3.	Criterion 3.1 High level government commitment	The process of formulating and implementing the NAP is led by government, with evidence of high-level commitment.	A - B
	Criterion 3.2 Broad-based political support	The NAP process has broad-based political support.	A - C
	Criterion 3.3 Responsibilities for implementation	Responsibility for implementing the NAP is clearly assigned to bodies with appropriate authority.	A - C

	Criterion 3.4 Coordination with sponsors	The NAP process is coordinated with its sources of funding.	B - C
Principle 4. Comprehensive and coordinated policy process			**A B C D**
4.	Criterion 4.1 Build on existing processes	The NAP is based on existing strategic planning processes, with coordination between them, and mechanisms to identify and resolve potential conflicts.	A - C
	Criterion 4.2 Analysis and information	Implementing the NAP is based on a comprehensive analysis of the present situation and of forecasted trends and risks, using reliable information on changing environmental, social, and economic conditions.	B - C
	Criterion 4.3 Realistic goals	The NAP is based on a realistic analysis of national resources and capacities in the economic, social, and environmental spheres, taking account of external pressures in the three spheres.	B - D
	Criterion 4.4 Decentralisation	The NAP process embraces both national and decentralised levels, with two-way iteration between these levels.	C - D
Principle 5. Targeting, resourcing and monitoring			A B C D
5.	Criterion 5.1 Budgetary provision	The NAP is integrated into the budget process, such that its measures have financial resources to achieve their objectives.	C - C
	Criterion 5.2 Capacity for implementation	The NAP includes realistic mechanisms to develop the capacity required to implement it.	C - C
	Criterion 5.3 Targets and indicators	Targets have been defined for key strategic economic, social, and environmental objectives, with indicators through which they can be monitored.	C - D
	Criterion 5.4 Monitoring and feedback	Systems are in place for monitoring the implementation of the NAP and the achievement of its defined objectives, for recording the results, and for reviewing its effectiveness as a strategy for sustainable development, with effective mechanisms for feedback and revision within the planning process.	B - D

2.3. Limiting Factors Analysis (LFA)

Gullison & Hardner (2009) developed a method for finding the likely obstacles relevant for preventing the achievement of the long-term goals of sustainability programmes and projects. In case of a programme or project evaluation, the metaphor of limiting factors refers to obstacles that can prevent a programme from achieving its long-term objectives.

Focus group participants are asked to suggest and discuss factors perceived as most severely threatening the implementation of the NAP in Finland. Individual persons representing a range of different stakes may have different views on the severity of the obstacles, and therefore also the individual rankings can be collected to add the data for the analysis.

Please note that new factors can emerge in the long run. To follow up the progress in implementing the NAP, the scoring can be repeated from time to time.

Table 2.3. Factors recognised by the experts perceived to limit the achievement of the Finnish NAP goals most likely. The limiting factors were organised by subject after the focus group gathering. The scoring of the severity of the likely obstacles is 0 = does not limit in any way, 1 = the problem is manageable, 2 = limits to some extent, 3 = serious impediment to work, 4 = prevents completely the work.

Limiting factors identified by the focus group of experts	**The score of the limiting factors for achieving the goals of the Finnish NAP (0-4)**				
	0	**1**	**2**	**3**	**4**
1. Economy and resource issues					
General profitability of farming					
Cost of introducing new technologies					
Risks of introducing new pest management practices					
Time and workload needed for gathering and applying new knowledge					
Lack of resources for disseminating the new knowledge to farmers					
2. Biological and environmental issues					
Problems in pest observation: use of time, identification of species					
Climate and geographical location					
Lack of healthy propagation material					
Invasive alien species, new pests					
3. Policy issues					
Limited choice of PPPs on the market					
Contradicting goals of legislative requirements and cultivation practices					
Requirements set by clients, e.g. on residues in food					
Changes in financial incentives policies, e.g. removed obligation to harvest					
4. Information and communication issues					
Inability to utilise foreign research					
Knowledge brokering between the responsible actors of the NAP					
5. Attitudinal issues					
Disregard, felt uselessness of investing					

3. Making the programme theory of the NAP explicit

Following the boundary critique conducted by means of the heuristic tools presented above, two tools for formulating the systemic view on the programme theory of the NAP are proposed, in order to make the

underlying assumptions on how the NAP is intended to reach its targets explicit. The logic model framework based on W.K. Kellogg Foundation (2004) and Chen (2005) and the theory-driven model of Systemic Programme Logic (SPL) based on Wasserman (2010) are recommended, as summarized below.

3.1. Logic model of the NAP

Training of professional users is at the core of the relationships between different types of intervention included in the Finnish NAP, as discussed in Chapter 5.2 in detail. User training is thus also key to making the programme theory behind the NAP explicit, as illustrated in Figure 3.1.

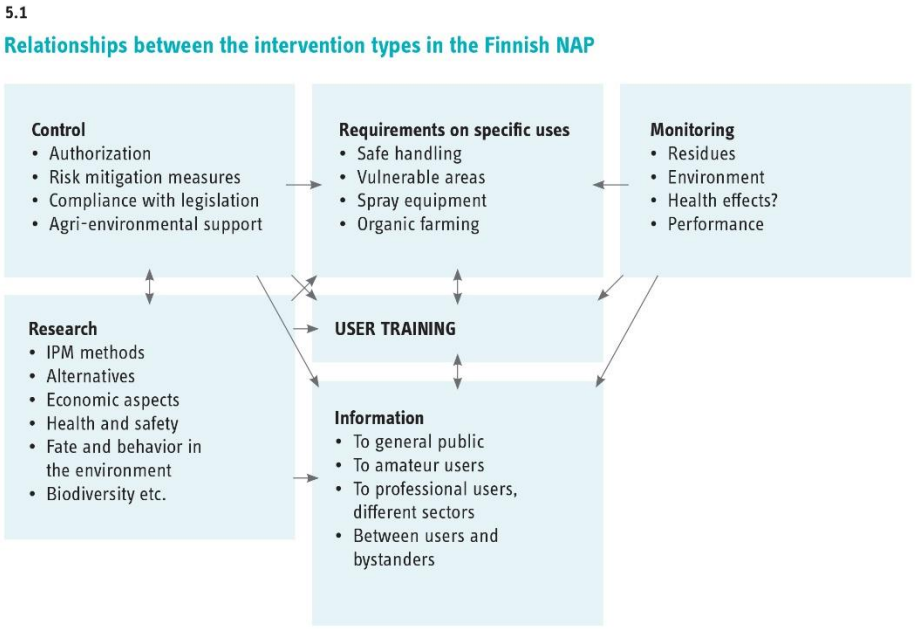

Figure 3.1. Relationships between the intervention types in the Finnish NAP.

Logic models highlight the programme components as milestones of achieving the intended goals, thus illustrating what is needed to realise the programme theory. As modified from models of W. K. Kellogg Foundation (2004) and Chen (2005), logic models for specifying how the specific NAP interventions are presumed to produce the intended outcomes are presented in Tables 3.1. to 3.6. The logic model for providing the professional users with training and certification is presented in Table 3.1. The logic model for the requirements related to PPP uses on sensitive areas and/or in specific conditions is presented in Table 3.2. The logic model for promoting research of sustainable use patterns is illustrated in Table 3.3 Table 3.4 shows the logic model for raising the awareness on safe uses of PPPs. In Table 3.5 the logic model for increasing the control measures is presented, and finally, the logic model for developing adequate monitoring system for demonstrating the evidence of the NAP outcomes is illustrated in Table 3.6.

As the views of different stakeholders may be divergent, in an ideal situation each organisation could make their view known by means of a logic model. Constructing the explicit programme theory for the whole NAP would then be easier by means of the Systemic Programme Logic as proposed in the next Chapter 3.2.

Table 3.1. Logic model for training and certification of professional users of PPPs as a NAP intervention

1. Assumptions of the NAP Steering Committee: We as implementers of the NAP (authorities, researchers, advisors, trainers) believe and presume that trained, skilful and knowledgeable users use PPPs safely and do not cause unnecessary exposure to humans or to the environment. Trained users choose the least harmful PPP available and follow the use instructions. Authorities do not authorise the PPPs unless the risks are acceptable. Providing information makes the general public cautious and informed on PPP use. Research and advice produce appropriate IPM methods to all crops. ↓ ↓ ↓
2. Resources / Inputs required from the implementing organisations: In order to accomplish our activities we will need the following: - The training and certification providers have adequate staff, expertise and resources for organising attractive training events, tailored to the needs of specific production sectors. -The authorities, research and advisory organisations have adequate funding to the development of innovative education material for the training. - The competent authority has adequate staff, expertise and time for training, authorising, controlling and supporting the trainers. - The research institutes have adequate resources to disseminate their research findings to the trainers and advisors. ↓ ↓ ↓
3. Activities provided by the implementers: In order to gain the sustainable use of PPPs we will accomplish the following activities: System for authorisation of the training and certification providers is enforced by end 2013. Training and certification events are available to different production sectors, retailers and spray equipment inspectors. Training material is available to professional users, covering all training subjects as referred to in Annex I of the SUD. All professional users and retailers are certified by 2021. ↓ ↓ ↓
4. Outputs expected: We expect that once accomplished these activities will produce the following evidence of service delivery: Number of training and certification providers authorised. Number of accredited spray equipment inspectors. Number of certificates granted yearly. Number of training events organised / number of participants in training events yearly. Training material is available at the website of Tukes. Surveys on the further needs of participants in basic training are conducted to sketch the higher level of training. ↓ ↓ ↓
5. Short- and long-term outcomes expected: We expect that if accomplished these activities will lead to the following changes **in 1-3 years:** Obligations of the SUD are fulfilled. Communication is increased. Professional users and retailers are encouraged to participate the training and to use the advisory services. The training events are perceived so attractive that users are willing to participate. **in 4-6 years:** IPM principles are largely adopted in the farms and transition to more systemic levels of IPM implementation occurs. Users choose least harmful methods. Non-chemical methods are prioritised. Best available technologies are in use. Risk of resistance is avoided. ↓ ↓ ↓
6. Impact: We expect that if accomplished these activities will lead to the following changes in 7-10 years: Further training is available to the professional users, retailers and spray equipment inspectors. Development of further training is based on the surveys of the needs of participants in basic training events. Collective learning has happened, knowledge on safe handling of PPPs increased, better practices adopted, precautionary principle followed, plant protection practices become sustainable, and perceived risks are decreasing.

Table 3.2. Logic model for actions related to PPP uses on sensitive areas and / or in specific conditions as a NAP intervention

1. Assumptions of the NAP Steering Committee: We as implementers of the NAP (authorities, researchers, advisors and trainers) believe and presume that introducing specific requirements to PPP use in sensitive areas and / or specific conditions causes the following: Trained, skilful and knowledgeable users use PPPs safely and do not cause unnecessary exposure to humans and to the environment in the areas requiring specific protection. Authorities do not authorise the PPPs to these uses unless the risks are acceptable. Providing information makes the general public cautious and informed on PPP use in sensitive areas and / or conditions. Informed citizens perceive the risks from PPP use as decreasing. ↓ ↓ ↓
2. Resources / Inputs required from the implementing organisations: In order to accomplish our activities we will need the following: - Professional users receive specialised training and information dealing with these conditions. -Authorities have adequate staff, expertise and time for assessing the risks and deciding on the authorisation of PPPs to be used on these areas and / or conditions. -Trainers and advisors have adequate staff, expertise and time for providing training and advice for the users of PPPs on sensitive areas and specific conditions. -Authorities, researchers and advisors have adequate staff, expertise and time for informing the citizens of the conditions of PPP use in these areas. ↓ ↓ ↓
3. Activities provided by the implementers: In order to gain the sustainable use of PPPs we will accomplish the following activities: We train, instruct and control the users to avoid using chemical PPPs in sensitive areas and / or specific conditions, to choose least harmful methods, to prioritise non-chemical control methods and to use chemical PPPs only on proven need. We guide the sprayers to adopt best available spraying technologies. We authorise PPPs to such uses only when the risks are negligible. We provide the general public with information about the uses of PPPs in sensitive areas and specific conditions. ↓ ↓ ↓
4. Outputs expected: We expect that once accomplished these activities will produce the following evidence of safer use: Training and information on PPP use in sensitive areas and / or specific conditions is available and is communicated actively to all stakeholder groups. Informed users cause less exposure of PPPs to human health and to the environment. The use of PPPs in sensitive areas and / or specific conditions is based on proven need and follows the precautionary principle. ↓ ↓ ↓
5. Short- and long-term outcomes expected: We expect that if accomplished these activities will lead to the following changes **In 1-3 years:** Compliance of guidance and legislation is achieved. Obligations of the SUD are fulfilled. Training and certification system is in operation. **In 4-6 years:** All professional users have taken the qualification. Least harmful plant protection methods are in use in sensitive areas and / or specific conditions. Non-chemical control methods are prioritised and chemical PPPs are used only on proven need. Best available spraying technologies are used. Risk of resistance of pests to chemical PPPs is avoided. Collective learning on these conditions is happening. ↓ ↓ ↓
6. Impact: We expect that if accomplished these activities will lead to the following changes **In 7-10 years:** Users adopt precautionary principle to guide the plant protection decisions on sensitive areas and / or specific conditions. Knowledge on safe handling of PPPs is increased and better practices are adopted. The perceived risks have decreased. Exposure to bystanders is negligible. Improved water quality, reduced spray drift events, decline of biodiversity stopped, etc. Plant protection practices in sensitive areas and / or specific conditions become sustainable.

Table 3.3. Logic model for promoting research of sustainable use patterns of PPPs as a NAP intervention

1. Assumptions of the NAP Steering Committee: We as implementers of the NAP (authorities, researchers, study sponsors, participants) believe and presume that research increases the knowledge on alternative plant protection strategies to chemical PPPs, thus contributing to the adoption of sustainable plant protection methods in practical cultivation, IPM improves ecological, economic and social sustainability. Research increases the knowledge on the fate and behaviour in the environment and on the safe handling and use of PPPs, which in turn leads to a decreased exposure to PPPs and to reduced environmental load of PPPs. ↓ ↓ ↓
2. Resources / Inputs required from the implementing organisations: In order to accomplish our activities we will need the following: - Research institutes have adequate staff, expertise and time for conducting the research and reporting it. -The sponsors have adequate funding to allocate to the research projects for producing data to contribute the NAP implementation. - The study participants have adequate expertise and time for participating in the research projects. - The authorities have adequate staff, expertise and time for reading up on the results and using them in the decision-making on PPPs. ↓ ↓ ↓
3. Activities provided by the implementers: In order to gain the sustainable use of PPPs we will accomplish the following activities: Studies on safe working practices and PPEs. Studies on the exposure and effects of PPPs in the northern climate conditions. Systemic studies to develop alternative control methods, including the organic farming. Studies on collective learning and attitudinal change of farmers and users. Studies on effectiveness of knowledge brokering via training and certification of PPP users. Studies on media coverage reached by information campaigns... ↓ ↓ ↓
4. Outputs expected: We expect that once accomplished these activities will produce the following evidence of service delivery: Authorities use the research findings to prove that the PPPs are authorised only if the risks are acceptable and risk mitigation measures in use. New methods of use are introduced once there is scientific knowledge available. The decisions made are based on scientific knowledge in Finnish conditions. ↓ ↓ ↓
5. Short- and long-term outcomes expected: We expect that if accomplished these activities will lead to the following changes **In 1-3 years:** New methods of use are introduced once there is scientific knowledge available. **In 4-6 years:** Disseminating the research findings via trainers and advisors to farmers encourages the practical development of IPM methods to all crops. Research findings in Finnish field conditions contribute to the systemic understanding of the users and farmers about the ecosystem services. Risk mitigation measures are adjusted once there is scientific knowledge available. ↓ ↓ ↓
6. Impact: We expect that if accomplished these activities will lead to the following changes in 7-10 years: Increased knowledge contributes to the confidence of the citizens to the authorities and their perceived risks will decrease. Collective learning and attitudinal change of farmers and users makes them to adopt more sustainable plant protection practices. Based on the increased knowledge the actions and measures of the NAP can be targeted more efficiently to its goals.

Table 3.4. Logic model for awareness-raising and information about the safe uses of PPPs as a NAP intervention

1. Assumptions of the NAP Steering Committee: We as implementers of the NAP (NAP steering committee, authorities, media, researchers, advisors, trainers, trade, industry, farmers' organisations) believe and presume that providing information makes the general public cautious and informed about PPP use and its risks. Informed users can and will reduce the exposure via using more environmentally friendly methods of plant protection. Informed citizens perceive the risks from PPP use as decreasing. Confidence of the informed citizens regarding the safe food production increases. Authorities do not authorise the PPPs unless the risks are acceptable. ↓ ↓ ↓
2. Resources / Inputs required from the implementing organisations: In order to accomplish our activities we will need the following: - The implementers have adequate staff, expertise, time and resources for producing information material on safe handling and use of plant protection products and for disseminating it to the general public - The implementers have adequate funding for establishing awareness-raising campaigns attractive to non-professional users, consumers and general public. - The implementers have adequate staff, expertise, time and resources to participate in fairs, exhibitions and other events and to answer the questions asked by the public. ↓ ↓ ↓
3. Activities provided by the implementers: In order to gain the sustainable use of PPPs we will accomplish the following activities: Information is actively distributed to different recipient groups on safety issues, protection of professional and non-professional users, bystanders, residues in food, methods of reducing the risks to the environment, agricultural practices etc. The information is available in different forms: websites, professional journals, magazines, brochures, fairs and exhibitions, training materials and expert replies to questions from the citizens and the media. ↓ ↓ ↓
4. Outputs expected: We expect that once accomplished these activities will produce the following evidence of service delivery: The information material produced is readily understand-able to different consumer groups and lay persons. Following the dissemination of information the PPPs will be used cautiously and only on necessary needs. Better practices are adopted. Risk of resistance is avoided. The coverage in the media of the information campaigns is increasing. ↓ ↓ ↓
5. Short- and long-term outcomes expected: We expect that if accomplished these activities will lead to the following changes **In 1-3 years:** Communication increased, information is received and is interesting to the recipients. Information on the compliance and achievements of the NAP is provided to policy makers and citizens **In 4-6 years:** Knowledge on safe handling of PPPs increased, safer plant protection practices adopted, non-professional users choose plant protection methods causing least risk to the human health and the environment (mainly non-chemical and lower risk methods). Consumers are able to avoid purchasing and using illegal and counterfeit PPPs on the market. ↓ ↓ ↓
6. Impact: We expect that if accomplished these activities will lead to the following changes **in 7-10 years:** Informed policymakers take enlightened decisions that benefit most stakeholders and interest groups. Collective learning happened. Perceived risks decreased Sustainable use of PPPs is achieved by NAP actions. PPPs will not cause significant adverse effects on human health and the environment by 2020. (= The global objective of the Johannesburg World Summit is achieved.)

Table 3.5. Logic model for increasing the control of PPPs as a NAP intervention

1. Assumptions of the NAP Steering Committee: We as implementers of the NAP (surveillance authorities, accredited sprayer inspectors) believe and presume that increasing the control helps revealing the possible non-compliance of the PPP legislation and increases the perceived confidence of the citizens to the authorities. Being aware about control measures, the users are willing to avoid unnecessary human exposure and load of PPPs to the environment. Authorities do not authorise the PPPs unless the risks are acceptable. Spraying equipment in use fulfil the environmental requirements. ↓ ↓ ↓
2. Resources / Inputs required from the implementing organisations: In order to accomplish our activities we will need the following: -Authorities involved have adequate staff, expertise and time for conducting the surveillance and control measures as required by the relevant legislation. - Accredited sprayer inspectors have adequate staff, expertise and time for conducting adequate number of control visits according to the surveillance plan yearly. -The control authorities have adequate staff, expertise and time for informing the citizens and the decision-makers of the results of control activities. ↓ ↓ ↓
3. Activities provided by the implementers: In order to gain the sustainable use of PPPs we will accomplish the following activities: We assess if the conditions of authorisation of specific PPPs are fulfilled, and set appropriate use restrictions and risk mitigation measures prior to the authorisation and release of PPPs on the market. We control that the PPPs are marketed in compliance with the legislation, and used in accordance with GAP and IPM principles and other legislation. We control that the spray equipment fulfil the environmental standards. ↓ ↓ ↓
4. Outputs expected: We expect that once accomplished these activities will produce the following evidence of service delivery: The number of authorisation decisions is within the yearly agenda of Tukes. Number of control visits to be organised is within the yearly agenda of Tukes and other authorities. Number of spray equipment tested is within the yearly agendas of accredited inspectors. ↓ ↓ ↓
5. Short- and long-term outcomes expected: We expect that if accomplished these activities will lead to the following changes **In 1-3 years:** Compliance to the legislation is achieved. Obligations of the SUD are fulfilled. Surveillance system for market and use is in operation. **In 4-6 years:** Spray equipment testing system covers also other types of sprayers than tractor mounted sprayers. The interval of sprayer tests will be shortened from five to three years. The environmental monitoring system is in operation and the data produced is used in the environmental risk assessment and risk management of PPPs. ↓ ↓ ↓
6. Impact: We expect that if accomplished these activities will lead to the following changes **In 7-10 years:** The decreasing number of non-compliance cases observed in the control visits indicate that the knowledge on safe handling and use of PPPs is increased and better practices are adopted. The best available technique is in use in spray equipment.

Table 3.6. Logic model for developing adequate monitoring system for demonstrating the evidence of the NAP outcomes

1. Assumptions of the NAP Steering Committee: We as implementers of the NAP (surveillance and monitoring authorities, researchers) believe and presume that increasing monitoring helps to reveal the possible non-compliance of the PPP legislation and increase the perceived confidence of the citizens to the authorities. Being aware about traceability of PPP residues by control measures and monitoring in food commodities and in the environment, the users are willing to avoid unnecessary human exposure and load of PPPs to the environment. Authorities do not authorise the PPPs unless the risks are acceptable if the PPPs are used according to GAP. ↓ ↓ ↓
2. Resources / Inputs required from the implementing organisations: In order to accomplish our activities we will need the following: -Authorities organising the monitoring research have adequate staff, expertise, time and analytical capacities for conducting the monitoring and reporting it. -The institutes responsible for monitoring have adequate staff, expertise and time for publishing and informing the citizens and the decision-makers of the results of the monitoring and control activities. ↓ ↓ ↓
3. Activities provided by the implementers: In order to gain the sustainable use of PPPs we will accomplish the following activities: We perform adequate monitoring of the PPP residues in food commodities and in the environmental compartments to control that the relevant reference values (MRLs or EQSs) are not exceeded in the plant products or in the environmental samples. In case of exceedances we help the authorities to trace the reasons for exceedances, and organise withdrawals of the food commodities from the market. ↓ ↓ ↓
4. Outputs expected: We expect that once accomplished these activities will produce the following evidence of service delivery: The residue levels in the crops indicate if the PPPs have been used according to GAPs and the level of human exposure via the food. The number of vegetable samples to be analyzed annually (approx. 250 samples / year) is included in the monitoring plan of Evira. The concentrations found in surface and ground waters, soils and air indicate the level of environmental load and the level of exposure of non-target organisms to PPPs. The water sampling and analysis is included in the annual environmental monitoring plan of SYKE. ↓ ↓ ↓
5. Short- and long-term outcomes expected: We expect that if accomplished these activities will lead to the following changes **In 1-3 years:** Compliance to the food legislation is achieved. Obligations of the SUD are fulfilled. Results of monitoring studies are published frequently. **In 4-6 years:** Adequate environmental monitoring system is in operation and the data produced is used in the environmental risk assessment and management of PPPs. Trends in exceedances of MRLs in food commodities and EQSs in waters are decreasing, thus indicating that the uses of PPPs are causing less exposure to consumers and to the environment. ↓ ↓ ↓
6. Impact: We expect that if accomplished these activities will lead to the following changes **in 7-10 years:** The established monitoring system enables to conclude on trends in residue concentration in food and in the environment. The residues present in the food do not cause unacceptable exposure of the consumers. The chemical and biological state of the surface and ground waters is good, indicating that the exposure of aquatic organisms is negligible. The number of non-compliance cases observed in the control visits indicates that the knowledge on safe handling and use of PPPs has increased and better practices have been adopted.

3.2. Systemic Programme Logic for the Finnish NAP

Based on the logic models of NAP interventions as presented previous tables, the programme theory can be outlined by means of the Systemic Programme Logic framework, as presented next in Figure 3.2. and earlier in Figure 6.6. A Systemic Programme Logic framework (SPL) based on Wasserman (2010) is proposed for clarifying the assumed benefits and outcomes of implementing the Finnish NAP. The figure illustrates how the participants, service providers and their communities interact to produce the expected outcomes and impacts. Additionally, the framework provides evaluation points for the different relationships between actors. The numbered evaluation points describe where and how the relationships between the NAP actors influence the implementation of the NAP and how they can be assessed. Specified evaluation questions for different forms of evaluation, as presented in Chapters 1.1-1.5 of Appendix 3, can then be applied to each evaluation point to guide the collection of evidence. Applicable types of research are also proposed for gathering the data.

6.6

The systemic program logic of the NAP interventions, based on Wasserman 2010

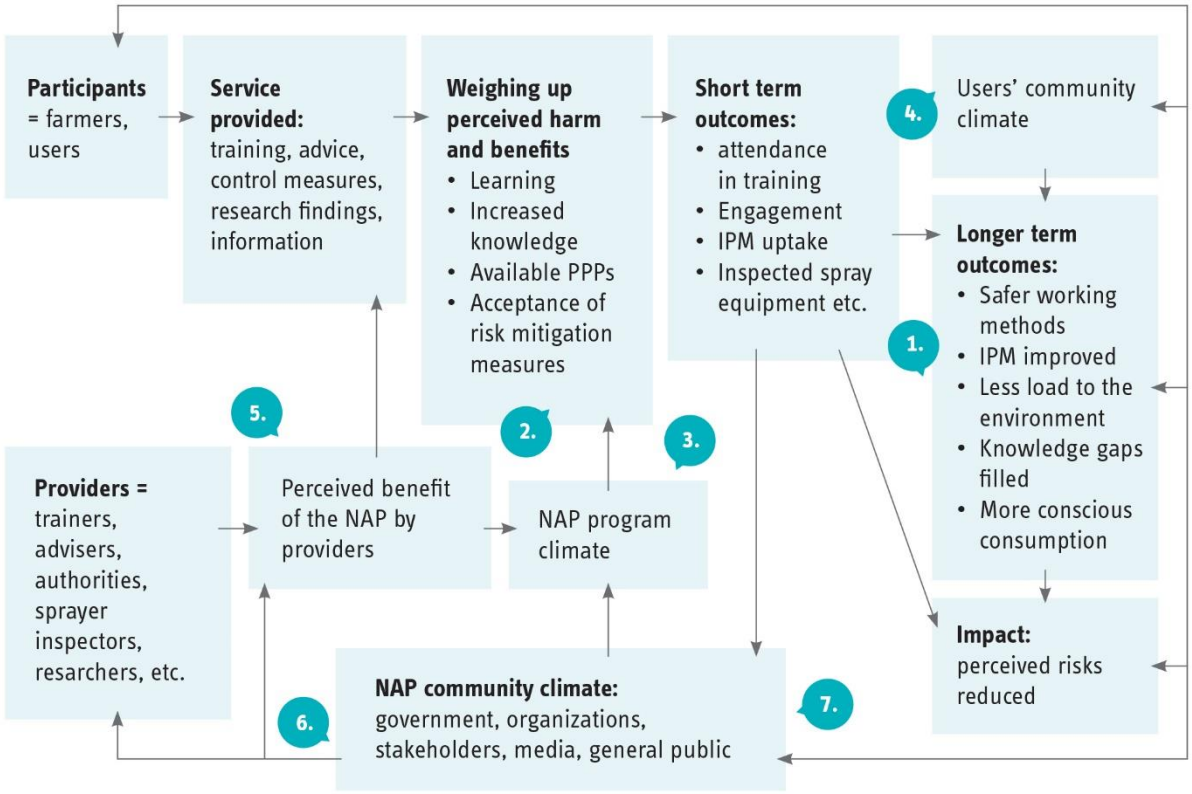

Figure 3.2. Systemic programme logic of the NAP interventions (based on Wasserman 2010). The numbered evaluation points 1-7 are explained in the text.

Proposed SPL evaluation points in the Finnish NAP:

1 = Participant to outcome: intended intermediate and longer-term outcomes and how they can be measured. How users of plant protection products value changes in their attitudes, skills,

behaviours etc. This measure predicts the overall success of the activity. Surveys on attitudes and perceptions of professional users who participate the NAP activities.

2 = Participant to programme activities: The amount and nature of interaction between PPP users and training and advisory services, control measures, research findings, information etc. necessary to produce outcomes. Contextual influences expected to affect the quality of received services. How human perception/experience of interventions (training, information and research findings disseminated, control by authorities etc.) affects the outcomes. Perceived benefits and possible disadvantages are weighed up and affect the willingness to participate and produce the expected outcomes. Surveys and interviews with PPP users on their perceived learning, usefulness, experiences and feedback on NAP activities, willingness to participate, acceptance of risk mitigation measures etc.

3 = Participant to provider: Contextual influences expected to affect the quality of the provider-participant relationships. How human perceptions of relationships affect the relationship and its outcomes. Perceptions of the ability of the providers to produce benefits and serve the users, e.g. expertise of the trainers, authorities, researchers. Collection and analysis of participant feedback from training events, extension services, spray equipment inspections, awareness-raising campaigns etc. Expert surveys and interviews, document analysis.

4 = Relationship of the participants' own social community of peers (farmers, professional users etc.) to participants' outcomes: Quality of influence of support networks. Expected community perceptions and influence on specific NAP interventions, thought leaders' attitudes on participation in NAP activities and outcome sustainability. Users' visions on control priorities, research needs, communication support etc. Social norms of the peer community influence the adherence of participants' behavioural change expected as a result of received training. Media and document analysis, feedback from sectoral organisations, expert surveys etc.

5 = Providers to their outputs: Expected contextual influences on providers' abilities and motivation to produce the interventions defined in the NAP (training, control and surveillance, research, information). How human perception/ experience of producing the services affects the outcomes the activity produces; how a provider experiences her or his work may affect the outcomes as much as the intervention itself. Surveys and interviews with service providers who organise the NAP activities on how they perceive the learning, usefulness and feedback from NAP activities they are providing.

6 = Providers to sponsoring organisation: Expected organisational supports for providers' ability to produce programme activities. How human perception / experience of the workplace affects motivation, productivity, cretivity, adaptability etc. Quality of support to the implementers from their background organisations, sponsors, stakeholders and society as a whole influences the outcomes they produce. Long-term visions and strategic planning for directing the NAP actions, target-setting. Surveys and interviews with service providers on their needs for resources, knowledge and other support from their background organisations and the NAP Steering Committee. Strategic research agenda and funding directed to implementing it.

7 = Providers' functionality as a buffer of evaluation results: Expected provider response to evaluation results and how those responses will affect the production of outcomes. Human response to performance indicators and its affect on motivation, productivity etc. Social norms

of the NAP community influence the adherence of collective and organisational learning expected as a result of implementing the NAP. Expert consultations, surveys and interviews, media and document analysis, indicator studies.

The measures to these evaluation points can be either quantitative (e.g. Likert scale responses to questionnaires surveying the attitudes) or qualitative (e.g. open-ended interview data). Depending on the purpose of the evaluation, type of data to be gathered and resources available, case-specific evaluation questions for each evaluation point can be modified. Moreover, the policy level to be considered may dictate the specific evaluation questions to be applied. However, regardless of the policy level to be chosen, whether national or local, it is important to take equal consideration of the views of different stakeholders and organisations bearing a variety of different perspectives on the NAP, in order to empower them in the social discourse on what a sustainable use of plant protection products would mean.

4. Summary on gathering evidence of success in implementing the NAP

Table 4.1. Summary of key measures of evidence and proposal on how to collect data for assessing the success of implementing the Finnish NAP. Intervention areas refer to Figure 3.1.

Intervention area	Measures and indicators	Proposal for collecting data
Compliance with legislation	• Legislative requirements fulfilled • Timelines adhered • Indicators proposed by FVO	• FVO audits and evaluations
Training and extension	• Supply and demand of training and advice in each sector • Demographical data of participants • Quality of training material • Feasibility of training and advice with regard to facilitation and creating space for social learning • Explicit agroecological approach in training and extension • Attitudes and perceptions of training and extension providers • Attitudes of professional users • Knowledge gaps between top performers and average users	• Analysis of training providers • Analysis of participants in training events and users of advisory services • Analysis of feedback and proposals from participants • Analysis of training methods and contents • Surveys on attitudes of trainers and advisors • Surveys on attitudes of PPP users, stratified sampling of different user groups
Specific use requirements	• Crop rotation in use, reasons and bottlenecks of not implementing • Deployment of organic farming • PPP uses in green areas and non-agricultural uses • Aerial spraying permits, if any • Storing and disposal of obsolete PPPs • Sales and uses of professional vs. non-professional PPPs	• Analysis of statistical data, surveys and interviews, case studies • Interviewing experts within greenery sector • Analysis of reasons for exceptional permits for aerial spraying cases • Analysis of storage surveillance cases and amounts of obsolete PPPs received at Ekokem

		• Analysis of sales and uses of PPPs, divided by product groups, user groups, professional and non-professional uses, regions etc.
Control and surveillance	• Evidence of cases of illegal or improper use of PPPs • Cases of MRL exceedances in food • Evidence of risk reduction in PPP authorisation • Evidence of implementation of cumulative risk assessment in PPP authorisation • Evidence of using substitution in PPP authorisation • Cases of using derogations of authorisation requirements laid down in 1107/2009. • Condition of spray equipment	• Analysis of surveillance cases, reasons for infringements and non-compliance with legislation, penalties etc. • Analysis of authorisation decisions, applicability and reasons for withdrawals, restrictions and specific safety instructions • Analysis of sales and use patterns of hazardous PPPs subject to specific safety provisions or restrictions of use • Statistics and surveys with authorised spray equipment inspectors
Research	• Improved integration and coordination of research efforts between different disciplines • Combining farming practices, social learning and dynamic monitoring of exposure from PPP use to a wider societal impact of IPM • Evidence of impact of refining the conditions of authorisation • Qualitative evidence of effects of PPP use in human health • Improving the implementation of appropriate human exposure indicators • Improving the implementation of environmental risk indicators • Criteria for reducing dependency on chemical PPPs • Longitudinal evidence of introducing IPM practices in field • Support institutional change in transition to sustainable crop protection	• National research programme and strategic research agenda on plant protection research • Systemic, multidisciplinary research projects • Assessment and modelling of authorisation options with different mitigation measures • Interviews and surveys with users on perceived symptoms from PPP use • Analysis, testing and developing of appropriate risk indicators for Finnish conditions • Analysis of options and practices of plant protection in conventional vs. organic farming • Analysis of on-farm decision-making on plant protection before and after the mandatory introduction of IPM in 2014 • Engaging stakeholders in knowledge production
Information and communication	• Shared communication plan and communication network between stakeholders • Centralised platform for PPP information	• Stakeholders to actively circulate their data to other actors • Highlighted role of NAP Steering Committee in information exchange between the actors

	• Retailers to actively recommend personal protection equipment in connection to selling PPPs • Increased consumer and citizen awareness following information campaigns • Availability of NAP information material in both official languages • Active dissipation of research findings • Providing information and considering the costs and outcomes of NAP implementation projects for priority-setting	• Building up the IPM portal and NAP websites at Tukes, regular updating • Analysis of PPP sales statistics • Surveys on consumer awareness, attitudes and perceptions on PPP use • Systematic recording and analysis of citizens' references to PPP issues • Funding available for research projects to communicate the results • Cost-effectiveness assessments
Monitoring	• Accountability, general management information of NAP projects • Monitoring of pesticide residues in food • Monitoring of PPP exposure in the environment • Good chemical and ecological status of natural waters (Directive 2000/60/EC)	• Work contribution, resource allocation in organisations • Measuring the MRL exceedances in food commodities • Measuring the concentrations of PPPs in environmental compartments and biota • Measuring the EQS exceedances in surface and ground waters

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