203

Farmers' behavior and the provision of public goods: Towards an analytical framework

R.A. Jongeneel
L. Ge

werkdocumenten

WOt
Wettelijke Onderzoekstaken Natuur & Milieu

WAGENINGEN UR
For quality of life

Farmers' behavior and the provision of public goods: Towards an analytical framework

The 'Working Documents' series presents interim results of research commissioned by the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu) from various external agencies. The series is intended as an internal channel of communication and is not being distributed outside the WOT Unit. The content of this document is mainly intended as a reference for other researchers engaged in projects commissioned by the Unit. As soon as final research results become available, these are published through other channels. The present series includes documents reporting research findings as well as documents relating to research management issues.

This document was produced in accordance with the Quality Manual of the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu) and has been accepted by Floor Brouwer, programme coordinator of WOT Natuur & Milieu.

WOt Working Document **203** presents the findings of a research project commissioned by the Netherlands Environmental Assessment Agency (PBL) and funded by the Dutch Ministry of Agriculture, Nature and Food Quality (LNV). This document contributes to the body of knowledge which will be incorporated in more policy-oriented publications such as the Nature Balance and Environmental Balance reports, and Thematic Assessments.

Farmers' behavior and the provision of public goods: Towards an analytical framework

R.A. Jongeneel

L. Ge

Werkdocument 203

Wettelijke Onderzoekstaken Natuur & Milieu

Wageningen, augustus 2010

Abstract
Jongeneel, R.A. & L. Ge, 2010. *Farmers' behavior and the provision of public goods: Towards an analytical framework. .* Wageningen, Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu), WOt-werkdocument 203. 64 p;.6 Figs.; 9 Tabs.; 58 Refs.; 1 Appendix.

The new CAP reform aims to stimulate the role of agriculture as provider of public goods. An analytical framework is developed to model farmers' decision making and to gain insight into farmers' behavior in response to a number of policy instruments. The framework integrates characteristics of farm, farmer, market, as well as the policy instruments. Theoretical analysis suggests that attitudes, off-farm employment opportunities, non-pecuniary benefits and expectations of future developments can play important roles in farmer's decision making regarding the provision of public goods. Empirical research is needed to test the hypothesis.

Key words: Attitude, Externalities, Farmers' behavior, Farm decision making, Green and blue services, Jointness, Multifunctionality, Nonpecuniary benefits, Opportunity costs, Option value, Pigovian subsidy, Public goods, Risk and uncertainty, Time inconsistency, Transaction costs

This report is written as part of the 'Groene en blauwe diensten-project' (so-called Green and blue services) of the Netherlands Environmental Assessment Agency (PBL). This WOT research project aims to contribute to the project 'Verkenning effecten herziening Gemeenschappelijk Landbouwbeleid' (on the future of the Common Agricultural Policy) of PBL. The task of PBL is to provide the government with analyses of environmental policy issues.

PO Box 29703, 2502 LS Den Haag
Phone: (070) 335 83 30; fax: (070) 361 56 24; e-mail: informatie.lei@wur.nl

The Working Documents series is published by the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu), part of Wageningen UR. This document is available from the secretary's office, and can be downloaded from www.wotnatuurenmilieu.wur.nl.

Statutory Research Tasks Unit for Nature & the Environment, P.O. Box 47, NL-6700 AA Wageningen, The Netherlands
Phone: +31 317 48 54 71; Fax: +31 317 41 90 00; e-mail: info.wnm@wur.nl;
Internet: www.wotnatuurenmilieu.wur.nl

Inhoud

Summary

This study tries to improve the insight into the decision for participation in multifunctional agricultural activities (e.g. biodiversity and landscape preservation schemes, etc.). Often these activities have an externality or public good character, which implies that the market will fail to ensure an efficient allocation. In order to achieve an adequate provision of these multifunctional outputs and/or 'public goods' an active involvement of the policy maker is required. The study starts with having a look at the peculiarities of this public good-management task. Also the interaction of such a public good policy with a country's other policies, notably its trade policy, is considered. It is argued that in general compensatory payments or financial penalties are the appropriate way to stimulate optimal public good provision (or reduction of public bads). It is concluded, that in general, this provides no justification for (protective) trade policies. However, the public goods issue needs proper treatment in the WTO trade negotiation framework: countries should have autonomy in the way they use taxes and subsidies, at least as far as these payments are properly targeted and the implied compensations (or punishments) are proportional with the efforts (or harm) made.

Significant attention is paid to concepts and production technology. With respect to the latter in particular the degree of jointness appeared to be crucial. Private and public outputs can be complementary, independent or competing. Moreover, the trade-off between private and public outputs is most likely to be non-constant, but changing with changing private output levels. This may even lead to complementarity-competing-switches. As a general point, the results emphasize the need to carefully analyze how the public outputs are produced and their way of interaction with the private output. There is also a link from this to the determination of a proper remuneration of public good provision activities.

As regards the behavior of farmers, in contrast with many other studies, this study takes into account the role that farmers' attitudes, intrinsic motivations and moral convictions might play. Therewith also the potential impact of these factors on the participation decision can be analyzed. From the solution of the farmer's utility maximization problem, and some further comparative statics analysis, the role of these and other factors has been clarified. Moreover, the specific issues involved in case of multi-annual contracts are separately discussed. This made clear the crucial role of expectations, uncertainty and 'irreversibility' on the participation decision. Also insight is gained in what factors might lead to postponement of participation decisions. This could have been further extended to lock in-effects and compliance issues.

The study has a strong analytical focus. As such it does not yet provide insight into the empirical importance of the various issues, and an empirical follow-up is recommended to create a more complete picture. However, this study provides valuable input about how to properly model public good activities. This is in particular useful, since the models used for policy analysis in this realm are still in need of further improvement, in particular with respect to the public good outputs. As the analysis shows, not only the regular variables explaining economic supply activities (such as output and input prices) are important, but also the contract specification is crucial, since it is this that determines the opportunity costs of participation. It was argued that this relationship is complex. However, given that the basic mechanism is understood, the framework provides in this study might also be a guide to more simplified (or reduced form) approaches.

1 Introduction and context

1.1 Aim of the research

This WOT research project aims to contribute to the project 'Herziening Gemeenschappelijk Landbouwbeleid' of the Netherlands Environmental Assessment Agency (PBL), which has as its main task to advise the government on environmental policy issues. In the debate about future CAP reform and future budget allocation to agriculture the role of agriculture as a provider of public goods and services has become increasingly important. This report adds to that debate in three ways:

1. It analyses a number of contextual issues in this debate. These include the role of governance aspects and the linkage of public goods and trade issues;
2. It clarifies a number of concepts (such as public good, externality, jointness, etc.) based on a survey of the literature and studies the implications they have for the policy context;
3. It focuses on the behavior of farmers under different policy-incentive schemes and tries to explicitize things like opportunity costs of policy restrictions, the participation decision, and provides an analytical framework to better understand the explanatory factors and impacts.

Whereas the main aim of this study is step 3, the authors considered it crucial to also go through steps 1 and 2, although in a less detailed way. The main reason is that a good analysis of step 3 requires insight into the policy context and issues (for example knowledge about the type of policy instruments that might be used and thus have to be considered in step 3).

As indicated the main emphasis will be on step 3. First a formal approach will be followed. It has the advantage that one can focus on key issues and abstract from a lot of practical details, which always are there, but often are not decisive for analyzing the basic mechanisms. Moreover, it opens up the possibility to link the analysis with the theoretical economic literature and therewith ensure a kind of soundness of results and implications. The approach has as a disadvantage that highly abstract results might be obtained, which have no direct translation into the day to day practical policy realm. For that reason the translation of the obtained theoretical insights for the policy sphere is an explicit aim of this study. Readers interested in the practical lessons might skip the theoretical parts (e.g. skip Chapter 5, but directly go to Chapter 6).

1.2 Aspects and issues

Public good policy concerns a wide range of issues and can be approached from different angles. Figure 1 provides a scheme distinguishing supply, demand and organizational aspects of public goods concerning farmers as a supplier of public goods.

From an organizational perspective, demand and supply of public goods can be arranged through three types of institutions: market, government and clubs. Market produces public goods as externalities to its transactions of private goods. Since externalities are not taken into account in the decision making of individual market agents, supply of public goods through markets often fails to reach socially optimal outcome. Government and clubs, representing collective interests, can achieve socially optimal outcome by internalizing the externalities. The role of government is particularly important in public good provision as in principle goods concern the society as a whole.

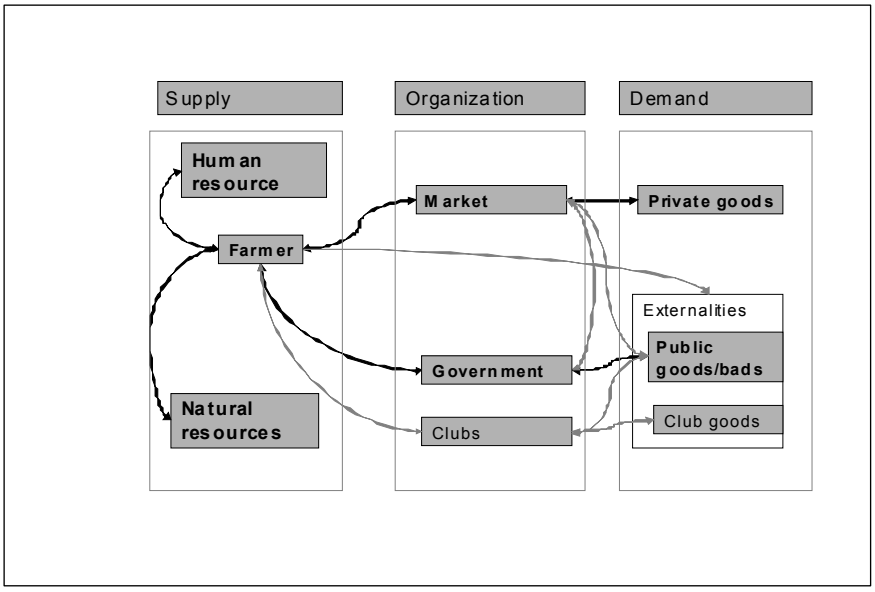


Figure 1: Overview of research related to the provision of public goods by agriculture

As regards the supply side, a crucial issue is the farmer's behavior in allocating natural and human resources to the production of marketed goods and public goods. How is the farmer, being a controller of resources and supplier of private goods, going to respond to different policies or policy instruments (regulations, contracts, subsidies, etc.) aiming to stimulate the provision of public goods? In particular, when participation in public good provision schemes is voluntary, insight into the likely level of participation and the factors explaining a certain degree of participation is crucial. Also the role and degree of connectedness between private good and public good provision is likely to be important to assess final policy outcomes. There exists extensive literature on policy instruments and farmer's behavior but it needs further tailoring to the current issue (agriculture as a specific sector, providing specific public goods).

The demand side of public goods concerns the society's preferences and willingness to pay for public goods. Stated preferences methods such as contingent valuation methods and choice experiments are often used to assess the benefit of the public goods to the 'public' (e.g., Brower 2008). Occasionally, revealed preferences are also used by checking the voting behavior (e.g., Schram and Van Winden 1989). In this study the valuation and demand issue will not be dealt with in any detail.

In general, direct demand for public goods and other organizational forms of public goods provision are all relevant. The institutional framework of public good provision has received considerable attention in literature (see e.g., Hodge 2001). This research focuses on the behavior of farmers and looks into the incentives and constraints generated by policy instruments and their potential impact on farmer's behavior. However, this cannot be done in isolation from how demand will be organized and implemented by means of different policy arrangements. For example, it makes a difference when farmers face incentive contracts, get remunerated based on performance or direct regulation will be enforced on them. Moreover, contracts can differ in flexibility and extension (individual, group, regional contracts, etc.). In this study the policy context and institutional or organizational issues will be reflected upon, because an assessment of this is a prerequisite to select a stylized set of typical and likely policy arrangements on the one hand, and also to get insight into the set of (affected) variables that is relevant to consider in the analysis (e.g. profits, participation, costs, etc.) on the other hand.

1.3 CAP reform and Dutch policy proposition on the provision of public goods

The Common Agricultural Policy (CAP) is one of the corner stones of the EU integration process. The CAP was originally developed in the late 1950s and 1960s, mainly in the form of market and price (support) policy (Pillar I). Since the beginning of the 1990's, the CAP has gradually evolved into a direct income payment systems with an additional rural development component (Pillar II). Important steps in this process are: the MacSharry reform in 1992, Agenda 2000 in 1999, the Midterm Review in 2003 and the Health Check in 2008 (see for example Keyzer *et al*, 2003). Moreover, first decisions on the financing of the EU including the CAP beyond 2013 will be taken in the Announcement of the Commission that is scheduled for November 2010.

The MacSharry reform involves an important change of direction for the CAP. The essential change is the increasing substitution of price support by direct payments to farmers. In the 2003 Midterm Review it was decided to over time fully decouple most direct payments (single farm payment scheme, SPS) from production. At the same time receipt of payments was made conditional on the eligible farmers satisfying certain minimum requirements with respect to biodiversity, environment, health, animal welfare and sustainable land use practices (obligatory cross-compliance). The recent Health Check further extended the decoupling to include all direct payments and simplified the cross-compliance policy, without affecting its substance.

Driving forces behind the CAP reforms were: the huge intervention stocks, international conflicts and rapid increasing budget expenditures in the 1970s and 1980s; the GATT-WTO negotiations in the Uruguay Round (1986-1994) and to a lesser extent the still inconclusive Doha Development Agenda Round (2001-?); the changing desires and needs of the European citizens; the changing position of agriculture in the rural economy; the changing role of governments in the European society; and the enlargement of the EU (Keyzer *et al*, 2003).

New developments in CAP since the Health Check emphasize the role of agriculture as a 'provider of public goods', 'an energy provider', 'a climate changes mitigator'. In summary, public support to agriculture is increasingly justified due to the public service generated by agriculture which is unpaid in the market. The old justification of the CAP as an instrument to enhance productivity and income support is of declining significance.

1.4 Dutch vision of the future of CAP, policy objectives and policy instruments

The Dutch vision on the CAP (De Houtskoolschets) advocates a transition from the current direct income payments scheme to a targeted bonus reward system from 2014 onwards. The proposed new system aims at stimulating the provision of public goods such as landscape, soil quality, conservation of biodiversity. The Netherlands Ministry of Agriculture, Nature and Food Quality (LNV) has proposed in its strategic vision a further targeted policy which stimulates the provision of public goods (LNV 2008), therewith following the advice from The Dutch Council for the Rural Areas (RLG 2007) and The Social and Economic Council of the Netherlands (SER 2008).

Dutch agriculture faces unmistakable threats: environmental degradation, climate change, withering nature reserves, and the urban pressure on the quality of life on the countryside.

Agricultural entrepreneurs must respond to this changing social-economic environment. There is challenge for both policy maker and agricultural producers to counteract the threats, profit from the opportunities, and in realizing these objectives, effectively and efficiently make use of European funds.

The overall policy goal in the Netherlands with regard to agriculture is to stimulate the welfare enhancing role of agriculture within the framework of the CAP. In particular, the objectives are food security and safety, competitiveness of Dutch agriculture, minimal generation of negative externalities, minimal distortion of the market and optimal provision of public goods given a pre-specified budget constraint.

The advisory council SER recommended a 4-group model, as shown in Table 1, as a tool to guide the applicability of policy instruments in terms of income support or public goods provision. According to their philosophy in case there are no physical (e.g. mountainous area) or institutional handicaps (e.g. Natura 2000 zone) and farms don't contribute to the provision of public goods, no income support is necessary. To the extent there are such handicaps compensations might be justified. Moreover, innovation policy can still be implemented for this group (e.g. Group 1). The existence of handicaps presents an argument for income support, whereas the provision of public goods presents an argument for targeted policies facilitating their supply. The reference to cross-compliance makes sure that minimum standards with respect to food safety, biodiversity, environment, animal welfare, health, etc. are satisfied. Although the SER is not very precise on this it would be logical to impose the cross-compliance conditionality to all payments farmers (for whatever reasons) receive from the government (e.g. also add this condition to Group 4).

As Table 1 further suggests public goods provision is relying on voluntary participation, not on regulation. (In reality certain public goods might be directly linked to certain farming systems, being natural byproducts of certain farming practices, or jointly produced with private outputs). Voluntary provision of public goods presupposes the availability of a set of contracts (specifying both requirements and compensation) farmers can freely choose of. The SER largely follows the existing trend in CAP reforms, with as a main exception that it limits income support to special cases, whereas the Commission still acknowledges a more general need for income support of agriculture.

Table 1: Groups of Agricultural Producers and Corresponding Instruments (SER 2008)

Production	**Without Handicap**	**With Handicap**
Regular production + no public goods	**Group 1** - No income support - Innovation policy	**Group 2** - Income support Cross compliance
Regular production + Public Goods	**Group 3** - No income support - Voluntary provision of public goods	**Group 4** - Income support - Cross compliance Voluntary provision of public goods

1.5 Farmer's behavior with respect to the new CAP

Implementing the new CAP raises many theoretical and practical questions. For example, is the coupling of CAP funds with public good provision justified? While public good provision is often used as an argument for compensating farmers, some critics consider the payment as hidden government subsidy which will have distortive effect on agricultural production and trade (Potter and Tilzey 2007). Further more, if the policy aims to stimulate public good

provision, which instruments can better realize the goal of the policy? Should a uniformed payment scheme be preferred to a differentiated scheme? The most relevant ones, however, concern the farmers' response to the instruments. Information about this is crucial, for example to assess whether the policies will be sufficient to achieve the policy objectives. How will different policy instruments influence farmers' decision making? What factors are expected to influence farmers' acceptance of policy instruments? How can policy design take into account of these factors?

In order to gain insight into farmers' decision making, an analytical framework is developed in this research. In particular, the framework addresses following questions:

- What are the theoretical issues relevant to the design of public good policy?
- Why should provision of public goods such as green and blue services be stimulated and rewarded?
- Which insight can theory provide in farmer's behavior in response to policy instruments?
- What impacts might result from transforming the single farm payment scheme into a new system of payments (e.g. flat rate) or re-targeted payments?
- What incentives and constraints do the policy instruments impose on the farmers?
- What are the factors that determine the participating behavior of farmers?
- How can these insights be translated to practical lessons?

1.6 Reading guide

Before presenting the theoretical background of public good policy in Chapter 3, Chapter 2 introduces a number of important concepts and definitions related to the policy debate. A formal analysis on farmer's behavior in response to four different policy instruments will be illustrated in Chapter 4. The analysis provided in Chapter 4 is mainly static. Chapter 5 relies on a multiperiod analysis in order to illustrate the intertemporal aspects, for example such as those associated with multi-annual contracts. As such this chapter should improve the insight in the potential role of option values in the farmer's participation decision. Practical implications for policy design and evaluation are presented in Chapter 6.

2 Concepts, definitions, and theoretical issues

Agricultural policy, especially the CAP, concerns a number of prominent but elusive concepts such as public goods, externality, jointness, multifunctionality, and coupling. The elusiveness of these concepts can lead to confusion in political or academic debates. It is therefore important to give clear definition of these concepts for the analysis.

2.1 Public goods

The provision of public goods has been an important issue in the discussion about public policy and public expenditure. In economic theory, public goods refer to goods or bads that possess the property of nonrivalry and nonexcludability (see e.g., Samuelson 1954). Non-rivalry means that the good, once produced, can be consumed by an additional consumer at no additional cost. One person's enjoyment of the benefit of a public good does not interfere with another's consumption of it. Non-excludability refers to the property that consumers cannot be excluded from consuming the public good once it is produced. Typical examples mentioned in standard textbooks of economics are national defense, clean air, and general infrastructure.

Real-world goods are seldom strictly non-excludable and nonrivalry. The 'public-ness' of a good has often a temporal or spatial dimension which makes almost all goods impure in the strict sense. The notion of 'local' public goods, partially excludable public goods etc. refer to various kinds of impure public goods. A classification of public goods according to different degrees of excludability and rivalry is shown in Table 2, based on OECD (2001).

Whether a good or service is excludable can change due to technological developments. For example, encryption allows broadcasters to sell individual access to their programming, while it was not possible before to exclude everyone with a receiver from receiving the radio signal. It should be emphasized that the property of being 'public goods' is not inherent to a good or a service, but rather determined by the incentive structures provided for the production and/or consumption (Cornes and Sandler 1996).

Table 2: Classification of Private and Public Goods

		Rivalry		
		Non-rival	**Congestible**	**Rival**
Excludability	**Non-excludable**	Pure public goods e.g. National defense	Type II: e.g. Open access resources, lake, forest	Type II: e.g. Open access resources
	Partially	Type I: e.g. Local pure public goods	Type III: e.g. Common property resources	Type III: e.g. Common property resources
	Excludable	Type IV: e.g. Toll road without congestion	Type V: e.g. Club goods	Private goods e.g. A loaf of bread

Source (OECD 2001, p77)

2.2 Externalities

In economic theory, externality refers in general to the impact of an economic transaction on a party (parties) that is (are) not directly involved in the transaction. More formally, Baumol and Oates (1988, 17-18) link externalities with two conditions:

1) An externality is present whenever some individual's utility or production relationships include real (i.e. non-monetary) variables whose values are chosen by others (persons, corporations, governments) without particular attention to the effect on the welfare of the individuals receiving the externality;
2) The decision maker, whose activity affects others' utility levels or enters their production functions, does not receive (pay) in compensation for this activity an amount equal to the resulting benefits (or costs) to others.

They consider an externality to be present if condition 1) is satisfied. The second proviso is required if the externality is to have all of the (un)pleasant consequences (inefficiency, resource misallocation) that are associated with the concept. For this latter reason the phenomenon is sometimes stated to be a Pareto-relevant externality (i.e. an externality that prevents the necessary conditions for Pareto-optimality to be satisfied).

Extensive theoretical treatment of externality can be found in environmental economics where the externality problem belongs to a class of 'no technical solution problems' that require proper social arrangements. In one way or another, all environmental and natural resource problems associated with overexploitation or under provision of public goods, arise from incompletely defined and enforced property rights (Libecap 2009). Arrow (1971) associates externalities with the absence of some markets for the trading of items affecting the welfare of economic agents. Many externalities partake of the character of public goods (Bator 1958). The nonrivalry property of public goods can exist because the quantity of the goods is too high to be depleted. As a further distinction Baumol and Oates (1988) mention a subclass of undepletable and depletable externalities, depending on whether their form or impacts are public (polluted air, water or noise) or rather have a more private character (dumping waste on property)[1].

In a classic paper Viner (1931) made a distinction into technological and pecuniary externalities. In the latter case one individual's activity level will affect the financial circumstances of another's, but need not produce a misallocation of resources in a world of pure competition. Pecuniary externalities result from the changes in prices of some inputs or outputs in the economy, while the underlying technology remains unchanged. Unlike pecuniary externalities, a technological externality involves a shift in the transformation functions relating quantities of resources as independent variables and output quantities or utility levels of consumers as dependent variables. Pecuniary externalities are irrelevant for the optimality of the market equilibrium (they don't introduce divergences between private and social marginal rates of substitution and transformation). Technological externalities have policy relevance as they do cause the divergence between private and social marginal rates of substitution and transformation.

[1] A public good or externality in principle is a commodity that is not depletable (which is similar to non-rivalrous): the use of a unit of the good by one agent does not preclude its use by other agents. Occasionally an externality might, however, have a depletable character in that third parties might have some control over the amount of the externality they receive (be it not without a cost). An example could be that a certain trash externality is generated, where an individual receiving this externality might have some power to pass it on to others. Another example could be acid rain.

Agricultural production generates many externalities. Positive externalities such as wildlife and landscape increase the social value of agriculture, while negative externalities such as environmental degradation have led to increasing social pressure on agricultural production. In justifying public expenditure on externalities, positive externalities are often used interchangeably with public goods (and conversely, negative externalities with public bads). However, positive externalities and public goods, although closely related, are conceptually distinct from each other and have different policy implications. In particular, the number of recipients of the externalities is a crucial factor for policy intervention as they can significantly influence social welfare. To derive policy implications for the provision of public goods, it is necessary to elaborate on the link and distinction of these two concepts (Figure 2).

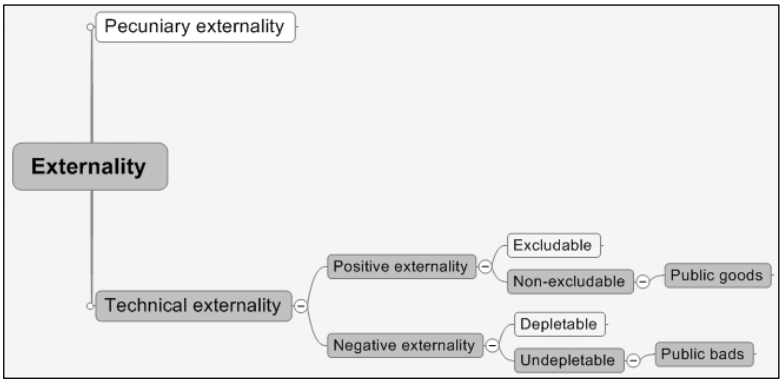


Figure 2: Classification of externalities

2.3 Interconnectedness of production

Depending on the underlying technology, private and public goods outputs may be interconnected in various ways (see Appendix 1). Public goods are interconnected with agriculture through the use of inputs, the production methods, or qualities concerning the private goods produced by agriculture. In general, interconnectedness between public good production and private good production using the same set of inputs might show competition or complementarity in their production possibility sets through different forms of jointness in the production technology. Jointness in production of agricultural commodity and public goods such as landscape and biodiversity is the widely used argument to provide public support to farmers, as the production of public goods is not paid by the market. More specifically, for this case sometimes the argument is made that the public support can be granted in terms of classical price support to the commodity outputs. To the extent this reasoning is valid it raises an argument to justify the traditional way of support to agriculture. As will turn out below, this claim is contestable (see Section 2.4 below for a more detailed discussion).

2.3.1 Jointness

Externalities are often caused by jointness in production, which means multiple products are produced simultaneously but not all of them are simultaneously demanded. It implies also that when these multiple outputs are produced, inputs cannot be assigned specifically to each output. Or formulated in terms of the production function: it includes all outputs as a function of the inputs (Vatn, 2002, P313). In general there are three sources of jointness: 1) jointness due to technical interdependency; 2) jointness in non-allocable inputs (i.e., multiple outputs are obtained from one and the same input, e.g., grassland and meadow); 3) jointness in allocable fixed inputs (e.g., land and labor are typically fixed for one farm but can be allocated to different activities). Overall jointness is a combination of different sources.

The academic attention on jointness of production (joint multi-output production) dates back to the paper by Lau (1972). Traditionally jointness was seen as the primary reason for the existence of the multiproduct firm due to non-allocable inputs (Carlson 1939 (Reprinted 1969)). Carlson noted that, when there is more than one variable input, we must 'go to the relationship between costs and output'. A paper by Shumway, Pope and Nash (SPN, 1984) led to the debate on the existence and causes of jointness in agricultural production. According to these authors, many instances of multi-output production in agriculture are caused by allocable fixed inputs. This statement was questioned by Lynne (1988), who distinguished 'jointness in supply' due to a resource or capital constraint (processes connected behaviorally) and 'jointness in technology' due to technical interdependence. An empirical question regarding jointness is whether the jointness is true, or whether the jointness is temporary or permanent (non-joint technology appear joint in the short run due to fixed inputs or joint technology appear non-joint).

2.3.2 Complementarity

Production in agriculture can also comprise complementarity relationships between outputs and inputs, and inputs and outputs amongst each other. Complementarity between private and public good outputs should be distinguished from their jointness, although both result in a degree of positive correlation between outputs. In case of complementarity between two outputs, the production of one good contributes to an element of the production of a second good (Romstad *et al*, 2000, 12). Here the concerned element is jointly produced with the first output. As such, there is an element of jointness behind complementarity, but the ultimate interlinkage of the two outputs is weaker than in case both outputs would have been jointly produced. Complementarity often occurs within certain ranges. Beyond these the two products might compete for the common factor of production. An example of complementary-competing relationships might be cultural landscape and agricultural production. Agricultural production contributes to an open landscape. Note that in this example agricultural land functions both as an input to agricultural production and as a part of the output landscape. In that respect open area can be seen as a joint product of agricultural production, with the jointness coming from the land input/output use. However, when there would be too much agricultural production the landscape might become too open and for that reason be lower valued. So open area is for a certain range complementary to agricultural production, where at another range both are competing with each other.

2.4 Multifunctionality of agriculture and policy-issues

The concept of multifunctionality was introduced in 1998 at an EU meeting of the agriculture ministers in 1998. It refers to the fact that agricultural production has commodity outputs as well non-commodity outputs which include its environmental impacts and its contribution to rural employment. Beyond its primary function of supplying food and fiber, agricultural activity can also shape the landscape, provide environmental benefits such as land conservation, the sustainable management of renewable natural resources and the preservation of biodiversity, and contribute to the socio-economic viability of many rural areas (e.g. Keyzer *et al*, 2003). Moreover, it plays or might play a role in ensuring food security. As such the multifunctionality of agriculture is closely linked with the externalities or public goods attached to agriculture. It is often believed that agriculture provides the most typical win-win situation for the combined economic growth and enhanced environmental qualities (Vatn, 2002, 309).

In the standard trade theory, with perfect competition, no transaction costs, and only private (no public) goods, the standard result is that free trade secures the highest level of welfare and economic growth for all parties or countries involved (i.e. comparative advantage

theorem). However, the real world is more complex than this standard model, with public goods and bads existing alongside private goods. Moreover, in general externalities play a non-negligible role. The policy debate focuses on rational trade rules for a production process that gives both private and public outputs (Vatn 2002). The moot point is whether it is rational to have free trade for the private goods, while paying separately for the public ones. It is generally acknowledged in the literature that the existence of negative and/or positive externalities will affect welfare and might provide a reason of government interference. The traditional answer to externalities is to introduce corrective taxes or subsides in order to 'internalize' the externality (e.g. Baumol and Oates, 1988) [2]. As is shown by Paarlberg *et al* (2002, 328) corrective policies (Pigovian taxes and subsidies[3]) should be made in such a ways as to include all the externality impacts (both positive and negative). The dominant conclusion from the environmental economics literature is to keep policies aiming at influencing externalities detached from trade policy (see Paarlberg *et al*, 2002) because the impact of trade and trade liberalization on a country's overall welfare depends on whether the countries natural resources are correctly priced, which in return depends on whether appropriate environmental policies are in place. If such environmental policy is not in place, i.e., natural resources are not correctly priced (e.g., prices are lower than the opportunity costs of natural resources), the price mechanism will lead to overexploitation of resources and deterioration of the environment. In this case, free trade is likely to increase the negative effect through increased production volume. However, the problem is induced by the incorrect pricing of natural resources rather than by trade liberalization. As such trade is a magnifier of the negative effect, not a cause in itself (see Anderson and Blackhurst, 1992, also in Vatn (2002)).

An intriguing question is whether the trade rules following from the standard trade model still hold in case private and public goods are connected in production. In principle it could be argued that this result then also holds. However, as is argued by Vatn (2002) in some specific cases their might exist a trade-off where implications for the trade policy cannot be excluded. Two main issues required for this to happen are jointness and transaction costs. If private and public goods are interrelated in production and there are significant transaction costs, then it may not be rational to have free trade for the private good, while separately paying for the public ones. Vatn (2002) argues that in such a situation it could be the case that the efficiency loss due to introducing a trade distortion on the private good might be less than the reduction in transaction costs associated with the jointly produced public good provision.

As is shown by both Paarlberg *et al* (2002) and Vatn (2002) this issue could be brought one step further. When private and public goods are interrelated, the free trade market equilibrium can no longer be argued to be optimal. It might be possible by restricting trade (for example by introducing price distortions) to get an alternative equilibrium for which the gains in public goods dominate the welfare loss at the private tradable goods markets. The prime technical issue here is jointness in production. Of course, such an intervening trade policy would affect trade flows and by that the welfare of third countries. This introduces a prime value question about whose right should be defended when countries have conflicting interests; the one

[2] Later on this result was questioned by the contribution of Coase and his famous theorem. However, the practical relevance of Coase's theorem for the typical agricultural externalities is rather limited (due to for example large number of farmers and the high transaction costs associated with achieving bargaining agreements.

[3] Named after Arthur Pigou, a British economist who introduced these taxes and subsidies. A Pigovian tax is an optimal tax on the (negative) externality generating activity in such a way that the externality is properly internalized in economic behavior. The height of the tax should be chosen in such a way that Pareto optimality in the economy is restored. (In technical terms this implies that the optimal tax equals the marginal externality at the optimal solution).

protecting its public goods or the one that faces reduced export possibilities (Paarlberg *et al*. 2002).
Discussion on multifunctionality converged on three issues: 1) production relationships underlying the multiple outputs of agriculture and the externality and public goods aspects of these outputs; 2) methodological and empirical issues related to the measurement of the demand for non-commodity outputs, criteria and procedures for specifying domestic policy objectives, and mechanisms for evaluating progress; 3) policy aspects of multifunctionality, including its implications for policy reform and trade liberalization.

The nature and degree of jointness in the production of commodity and non-commodity outputs is the principal issue on the production side of multifunctionality. Jointness adds two new elements. First, any change in commodity production entails a change in the levels of the non-commodity outputs that are jointly produced with commodities. Secondly, jointness can create possibilities for economies of scope, i.e., cost savings generated through the joint provision of several outputs as opposed to their separate provision.

It is crucial to establish the extent to which the non-commodity outputs of agriculture are linked to or can be dissociated from commodity production. This has important implications for policy targeting and decoupling. Economies of scale arise if something inherent in the production process makes it cheaper to provide two or more outputs jointly rather than separately. It is important to identify the factors that determine whether or not there are economies of scope in the joint provision of commodity and non-commodity outputs by agriculture. If a technical interdependency is at the root of jointness, a change in the technical relationship is the most direct way of changing the supply of the non-commodity output (OECD 2001). An important policy issue is how to induce these changes.

A final issue on the supply side of multifunctionality is whether some non-commodity outputs can be supplied at a lower cost by non-agricultural providers. In this context it is important to know whether the non-commodity outputs can be separated from agricultural production and resource use.

2.5 Coupling and decoupling of support policy

It is well observed that public income support programmes can influence production decisions. There is an extensive body of literature investigating the effect of decoupled payment on production decisions. A great deal of uncertainty remains about how lump-sum payments influence production. A general consensus is that lump-sum payments have no effect on production with complete and perfect markets. Distortions can occur due to various market imperfections: incomplete labor markets, transaction costs, credit constraints, risk attitude (Hennessy 1998) and the effect of nonpecuniary benefits (Key and Roberts 2009).

Despite the extensive literature, questions concerning the compatibility of multifunctionality with market liberalization remain deeply unresolved (Potter and Tilzey 2007). Support measures can influence the quantity of production through several channels (Zahrnt 2009):
- *Prices*: Policies that raise producer prices apparently stimulate outputs.
- *Risks*: Any agricultural policy that increases farmers' wealth encourages production if, as is likely, wealthier farmers are less risk-averse. Specifically risk-diminishing payments induce additional production among risk-averse farmers.
- *Credit*: If farmers are credit constrained, any payment increases output. First, farmers can directly channel the payments into production. Second, farmers gain better access to credit, under the condition that support is likely to continue well into the future (thus reducing bankruptcy risks and driving up land values that can serve as collateral).

- *Structure*: Support measures influence the structure of production. On the one hand, marginal producers may stay in business if part of the fixed costs can be financed through support programs, (and they may even export at world prices) (see, e.g. Parks 1995). On the other hand, support measures may enable new investments which lead to increasing scale of production.
- *Expectations*: if farmers expect that entitlements for decoupled payments might be updated in the future, they are enticed to build reference quantities.

Based on its policy evaluation model and a series of empirical studies, the OECD (2006) concludes that production and trade effects differ strongly across policy instruments:
- Area-based payments are least distorting;
- Market Price Support (MPS) and output payments have a similar distorting effect that is significantly higher than area-based payments;
- Subsidies on variable input are the most distorting policy instrument.

However, these conclusions are drawn without taking into account of externalities. Considerations on externalities and their impact on national welfare raise the question whether the 'distortive effects' are justified on ground of welfare maximizing (see, e.g. Blandford *et al*. 2000).

3 Public policy and private decision making: theoretical background

3.1 Public policy and the provision of public goods

Externality is one of the main causes for so-called market failure and is often used as justification for policy intervention. Traditionally, the treatment to externality is to introduce corrective taxes or subsides (Pigouvian taxes or subsidies) to 'internalize' the externalities (Baumol and Oates 1988). This once dominant view was challenged by Coase (1960), who pointed out that the real choice was not between an inefficient market and an efficient government solution but rather among a variety of inefficient alternatives, private and governmental. In Coase's words: "All solutions have costs and there is no reason to suppose that government regulation is called for simply because the problem is not well handled by the market or the firm".

While the Pigouvian approach targeted at the generators of externality, Coase's treatment of externality dealt with the reciprocal nature of the problem. The analysis brought forward the role of the recipients of externalities and private initiatives such as negotiation in solving externality problems. As the example of the two neighboring farmers (cattle farmer and crop farmer), negotiation between the recipient and generator of externalities (straying cattle destroying crops) can result in efficient outcome when transaction costs are ignored. However, private initiatives such as negotiation may not lead to Pareto efficient outcomes when the number of recipients is large, due to high transaction costs and free-rider problem. Therefore, as Baumol and Oates (1988) pointed out, the importance of Coase's contribution does not undermine the relevance of public intervention as most environmental problems or resource problems concern large number of recipients.

Based on the nature and policy relevance, Table 3 provides a taxonomy of various externalities. In general, the externalities that are relevant to public policy are the 'public good' varieties involving large number of recipients. The relevance, however, is only a necessary condition for policy intervention since policy intervention may have its own 'failures' as will be explained later. As Table 3 shows (see top line and most left column) in case of a positive externality and excludability, there is no need (not relevant) for policy interference. As explained before, the reason is that pecuniary externalities are in general well taken into account in market exchanges so that no further policy correction is needed. Other cells can be read in a similar way.

Public intervention is not automatically justified if the 'good' is identified as 'public good' or 'market failure' exists. As noted in academic debate, the discussion whether market or government can do better is misleading (Holcombe 1997; Hausman 2008). Government intervention with respect to a specific market faces major problems: a) Administrative costs; b) Lack of information; c) Rent-seeking; d) Unforeseen consequences for other markets; e) inflexibility; and f) corruption. After Coase, it is widely accepted that government as well as market can 'fail'. Whether policy intervention and which type of policy intervention is desirable has to be based on cost and benefit analysis of alternatives and the nature and implications of the externalities.

Table 3: A taxonomy of externalities and their policy relevance (whether there is or is not a need for corrective government action)

Effect		**Positive externality**		**Negative externality**	
Characteristics		**Excludable**	**Non-excludable**	**Depletable**	**Non-depletable**
Nature	**Pecuniary**	Not relevant*)	Not relevant	Not relevant	Not relevant
	Technical	Not relevant	Relevant	Not relevant	Relevant
Number of recipients	**Small number**	Not relevant	Not relevant	Not relevant	Not relevant
	Large number	Relevant	Relevant	Relevant	Relevant

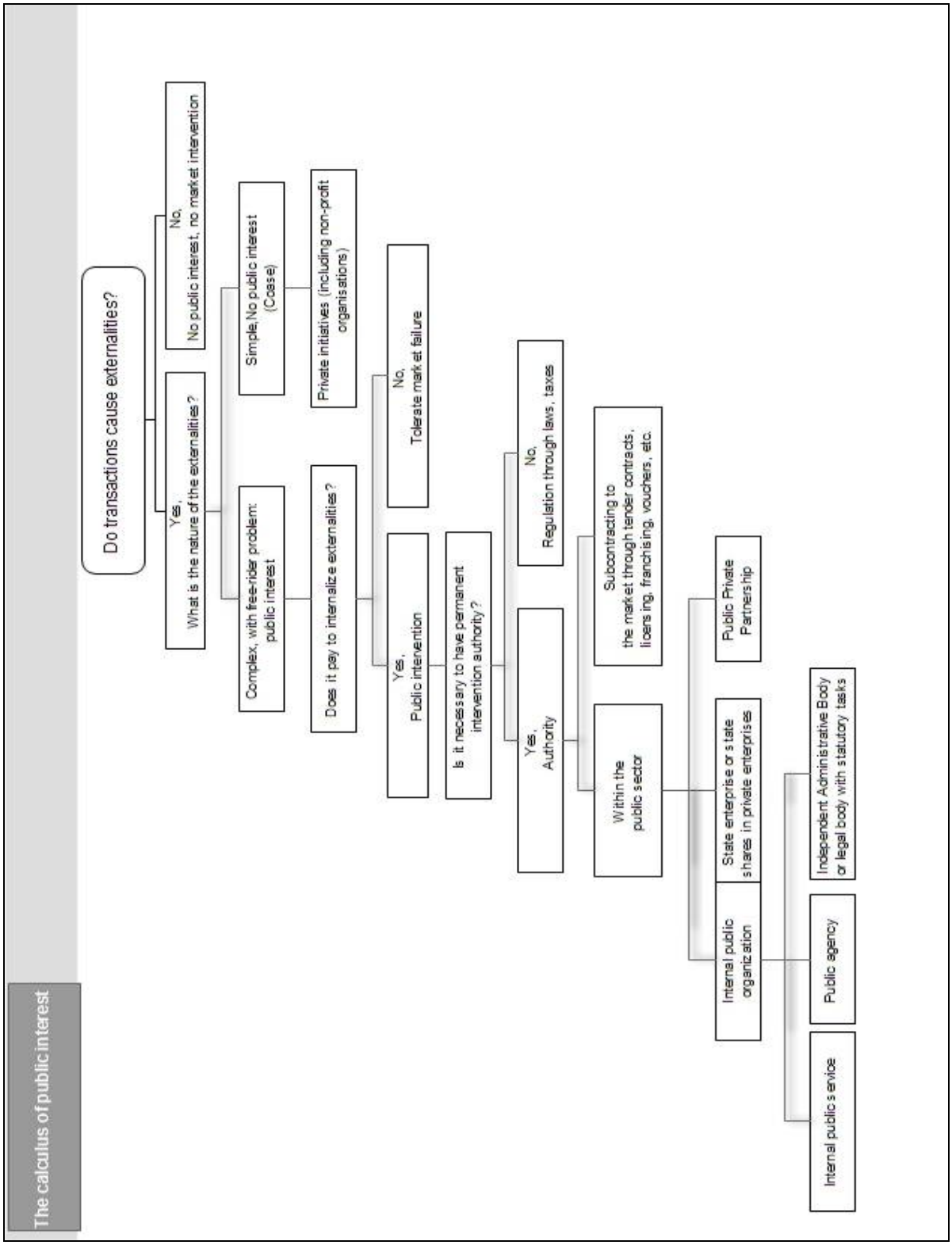
*) See main text for interpretation of cells. "Not relevant" means that in principle (from an efficiency perspective) no government action is required.

Teulings *et al.* (2003) analyzed the necessity and form of policy intervention and provided guidelines for the selection of public intervention. Figure 3 shows the roadmap they proposed in determining the necessity and selecting the proper form and instruments of policy intervention. When transactions cause no externalities, market intervention is not necessary. When externalities are of a simple nature, they can be left to private initiatives such as negotiation (c.f. Coase). Even though complex externalities with free-rider problem exist, it remains to be determined whether it pays to internalize the externalities through public intervention. The problems mentioned above can make it preferable to tolerate market failure because government intervention can fail as well.

When public intervention is necessary, Figure 3 indicates different forms of intervention, which imply different types of relationships between the government and the concerned agents. The intervention arrangements vary from regulation to in-house production by the public sector. It is important to note that different relationships entail different information needs for the administrator and incentive schemes for the concerned agents. Choice of intervention forms and instruments depends on their feasibility and implementation costs, which can be strongly influenced by the behavior of the concerned agents in terms of compliance or participation. In the face of information problem, a principal-agent (eg. policymaker-farmer) type intervention may induce opportunistic behavior. A partnership relationship, for example, may encourage efforts for mutual benefits. Good attention should therefore be paid to possible behavior of the concerned agents in choosing public intervention[4].

Government as an institution plays a key role in organizing the provision of public goods by setting public good policy and using policy instruments. The types of public goods, social values and ability to estimate economic values of the public goods affect the selection of public good policy and policy goals. Consequently, the choice of policy instruments depends on the policy goals, and should in principle change to the broader societal goals. A good overview of policy instruments can be found in Cubbage *et al.* (2007), ranging from free markets, to education and research, to incentives, to regulation, to government ownership and allocation.

[4] Further treatment of this issue is beyond the scope of this research project. See also Jongeneel *et al* (2009), which provides the results of a counterpart of this project and provides an alternative evaluation scheme for assessing the match between policy objectives and instrument use in the domain of biodiversity, water, and environment.



Source: Teulings *et al.* (2003, P201)

Figure 3: The calculus of public interests

3.2 Agri-environment policy

Public good policy related to agriculture aims to stimulate the provision of many environmental amenity services by agriculture and is commonly referred to as agri-environment policy. Agriculture is an atypical sector in terms of production and marketing due to the use of land and the connection between land and landscape. One justification of public support to agriculture is that the social values of agricultural is not paid. These social values include the reduction of negative externalities (some of which are 'public bads') and the generation of positive externalities (some of which are public goods). The difficulties faced by policies aiming at internalized externalities are the jointness of production.

In dealing with negative externalities such as pollution, a well-known principle in environment economics is the 'polluter pays principle' (OECD 1979). Similarly, public policy on the provision of public goods as positive externalities operates on the 'producer gets principle', i.e., producers of public goods receive remuneration for their inputs (Hanley *et al.* 1998). Economic analysis of a policy that remunerates provision of public goods would require information on both the supply price and demand price (willingness to pay). Supply price would be expected to vary across farmers, because of heterogeneity in farms and public goods which lead to different opportunity costs for the supplier (Hanley *et al.* 1998).

On the demand side, it is up to the policy makers to define the public goods. Public consultation can be done through the 'stated preference methods'. (see e.g : (Brower 2008). The most known stated preference methods are the contingent valuation methods. (CVM) and choice experiment. Stated preference methods are used in contrast to revealed preference, which are based on the observed behavior of the consumer.

One of the 'market failures' in supplying public goods is that a market for the public goods is missing. Government intervention can however create a market-like mechanism which induces the farmer to internalize costs or to receive remuneration for their contribution. There may be limits to what can reasonably be achieved by means of agri-environment contracts. Alternative social arrangements are suggested, for example, the role of non-profit organizations, donations etc. (Hodge 2001).

3.3 Challenges in the design of agri-environmental policy

Challenges faced by policy intervention are essentially due to two problems: information problem and value problem.

3.3.1 Information problem

Within the scope of agri-environmental policy, the most central public goods elements are landscape values (biodiversity, cultural heritage, amenity value of the landscape, etc.), food related aspects (food security, food safety, and food quality) and rural activities (rural settlement and economic activities) (Romstad *et al.* 2000). These goods are normally site or region specific[5]. Effective regulation and taxes require that politicians and regulators have information not only about social costs and optimal levels of production, but also about the (often varying) private production and compliance costs of individual users. This is a requirement that few regulators can meet.

[5] The counterpart project (see previous footnote) further explores the spatial aspect and the implications for policy making this raises.

A challenge to policy is that the economic valuation of many 'public goods'. Stated preference methods are often used to estimate the willingness to pay of the public, such as biodiversity (Christie *et al.* 2006) , landscape (Hanley *et al.* 2007).

As commonly observed in the literature on public goods, public goods yield private prices in the sense that the marginal costs and benefits of public goods are unknown to the 'public' or the public administrator. Theory of mechanism design demonstrated that efficient provision of public goods can be achieved by mimicking markets. Policies that contain signaling mechanisms of prices such as auctions facilitate economically more efficient decisions for the producers (Romstad 2008). A major challenge for public policy is therefore how to design the institutional framework.

3.3.2 Value problem and additionality

The value problem of public policy concerns moral and ethical standards that are used to make and judge the policy, in particular, issues such as rights and fairness can come into play.

The rights issue is particularly relevant to externalities. When negative externalities are generated by the use of privately owned resources such as land, it can be argued whether the generator should be punished since he has the right to use the resources. As pointed out by Coase, the problem of externalities has a reciprocal nature. The problem would cease to exist when there is no presence of the receiver. Whether the right of the generator (to use his resources) or the right of the receiver (not to be harmed) should be protected constitutes a value problem which requires political resolution.

With regard to fairness, one well known issue is the additionality criterion, which credits or rewards economic entities only for undertaking actions or projects that are motivated by a given policy. Actions or projects that have happened or will occur anyway (i.e., without the policy) are not rewarded even though they achieve the same goal of the policy. An important policy issue related to additionality is that the choice of baseline can 'penalize good actors for doing the right thing early'. Moral hazard can arise as a result of the additionality criterion since actors may have an incentive to switch back to conventional practice in order to be able to again adopt new practice required by the policy.

3.3.3 Payment schemes

When it is clear that certain public goods are desirable, as is reflected in a positive willingness to pay expressed by society, a next step is as how to provide the means and incentive to organize an adequate delivery of these goods (or externalities). As is known from the environmental economics literature, in general, it is not trivial whether one should let those who receive the benefits of the public goods also to pay for it.

Take as an example, an agriculture causing a positive externality (e.g. a nice landscape). Assume the government introduces a Pigovian subsidy aimed at ensuring the delivery of landscape services, and equal to the marginal social benefit caused by agriculture's positive externality. As a result agriculture is likely to introduce certain activities aimed at an optimal delivery of the landscape services. With the subsidy level properly chosen the provision of landscape services level would be optimal, i.e. a level in accordance with the society's (positive) valuation. Given that an attractive landscape is produced the beneficiaries undertake certain actions or activities (for example spent holidays in own region rather than elsewhere; some people living in the country might try to move to the attractive landscape). It can be proved that the induced level of 'consumption' activities that will be undertaken at this optimal

level of delivery landscape services by the beneficiaries is just efficient (Baumol and Oates, 1988, 20 and 43). Note that the private actions made by individual beneficiaries do not change the level of 'consumption' of noise by other beneficiaries (public good).

As an alternative the government could try to impose a tax on the beneficiaries[6], for example with the aim to finance the Pigovian subsidy given to agriculture. When the government would introduce a (consumption-)tax on the people living in the landscape, for example, less people valuing landscape are likely to move into the attractive region than in case without a tax. This is irrespective of the level of the public good provided. So the net impact of the tax on beneficiaries could be to reduce their level of consumption. Too few people would choose to enjoy the landscape services. This is clearly inefficient, because more people could enjoy the landscape without their consumption being at the cost of anyone else's consumption (NB landscape is here interpreted to be a real public good). This result is a specific translation of a more general result derived by Baumol and Oates (1988, Chapter 4):

> *In the presence of an externality, optimal resource allocation calls for pricing that involves zero taxation and zero compensation to those affected by the externalities (but non-zero taxation of their generators).*

There are some exemptions to this general rule, in particular when the number of recipients (victims or beneficiaries) is small[7], or the externality is shiftable. The main lesson is that introducing a general price (or price distortion) cannot do the job. In cases like this price asymmetry is required: a non-zero (positive or negative) price for the generator of the externality and a zero-price for the victim or beneficiary of the externality. Ordinary prices by their nature are symmetric between supplies and consumers. Only Pigovian taxes (negative externality) or subsidies (positive externality) satisfy this asymmetry criterion and therefore can be candidates for an efficient solution (Baumol and Oates, 1988, 29).

[6] For example, this could be a tax on all people living in the landscape, or a tax on people which are visiting the landscape for its attractiveness (e.g. a tourist tax).
[7] This now famous argument was raised by Coase (1985).

4 Impact of Policy Instruments on Farmer's Behavior: A Formal Analysis

4.1 Conceptual model of farmer's participation decision

Farm decision making has distinct features due to the use of natural resources which can cause externalities and quasi-fixed inputs that can lead to jointness of production. At the same time, farming is a business which interacts with the market through commodity inputs and outputs. An overview of the relationships is shown in Figure 4.

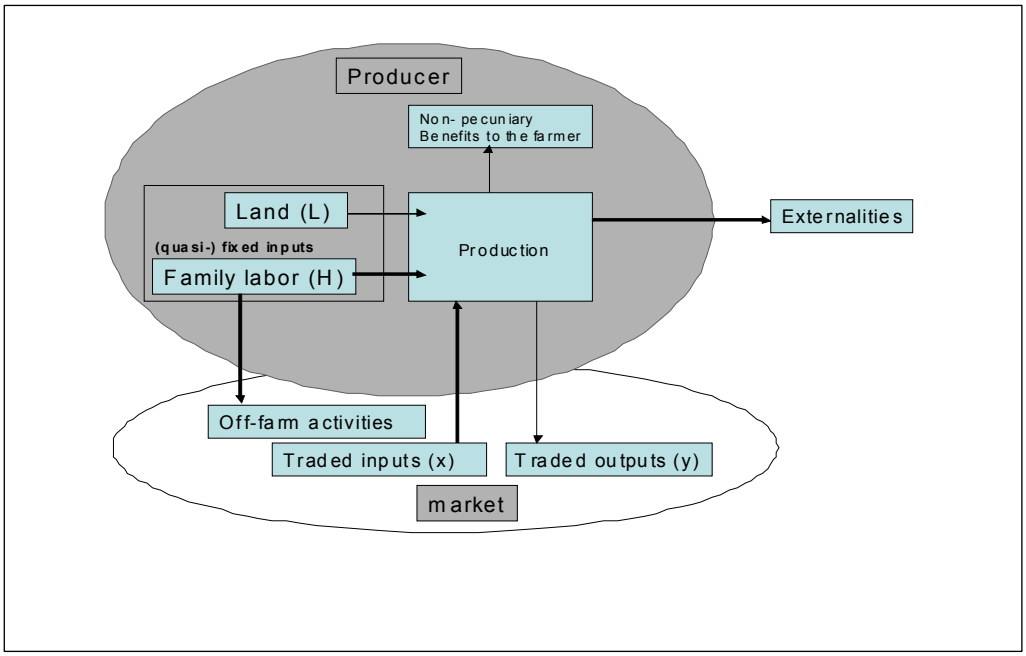


Figure 4. Internal and external linkage of agricultural production

Economic theory suggests that behavior is driven by a rich set of attitudes, values and preferences (Becker 1993). An increasing literature suggests that behavior of farmers is not driven only by the maximization of profits (e.g. Willock *et al*. 1999; Wynn *et al*. 2001; Dupraz *et al*. 2003; Defrancesco *et al*. 2008; Jongeneel *et al*. 2008). A strict profit maximization framework fails to encompass other values, beliefs, attitudes and intentions that can greatly influence economic behavior. A theory of behavior is needed to link psychological processes to economic decisions (Lynne *et al*. 1988). In other words, economic modeling needs to incorporate values, beliefs, attitudes and intentions of the decision-maker and integrate socio-economic psychological and farming variables into a comprehensive framework. Based on Vanslembrouck *et al*. (2002), such a framework is constructed and shown in Figure 5.

The central assumption of the conceptual model is that farmer's behavior is not only influenced by farmer and farm characteristics, but also by the characteristics of the requirement practices, and the payment scheme. Incentives and constraints that determine the participation decisions are formed by the decision context as well as intrinsic motivation of the farmer.

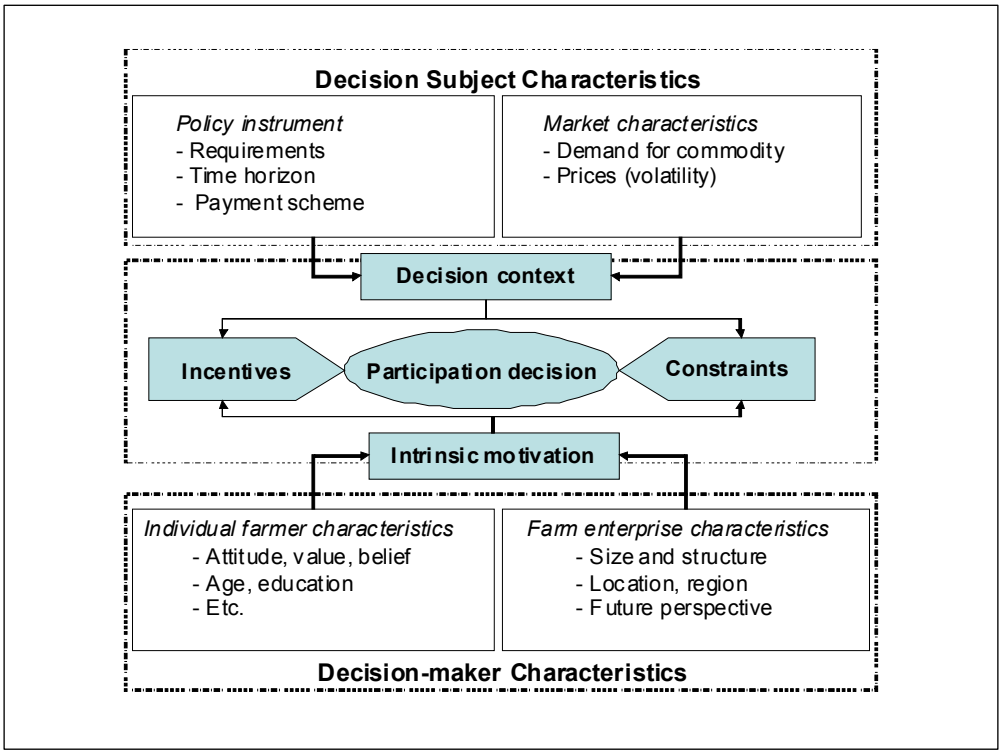


Figure 5. Conceptual model of the participation decision

4.2 Incentive for the agricultural producer

The conceptual model highlights the joint role of intrinsic motivation and decision context in shaping the incentives and constraints of participation decision (Table 4). The decision context refers to the characteristics of the decision subject, which consist of so-called scheme characteristics (characteristics of policy instruments) and market characteristics. Farm and farmer's characteristics determine farmer's intrinsic motivation to participate in the provision of public goods. This conceptual model can accommodate the observation that contribution to public goods can be motivated by intrinsic factors such as warm glow altruism and fairness, as well as extrinsic incentives such as sanctions and payments. Including attitudes in the conceptual model allows the consideration of non-pecuniary benefits of farming such as personal enjoyment of working on-farm, moral satisfaction through countryside stewardship (taking care of soil quality, biodiversity and landscape).

Theoretical and empirical evidence show that economic decisions are shaped by a range of motivations. It is sometimes observed that private contribution to public goods are not motivated by economic costs and benefits alone, but that people also have a moral or norm-based motivation. When ranges of motivations are present, a point of attention in the design of public good policy is the possible 'crowding out' effect of policy intervention. Psychological studies suggest that formal extrinsic incentives may crowd out intrinsic motivations (Reeson and Tisdell 2008). Some of the ideas from evolutionary biology indicates that provision of public goods can be an altruistic act out of the farmer's concern for the well-being of the society (Manner and Gowdy 2008). In this case, policy intervention may unintendedly crowd-out private provision of public goods.

Table 4: Incentives, constraints and indicative impacts generated by typical policy instruments

Policy instruments	Incentives and constraints	
	Pecuniary	**Non-pecuniary**
1. Area payment based on flat rate per hectare	- Increasing on-farm income - Reducing risk	Dedicating more time to working on-farm
2. Area payment with differentiated rate per soil type	- Increasing on-farm income - Reducing risk	- Dedicating more time to working on-farm - Better taking care of soil quality
3. Compensation scheme based on cross compliance (fixed)	- Increasing income possibility - Possible cost saving by adapting production technology	- Dedicating more time to working on-farm - Using environmental friendly technology
4. Compensation scheme (reward based on public goods outputs)	- Increasing on-farm income possibilities - Possible cost saving by adapting production technology - Possible cost saving by adapting production technology	- Increasing level of environmental goods - Dedicating more time to working on-farm - Using environmental friendly technology

4.3 The economic model

A utility maximization framework is used to understand and model producer behavior with respect to the provision of public goods. Consider that the agricultural producer's utility is determined by his monetary income (profit from production of marketed commodities, supply family labor to off-farm labor market, and net reward from provision of public goods), non-pecuniary benefits from on-farm production activities and leisure. Denote the utility function for a producer *j* as $u^j(I,B,R)$

with:

I = monetary income;

B = non-pecuniary benefits of farm production, modeled as a function of family labor used for on-farm production;

R = Leisure.

The superscript *j* is dropped when only one producer is considered. The form of the utility function is shaped by the farmer's value, attitude, and belief and differs therefore among farmers.

Following (Key and Roberts 2009), we also use an additive utility form, i.e.:

$$u(I,B,R) = U(I) + B(h) + R(r),$$

where:

$$I = py + mw - xq - vl - F,$$

with

y = marketed outputs (vector of marketed outputs in case of multiple outputs)

p = output price (vector of output prices in case of multiple outputs)
w = wage at the labor market
l = amount of land
m = off-farm labor work
r = leisure time
h = family labor used for on-farm production
x = marketed variable input (vector of marketed inputs in case of multiple inputs, including hired labor)
q = input price (vector of input prices in case of multiple inputs)
v = fixed costs per hectare, these are fixed costs related to the use of land
F = fixed costs per farm, examples of the fixed costs are for example maintenance costs of machinery, rent costs for buildings, etc.

Further, we assume

$$U_I \succ 0, U_{II} \prec 0;$$

$$B_h \succ 0, B_{hh} \prec 0; \text{ and}$$

$$R_r \succ 0, R_{rr} \prec 0,$$

indicating a concave utility function and aversion of risk when income or other benefits are uncertain.

Family labor is modeled as an allocable fixed input which, when used for agricultural production, can bring non-pecuniary benefits to the farmer[8]. Family labor can also be employed in the labor market (off-farm work), in that case, the producer receives wage income from supplying the labor to the labor market[9]. Hired non-family labor is considered as marketed input.

To simplify the analysis, capital constraint is not considered. Instead, it is assumed that the farmer has perfect access to the capital market and capital is a marketed input with known prices. It should be noted that high debt ratio can lead to solvency problem for the farm. This can be extremely relevant in economic recession when it becomes difficult to obtain credit. Incentive to increase income may become overweigh by other considerations when there is severe capital constraint.

Considering the interconnectedness of the two production activities through fixed inputs (land and labor) and other possible technical interdependence, denote the joint production technology as:

$$F(y, Q, l, h, x; z) = 0$$

where
Q refers to non-commodity outputs (possible public goods that are valued by the society) and z indicates resource conditions such as soil quality. The joint production technology implies a production function for the commodity as:

$$y = f(l, h, x; z)$$

[8] This could be further refined as having the farmer getting different non-pecuniary benefits from traditional marketed outputs y and non-commodity outputs Q.
[9] There might also be non-pecuniary benefits associated with off-farm employment, but this is ignored.

and a production function for the non-commodity good:

$$Q = g(l, h, x; z)$$

Both production functions refer to the frontier of the production possibility sets.
Depending on the interconnectedness of public goods production and commodity production, production inputs l, h, x may or may not be allocable to the two production activities. When inputs are allocable or distinguishable, they are subscript with '1' for commodity production and with '2' for public good production.

Based on Romstad *et al.* (2000), the relationships between the two production functions can be described within the framework of output possibility sets and functional relations. In terms of output possibility sets, interconnectedness between private goods and public goods can demonstrate complementarity or competing relationship, as shown in Table 5.

Table 5: Interconnectedness of commodity and non-commodity production in terms of output possibility sets

Interconnectedness	**Competing**	**Complementary**
Commodity	$y = f(l_1, h_1, x_1; z)$	$y = f(l_1, h_1, x_1; z)$
Non-commodity	$Q = g(l_2, h_2, x_2; z)$	$Q = g(l_2, h_2, x_2; z)$
Output relationship	$\frac{dQ}{dy} < 0$	$\frac{dQ}{dy} > 0$

Complementarity between production of private goods and public goods means that increased private goods production expands the production possibility set for public goods production and vice versa. See Figure 6 for a graphical illustration: the left part of the production possibility curve shows an increase in Q with an increase in y (e.g. $\partial Q / \partial y > 0$) i.e. complementarity. This means that policy support that increases private goods production will favour the production of public goods. On the other hand, a competing relationship means that increased public goods production causes a downwards/inwards shift of the production frontier of private goods, which means that the producer will be reluctant to increase public goods production. In Figure 6 this is illustrated for the region where *y* is greater than *c*. Identifying complementarity and competing relationship is therefore highly relevant in stimulating the provision of public goods. As Figure 6 also illustrates the trade-off between the private and public output may not be constant, but could change with changing levels of private output y. Finally, Figure 6 (see lower right part) suggests that with very low levels of *Q* there might be complementarity: gains in *Q* can be easily realized without harming private output y[10].

[10] Figures like this one are easily drawn (see also Romstad *et al*, 2000) but should be treated with care if there is no supporting underlying formal analysis. In general the non-convex parts of a technology belong to the so-called non-economic region. For example, even in the case of a zero remuneration for Q (which would imply a vertically sloped relative price line) the optimal output mix would be a point in the non-complementary regions. In other words, the economic part is in general limited to the fat part of the PPF.

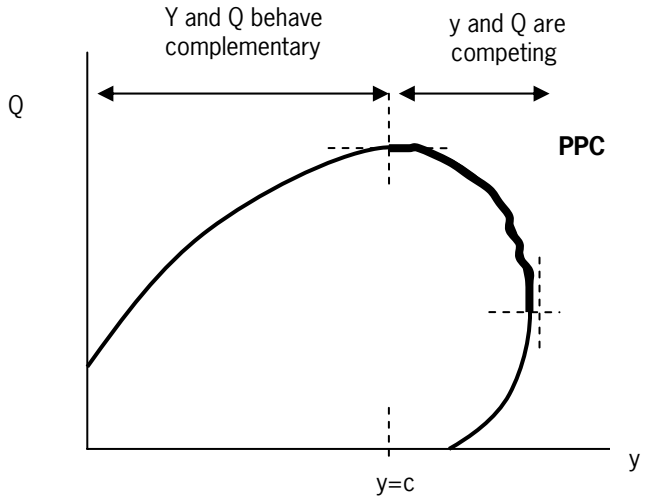


Figure 6: Trade-off between Q and y and the production possibility curve PPC

Within the functional framework, public goods production and private goods production may shown jointness through the use of inputs or the choice of production methods (Table 6). The existence of different forms of jointness means that the provision of different public goods may have different impact on the production of private goods and entail different choice problems. It is therefore important to distinguish the specific form of jointness in modelling farmer's decision making with regard to the provision of public goods (non-commodity outputs).

Table 6: Functional jointness between commodity and non-commodity production

Jointness of production	**Inputs into production**		**Modes of production**
	Non-allocable inputs	**Allocable fixed inputs**	
Commodity	$y = f(l, h, x; z)$	$y = f(l_1, h_1, x_1; z)$	$y = f_i(l, h, x; z)$, where *i* indicates a production mode.
Non-commodity	$Q = g(l, h, x; z)$	$Q = g(l_2, h_2, x_2; z)$, with $l_1 + l_2 = l;$ $h_1 + h_2 = h;$ $x_1 + x_2 = x;$	$Q = g(i)$
Technical relationship	$\frac{dQ}{dy} > 0$	$\frac{dQ}{dy}$ depends on $f(.)$ and $g(.)$	$\frac{dQ}{dy}$ depends on the production mode

Jointness through the use of inputs can occur when inputs are non-allocable (for example, animal as input for meat and manure) or allocable fixed inputs (i.e., land can be allocated to arable production or set-aside, but the total area of land is fixed.). When inputs are non-allocable, public goods are simultaneously produced with private goods, for example, grass

and meadow landscape use the same land. Policy instruments that increase the production of private goods will automatically increase public goods. For allocable fixed inputs, allocating part of a fixed input to public good production restricts the use of the input for private goods production. It does not necessarily follow that the production of private goods will be reduced due to possible substitution among inputs. The impact of public good production on private good production depends therefore on the specific shapes of the two production functions. Jointness through production mode means that public goods is a feature of certain production mode (for example, different farming system). In this case, provision of public goods requires switching among different production possibility sets (applying different production techniques or different farming styles), rather than within one possibility set.

4.4 Farmer's behavior in the provision of public goods

Different policy instruments pose different decision problem to the farmer and consequently induce different behavior. In general, following decisions are made with respect to a certain policy scheme:

- **Whether** to participate in the policy scheme (participation decision); This decision implies that the policy scheme is offered once-only.
- **When** to participate in the provision of public goods (timing decision); This decision is relevant when the policy scheme has a lasting, or multi-period nature, i.e., the participation decision can be made in the next period.
- **How** to participate in the provision of public goods (intensity decision), i.e.:
  - Technology choice (input use, intensive or extensive)
  - Land allocation (according to the quality of land, location)
  - Labor allocation (leisure, on-farm labor and off-farm employment)

To understand the farmer's reference point, it is important to gain insight into the baseline situations of the farmer without participation in the policy scheme for the public goods provision both in present and in the future. The decisions a farmer makes not only concerns current situation, but also may have consequences for the future. Both current situation and future expectations are important in farmer's decision making and should be considered. Expectation of the future plays a central role in rational choice theory, especially when decision-making involves choice under risk and uncertainty. The analysis that follows deals with situations without risk and uncertainty. In Chapter 5, considerations of risk and uncertainty will be introduced.

4.4.1 Farmer's basis situation without remuneration

Consider the basis situation in which there is no remuneration for the provision of public goods, the producer solves his utility maximization problem as follows:

$$\underset{l_1,h_1,m,x_1}{Maximize}\ \ u(I,B,R)=U(I)+B(h)+R(r)\,,$$

subject to:

$$l \le A;$$

$$h+m+r=H;$$

$$l,h,m,r,x \ge 0;$$

where:

$$I = pf(l,h,x,Q;z)+mw-xq-F-vl\,. \qquad (1)$$

with
A = total land area (endowment, in hectare);
H = total available family labor (endowment, in hours).

The Lagrangian is:

$$L(l,h,m,r,x) = U(I) + B(h) + R(r) - \lambda(l - A) + \mu(H - h - m - r) \quad (2)$$

The Kuhn-Tucker conditions for this problem are:

a) Land allocation

a1) $L_l = U_I(pf_l - v) - \lambda = 0$; (3)

a2) $\lambda \geq 0$; (non-negativity constraint) (4)

a3) $l \leq A$ (feasibility constraint) (5)

a4) $\lambda(l - A) = 0$; (Complementary slackness) (6)

Interpretation: If land is not a binding factor, i.e., $\lambda = 0$, condition a1) becomes $U_I(pf_l - v) = 0 \Rightarrow pf_l = v$, the farmer uses land for commodity production up to the point where the value of the marginal product equals the fixed cost per hectare. This implies that when the value of the marginal product is lower than the fixed cost (for example, due to low soil fertility or high rent for land, or high land price), the farmer may abandon the land (fallow or sell).

In the case when land is binding, i.e., $\lambda > 0$, land is fully employed in commodity production ($l = A$). The shadow price of land equals the marginal utility derived from the marginal profit, i.e., $\lambda = U_I(pf_A - v)$. This condition suggests that the opportunity cost of land when allocated to public good production depends both on land use intensity (marginal productivity of land) for commodity production and level of monetary income. Since farmer's marginal utility decreases with the level of income (i.e., $U_{II} \prec 0$), farmers with higher income would have lower opportunity cost than farmers with lower level of income, given the same level of land use intensity. Similarly, farmers with higher land use intensity have lower opportunity costs than farmers with lower land use intensity, given same level of income. This implies that for the same level of compensation, farmers with higher level of income and high land use intensity will be more prone to accept the compensation than farmers with lower level of income and lower land use intensity.

b) Labor allocation on farm, off-farm and leisure

b1) $L_h = pU_I f_h + B_h - \mu = 0$; (7)

b2) $L_m = U_I I_m - \mu = wU_I - \mu = 0$; (8)

b3) $L_r = R_r - \mu = 0$; (9)

Interpretation: From b1), b2) and b3), we have: $\mu = U_I pf_h + B_h = U_I w = R_r$. The shadow price of family labor is the sum of utility derived from marginal production value and marginal non-pecuniary benefits derived from working on farm.

c) Input use

c1) $$L_{x_1} = U_I I_{x_1} = U_I (pf_{x_1} - q) = 0; \quad (10)$$

Since $U_I \succ 0$, this gives $pf_{x_1} - q = 0$, which simply states that the value of the marginal product of input equals its market price.

To gain insight in the possible impacts of policy instruments on the allocation of quasi-fixed inputs, we can look at the comparative statics of the key variables. For example, policy instruments such as area payment has the effect of reducing *v*, the fixed cost of production per hectare. To gain insight on their possible impact on equilibrium labor allocation, we can look at the comparative statics of h and m with respect to the fixed cost *v*. Assuming interior solution, the second order condition gives:

$$L_{hh} = U_{II}(pf_h)^2 + B_{hh} + R_{rr} < 0; \quad (11)$$

$$L_{mm} = wU_{II} + R_{rr} < 0; \quad (12)$$

$$|H| = L_{hh}L_{mm} - (pU_{II}f_h w + R_{rr})^2 > 0; \quad (13)$$

Replacing the shadow price $\mu = R_r = R(H - h - m)$ and total differentiating equation 7) and 8) with respect to h_1, m and v by replacing the shadow price with $\mu = R_r = R(H - h - m)$, using Cramer's rule, we have:

$$\frac{dh}{dv} = \frac{R_{rr}U_{II}(pf_h - w)}{|H|} < 0 \quad (14)$$

$$\frac{dm}{dv} = \frac{U_{II}w(U_I p^2 f_{hh} + B_{hh}) + U_{II}R_{rr}(pf_h - w)}{|H|} > 0 \quad (15)$$

The comparative statics shows that *ceteris paribus*, an area payment that reduces the farmer's fixed per hectare cost of land would increase on-farm labor and reduces off-farm supply. Area payment also influences opportunity costs of land and labor by changing the marginal utility of income. The area payment can therefore in the long run change the production structure (for example, substitution effect of labor and other inputs).

Based on the analysis above, Table 7 summarizes opportunity costs for key production inputs and the factors that can influence these opportunity costs. The information can be used to infer farmer's opportunity cost in participating in a specific policy scheme and understanding their participation behaviour.

In the basis situation, a farmer can produce public goods due to three reasons:

1) Public goods enter the utility function through non-pecuniary benefits;
2) Public goods do not enter the utility function directly, but forms the shape of the utility function through other moral motives such as altruism, responsibility for countryside stewardship;
3) The producer doesn't derive utility from the public goods, but the public goods is jointly produced due to technical interdependency with commodity production.

Table 7: Farmer's opportunity costs for the provision of public goods

Production inputs	**Opportunity cost**	**Factors**
Land allocation (l)		
$l_1 = A$	$\lambda = U_I(pf_A - v)$	- Attitudes that determines the shape of $U(.)$; - Income level which determines the marginal utility of income; - Fixed per hectare cost of land (for example, rent) which can shift income level and changes the marginal utility of income; - Commodity prices; - Productivity of land (influenced by soil quality, etc.)
$l_1 < A$	$\lambda = 0$	
Family labor (h_1 , or r)		
$m = 0$ This can occur in two situations: 1) There is no off-farm employm opportunity; 2) The off-farm wage level is lower than ($U_I pf_h + B_h$), i.e., marginal utility derived from the value of marginal production of labor on farm as well as from non-pecuniary benefits of farming.	$\mu = U_I pf_h + B_h$ $= R_r$	- Attitude that determines the shape of $u(.)$ and B(.), especially, marginal utility of monetary income and non-pecuniary benefits; - Commodity prices - Marginal productivity of family labor on farm - Off-farm employment opportunity - Age, education etc. which determines the possibility of being employed off-farm - Farm location, which can influence the accessibility to labor market and therefore the possibility of off-farm income
$m > 0$	$\mu = U_I w$ $= U_I pf_h + B_h$ $= R_r$	
Variable input (x)	$q = pf_x$	- Commodity prices - Marginal productivity of variable inputs

4.4.2 Participation decision based on opportunity costs

Using rational choice theory, the farmer will participate in the policy scheme for the provision of public goods if and only if the participation increases the maximized utility $u(l^*, h^*, x^*, m^*, r^*, Q^*)$, i.e., $du(l^*, h^*, x^*, m^*, r^*, Q^*) \geq 0$. This requires a close look at the necessary changes that must be made to comply the policy and their net impact on the utility of the farmer. Based on the utility function of the farm, we have:

$$du^* = U_I pf_{l^*} dl + (U_I pf_{h^*} + B_{h^*})dh + U_I w dm + U_I (pf_x - q)dx + R_r dr$$

and from the first order conditions in 4.4.1, this becomes $du^* = \lambda dl + \mu(dh + dm + dr)$, the decision rules states therefore a rational farmer will only participate the policy scheme if the use of quasi-fixed inputs is compensated at least at their opportunity costs. It is therefore necessary to identify the changes the policy instrument would cause to commodity production and compensating them according to their opportunity costs.

Farms and farming practices vary across the country. Heterogeneity of farms and farmers implies heterogeneity of opportunity costs and production possibilities. For example, need for farm labor can have seasonal variation. In peak seasons (e.g., sowing or harvesting), the supply of farm labor will be higher for arable farming.

Many factors influence farmer's opportunity costs through commodity production function. For example, soil quality differs in different area which leads to variations in land productivity. Location of a farm can lead to different transaction costs to the farmer. Location of farm can also determine the potential of the farmer as a provider of public goods. For example, public goods such as landscape and biodiversity are often only possible in certain regions or certain locations.

Some empirical evidence confirmed these theoretical insights. For example, Hynes and Garvey (2009) found that farmers associated with a poor soil type are more likely to enter the Irish agri-environmental scheme REPS. This highlights the importance of taking into account of unobserved heterogeneity of farm- and farmer-specific characteristics when considering the opportunity costs of participation in voluntary agri-environmental schemes, or of determining the minimum compensation necessary to induce specific groups of farmers, or farmers at a specific location to participate.

4.5 Policy instruments towards provision of public goods

Targeted policy steps in where markets fail to reach sufficient provision of public goods. Traditionally, economic theory recommends externalities to be 'internalized' through direct control, subsidy and taxes. Relatively new, payment schemes based on the provision of public goods are already for some time present in the agricultural policy debate (e.g. the CAP's Agri-Environmental (AES) second pillar policies). As another example see Keyzer *et al* (2003, 37-39) who offers a suggestion and proposal to transform the EU's single farm payment scheme to a payment scheme for well-defined multifunctional services from agriculture.

Unlike commodity outputs, public goods as non-commodity outputs of agricultural production usually do not have well-defined qualities and units. As noted by Cornes and Sander (1996), however, public goods and externalities are incentive structures rather being inherently associated with certain activities. Identification and specification of the public goods is

therefore a critical step in designing policy instruments. When choosing policy instruments, it is also important to consider different degrees and mechanisms of the interconnectedness between commodity and non-commodity (potentially public good) production, as they can enhance or erode the desired effect of the policy instruments.

Table 8 provides a provisional overview, expressing some general expectations about how different instruments might affect the provision of public goods as non-commodity production, taking into account different possibilities with respect to the connectedness of private and public good outputs (competition, complementarity, and jointness). These expectations are based on the formal model, as it was presented in the previous paragraphs of this chapter. Note that that the model, considered before, analyzes Farmers' behavior at farm level. As such it treats individual farmers as price takers, and does not take into account the market effects, as they will arise if all farmers individually behave in a certain way. So, in order to analyze the full impact of behavioral changes the farm behavior models should be complemented by a model taking into account the market effects. Note further that the policy instruments are presented here in a rather abstract way. For a more detailed analysis the policy instruments need to be further specified.

Table 8: A provisional overview of possible effects of policy instruments on the provision of public goods with different kinds of interconnectedness between commodity and non-commodity production (based on a farm model-perspective)

Policy instruments	**Interconnectedness of technology F( )**		
	Use of inputs		**Jointness of outputs**
	Competing	**Complementary**	
Flat-rate payment	Reduce	Increase	Increase
Land quality specific area payment	Reduce	Increase	Increase
Cross compliance (creating public goods by restricting input use or technology for commodity production)	Increase	Reduce	Uncertain
Reward scheme based on outputs of public goods	Increase	Increase	Increase

On the reading of Table 8: introducing a flat-rate payment decoupled with public good provision in general increases the use of land for commodity production as it functions as a subsidy on land (*ceteris paribus*). If land use for commodity production is competing with land use for public good provision, this policy instrument will reduce public provision (see cell in first column and first row). On the contrary, if land use for commodity production is complementary to the provision of public good (based on the same land), this instrument will increase the provision of public goods related to the land (see first row, second column of Table 8). When public good is jointly produced with the commodity goods, increased commodity production will also increase public good production (see first row and third column of Table 8).

Similar reasoning can be made to other policy instruments to derive their possible effects on the provision of public good. Being a kind of a land-related subsidy, the land quality specific payment shares similarities with a flat rate. If cross compliance restricts a certain input and there are alternative competing inputs, the latter might increase as a consequence of a

substitution effect. If inputs are complementary they will follow the pattern of the restricted input and also being reduced. In case of joined production the final result is ambiguous. There are two counteracting tendencies: On the onde hand commodity output is likely to decline and then due to jointness for that reason also the public good output. On the other hand, the cross compliance policy explicitly targets to increase the public good output, which for that reason is likely to increase, thereby leaving the net result undetermined. Reward schemes, which directly remunerate the public good activity or production, are likely to increase the supply of the public good. In practice it might be rather difficult to implement such policies because of difficulties to clearly delimit, measure public goods.

Also the remuneration-schemes need to be specified. In general it makes a difference whether payments depend on efforts made (input use) or outputs delivered (performance based payment schemes). For an example of a spatially differentiated payments scheme see Hanley *et al.* (2007). Hanley also used choice experiments to estimate the demand of the public for different public goods. More discussions can be found in Fraser (Fraser 2009).
A number of common specifications are described below as examples. Depending on the form of the public good and the jointness of production, the inputs (quasi-fixed or variable) are sometimes allocable to the two types of production (for example land reserved for nature conservation). In that case, they are subscripted with '1' if they are used for the production of marketed commodities and '2' for the production of public goods.

1) $Q = g(l, h, \bar{x})$, the public good is jointly produced with commodity production, imposing restrictions on the use of variable inputs, for example, fertilizer. Standards or baselines are imposed on farmer's production decision. The compliance restricts the form of the production technology. Suppose the restricted production function become $\bar{y} = \bar{f}(l, h, x)$, or restrictions on input use, e.g., $\bar{y} = f(l, h, \bar{x})$. The public goods in this case are defined as:

$$Q = \begin{cases} 0, \textit{not complying} \\ 1, \textit{complying} \end{cases}$$

2) $Q = \bar{l}_2$, the public good requires special land allocation (for example, land used for water reservoir where commodity production is no longer possible).
   a) Area payment, flat rate; The reward to the provision of public goods is based on the area allocated to the provision of public goods. The production function of public goods is: $Q = g(l_2) = l_2$. Income effect: $S(Q) = sl_2$, where s denotes the payment rate.
   b) Area payment, dependent on land quality. $Q = g(l_2, z)$. Income effect: $S(Q) = \sum_{i=1}^{N} s_i l_{2i}$, where $\bar{s}_i$ denotes the payment rate corresponding to land quality i and N refers to the total type of quality a farmer allocates to public goods production.
3) $Q = g(l, h_2, x_2)$, the public good is jointly produced on the land for commodity production, with additional input of family labor and variable inputs; This in practice corresponds to two types of area payments: flat-rate area payment and differentiated area payment according to land quality.
4) $Q = g(h_2, x_2)$ the public good requires additional family labor and variable inputs, but no additional input of land.

4.6 Producer behavior with public goods production: participation intensity for buffer strips and set-aside

As shown in Section 4.5, different types of policy instruments pose different choice problem to the farmer and require correspondingly different analysis. In this section, a policy scheme which requires agricultural land to be allocated to the public good production (set-aside) is used as an illustration. Assume that no additional inputs are needed, we have: $Q = l_2$. The policy scheme requires a maximal land area ($\bar{l}_2$ ha) to be set aside for environmental purposes (e.g. by creating certain buffer zones). The farmer's decision problem becomes:

$$\underset{l_1,h_1,x_1,l_2,h_2,x_2,m}{Maximize}\ u(I,B,R), \text{ subject to}$$

$$l_1 + l_2 \le A;$$
$$h + m + r = H;$$
$$l_2 \le \bar{l}_2$$

where

$$\begin{aligned} I &= pf(l_1,h_1,x_1,Q;z) + sQ + mw - x_1q_1 - F - vl_1 \\ &= pf(l_1,h_1,x_1,Q;z) + sl_2 + mw - x_1q_1 - F - vl_1 \end{aligned}$$

with s as the compensation rate for l_2 .The Lagrangian is:

$$\begin{aligned} &L'(l_1,l_2,h,m,r,x) = \\ &U(I) + B(h) + R(r) - \lambda(l_1 + l_2 - A) - \mu(h + m + r - H) - \sigma(l_2 - \bar{l}_2) \end{aligned} \tag{16}$$

where λ, μ and σ are the Lagrange multipliers. The Kuhn-Tucker conditions for this problem are:

a') Land allocation

a1') $L'_{l_1} = U_I I_{l_1} - v - \lambda = U_I(pf_{l_1} - v) - \lambda = 0;$ (17)

a2') $L'_{l_2} = U_I I_{l_2} - (\lambda + \sigma) = U_I s - (\lambda + \sigma) = 0;$ (18)

a3') $\lambda, \sigma \ge 0;$ (non-negativity of land use) (19)

a4') $\lambda(l_1 + l_2 - A) = 0;$ (complementary slackness) (20)

a5') $\sigma(l_2 - \bar{l}_2) = 0;$ (complementary slackness) (21)

From conditions a1') and a2') , we have: $\sigma = U_I(s + v - pf_{l_1})$, which gives the shadow price of the maximal area $\bar{l}_2$ allocated to the public goods when compensation rate *s*. Setting the shadow price to zero gives optimal compensation rate which satisfies: $s = pf_{l_1} - v$. The optimal rate is therefore determined by the difference between the value of the marginal product of the land and per hectare fixed cost.

b') Labor allocation

b1') $L'_{h_1} = U_I pf_{h_1} + B_{h_1} - \mu = 0;$ (22)

b2') $L'_m = U_I I_m - \mu = wU_I - \mu = 0;$ (23)

b3') $L'_r = R_r - \mu = 0;$ (24)

The first order condition for labor use is the same as in the basis situation, i.e. $\mu = U_I pf_{h_1} + B_{h_1} = R_r$. However, equilibrium labor allocation can differ from the basis situation since allocating land to public goods production can change equilibrium monetary income and lead to substitution of labor for land as production inputs. To see the possible effect of s on labor allocation, we can look at the comparative statics of h_1 with respect to s. Assuming interior solution and total differentiating equation (22) with respect to s and h_1 gives:

$$\frac{dh_1}{ds} = -\frac{U_{II} Pf_{h_1} l_2 + B_{h_1 h_1} + R_{h_1 h_1}}{U_I pf_{h_1 h_1} + U_{II} p^2 f_{h_1}^2} < 0 \quad (25)$$

This means that a too high compensation rate s may decrease equilibrium on-farm labor.

c') Input use

c1') $L_{x_1} = U_I I^1_{x_1} = U_I (pf_x - q) = 0;$ (26)

Condition c') indicates that the first order condition for input use remains unchanged, i.e., it satisfies $f_{x^*} = q / p$. This means that if the provision of public good only requires setting land aside, participating in the policy scheme will not lead to the change in the use of variable input.

5 Extensions of the research: risk, uncertainty, information and time

The analytical framework in Chapter 4 deals with producer's decision making under certainty, assuming a static and riskless decision context. The framework can however be extended to take account of risk, uncertainty, and temporal issues. In particular, this chapter addresses following issues:

- Risk related to policy instruments and risk attitudes of agricultural producers;
- Asymmetric information and policy design;
- Multi-annual policy instruments;
- Producer decisions facing multiple policy instruments (synergy and competition).

5.1 Risk and risk aversion

Policy makers and planners need to consider farmers' risk-averse behavior when setting policies and programmes directly affecting the riskiness of farming, such as price stabilization. Responses to many other kinds of policy change are also likely to be affected by farmers' risk perception and risk aversion (Hardaker *et al.* 2004).

Risk attitude can be modeled with the shape of $U(.)$ as well as the arguments of $U(.)$. The shape of the utility function reflects risk aversion. When arguments of the farmer's utility function, i.e., monetary income, non-monetary benefits and leisure time are uncertain, rational choice theory states that farmers maximize expected utility. The concave shape of utility function from income implies risk aversion, since $E[U(I)] > U[E(I)],$ where E[.] is the expectation operator. Risk aversion can explain many seeming irrational use of land (Parks 1995). Classical rationality is often based on a profit-maximizing framework and perfect information. These are, however, two very strong assumptions that do not hold in reality.

It is possible that risk aversion can reduce at higher wealth level, which implies that wealthier farmers are likely to be less risk averse than less wealthy farmers. Riskless instruments such as area payment increase monetary income of farmer and may reduce risk aversion in other production decision. These considerations are used to explain the possible distortive effect of policy support measures even though they are decoupled with production.

Another issue related to decision making under risk and uncertainty is the so-called 'bounded rationality', which is the main issue of the Prospect Theory (Kahneman and Tversky 1979). According to Prospect Theory, arguments of utility are not the states of wealth (or other variables of interest), but the gains and losses of them. Key concepts in prospect theory reflect ideas such as reference dependence and loss aversion, which can be particularly relevant for the choice of contracts.

5.2 Asymmetric information and policy design

Voluntary contracts are challenged by the information asymmetry: government as the 'buyer' of the public goods knows less than landowners about the costs of contractual compliance. Theory and evidence have suggested the possibility of hidden action. Landowners in such

circumstances can use their private information as a source of market power to extract informational rents from the policymaker acting as supplier of the contracts.

As regards flat rate payments, for example, it is found that such payments led to a concentration of contracts on unproductive lands run by farmers with the lowest land use intensities (in other words, farmers with the lowest opportunity costs (Osterberg 1999).

Another potential problem with uniform payment concerns the heterogeneity of land and soil quality due to different locations. Without spatial differentiation, least polluting farms are mostly likely to participate in public goods production since their opportunity costs are lower.
Policy mechanisms that reduce informational rents can be broadly classified into three categories: 1) gathering more information on landowners in the form of costly-to-fake signals; 2) relying on screening contracts (self-selection mechanisms); or 3) harnessing competitive forces through procurement auctions (Ferraro 2008). In general, these are called revelation mechanisms. Compliance rewards are also suggested to stimulate compliance (Yano and Blandford 2009).

5.3 Multi-annual policy instruments and the option value

Once the term of the contract has expired, there can be no guarantee that the conservation assets will continue to be maintained. Even if government continues to offer a contract, higher agricultural prices or new market opportunities may persuade farmers to return to more intensive forms of agricultural production at the expense of any conservation benefits that have been achieved. This also raises questions about the ownership of the environmental assets generated through environmental contracts. The public may feel that they have a proprietary interest in the environmental assets to the extent that they have been created through the contribution of public funds. Farmers may anticipate this problem and so be reluctant to enter into environmental contracts in the first place, the concern being that restrictive designations might subsequently be introduced to protect long-term environmental gains (Hodge 2001).

The issue of uncertainty with respect to the future implies that not only foregone benefits at present are important, but also foregone benefits in the future may play a role in choosing current options. To illustrate this point, consider an *n*-period contract (for example, set land aside for n-period as in the example 2) in Section 4.5), which provides compensation (*S*) to the farmer equal to the forgone monetary income (ΔI), calculated on the basis of market prices (p) and other economic conditions (D). Assume the contract will be offered both in period 0 and period 1, and that the associated compensations that will be paid are based on the foregone income calculated using the actual information as known at the beginning of the period in which the contract is offered. The contracting period starts when the contract is accepted. If the contract is accepted in period 0, it will be binding in period 1 and the subsequent years, until the time of n periods has elapsed. Therefore, the decision to accept the contract is irreversible within a period of n years. If the contract is not accepted in period 0, it can be reconsidered in period 1 using information in period 1.

To simplify the illustration, assume that the farmer only compares the compensation and foregone income to decide whether to accept the contract. This can be seen as a simplified version of the decision model described in Chapter 4 in which all other changes are exactly offset in terms of utility and only monetary income needs to be compared.

The situation described above is summarized in Table 9, where the symbol $E_t(.)$ denotes expectation made in period *t*, the symbol ~ indicates dependency among the variables, and *r* is the discount rate. Note that the situation involves multi-period decision making (period 0 and period 1) and irreversibility (once the contract is accepted, it cannot be revoked).

Table 9: Multi-annual contract and expectation of future monetary income

Period		**t=0**	**t=1**	***t=i***
Item	**Notation**			***i* = 2, …,n**
Monetary income	I_t	I_0	I_1	I_i
Foregone monetary income in each period *t*	ΔI_t	$\Delta I_0 \sim p_0, D_0$	$\Delta I_1 \sim p_1, D_1$	ΔI_{2i}
NPV of expected total foregone income in each period *t*	$E_t(\Delta I)$	$E_0(\Delta I) = \Delta I_0 + \frac{1}{1+r} E_0(\Delta I_1) + \sum_{i=2}^{n-2} [(\frac{1}{1+r})^i E_0(\Delta I_{2i})]$	$E_1(\Delta I) = \Delta I_1 + \sum_{i=1}^{n-1} [(\frac{1}{1+r})^i E_1(\Delta I_{2i})]$	
Remuneration in each period *t*	S_t	$S_0 = \Delta I_0$	$S_1 = \Delta I_1$	S_0 or S_1
NPV of total remuneration	$E_t(S)$	$E_0(S) = \sum_{i=0}^{n-1} (\frac{1}{1+r})^i S_0$	$E_1(S) = \sum_{i=}^{n} (\frac{1}{1+r})^i S_1$	

Given the assumptions made (no changes in utility due to changes in non-monetary factors) the farmers behavior is reduced to profit maximization. As already noted before, this comes down to comparing the income forgone when accepting the contract with the remuneration it will bring. Since this optimization problem is characterized by multiple periods, both have to be evaluated in net present value terms. This requires proper discounting (at a discount rate r). The farmer will accept a contract if in the period *t* when it is offered it holds that $E_t(S)$ is greater than $E_t(\Delta I)$.

Table 9 shows how expectations with respect to future monetary income flowing from the farmer's main activity influence the farmer's decision making through the comparison of $E_t(\Delta I)$ and $E_t(S)$. The compensation provided by the policy instrument, $E_t(S)$, can be lower than the perceived opportunity costs in terms of expected foregone income, $E_t(\Delta I)$, i.e., $\Delta I_0 + \frac{1}{1+r} E_0(\Delta I_1) + \sum_{i=2}^{n-2} [(\frac{1}{1+r})^i E_0(\Delta I_{2i})] > \sum_{i=0}^{n-1} (\frac{1}{1+r})^i \Delta I_0$, which will strictly hold if $E_0(\Delta I_1), E_0(\Delta I_{2i}) > \Delta I_0$.This can happen when farmer expects that monetary income will increase in the future without engaging in the policy scheme, for example, due to increasing

commodity prices. In other words, future developments that may influence the profitability (and nonpecuniary benefits) of farming increases the opportunity costs of farming in giving up their land or current practices.

Empirical evidence indicated that farmers' participation behavior may change over time (Hynes and Garvey 2009). One explanation could be that expectations with respect to the future may change over time. For example, if the contract is not accepted in period 0, Table 9 shows that in period 1, expectation on foregone income in the contracting period becomes $E_1(\Delta I_{2i})$. This is likely to be different from the expectation in period 0 $E_0(\Delta I_{2i})$. As a result, the cost-benefit comparison may be different from period 0 even though the compensation amount S_t is updated to $S_1 = \Delta I_1$. On the other hand, if the compensation amount is not updated in period 1, i.e. $S_1 = S_0$, there will be incentive to postpone the decision if there is high uncertainty about ΔI_{2i} and the uncertainty will be reduced in period 1. This means that the farmer's participating decision may change over time due to changing expectations on future.

In economic literature it is now well established that in multi-period decision-making, uncertainty about future benefits and high upfront sunk costs create incentive to wait (see, e.g., Dixit and Pindyck 1994). The opportunity to decide later creates option value which increases the current foregone benefits. Option values are important when decisions entail some irreversibility. For example, the participation in public provision may imply that in the future, when farming becomes more profitable, the farmer cannot freely or costlessly return to (traditional) farming again. A rational farmer can therefore anticipate future developments in agri-environmental policy and general social-economic contexts and keep options open by not participating the policy scheme in the first periods.

Another issue related to multi-period instruments or schemes is the problem of 'time inconsistency'. Time inconsistency refers in general to the situation in which some agent, planner, or objective maximizer must make a choice about an action or decision in some future plan and in which what is optimal initially is no longer optimal at a later date. This change in what is optimal occurs despite the fact that nothing new is learned and no physical circumstances change, except that decisions of the past are locked in place.

Public goods are not inherent to certain goods but are determined by a certain incentive structure which reflect the society's value. Both the incentive structure and the society's value system can change in the future. A green or blue service may ceased to be a 'public good' due to changes in public values and entails changes in the policy and its instruments. Farmers may be afraid that the compensations that were expected from the policy may not be realized due to changing social or policy circumstances. These considerations can have a significant effect when the farm is risk averse.

An important future research line is how to incorporate farmers' expectations of future developments into policy design. Payment schemes might need to include some contingency claims which entitles the farmer to be compensated if, as a consequence of participating in the policy scheme, the farmer finds himself in a disadvantageous position. Retaining these claims in the future might induce participation in the policy scheme, however, it can increase the implementation costs of the policy. How to reach a social optimal needs further investigation.

Box Time inconsistency

We can use a simple example to illustrate the time inconsistency issue. Consider a farmer who would like to receive payment for public goods provision. A pair of obvious questions are: (1) would the farmer like to receive the payment, and (2) would the farmer like to not produce the public goods (to save the costs). The answers are yes and yes. Unfortunately for the farmer, the second option is usually not open. A pair of less obvious questions are: (1) at the time of entering the public good provision scheme (signing the contract), would the farmer like there to be an enforcement agency that would ensure that he produces the public good, and (2) at the time of delivering the public good, would the farmer like there to be an enforcement agency that would ensure the public good is produced. The answer to the second question is likely to be no, for production of public goods (which incurs costs) is not desirable to the farmer. The answer to the first question, however, is likely to be yes. In order to grant the payment to the farmer, the government must have some reassurance that the public good will be produced, and the enforcement agency will provide that reassurance.

The farmer might have a rank ordering over three possible outcomes: A – no payment, no public good provision, B – payment, public good provision, C - payment, no public provision. C is the most preferred, while B is next. The worst outcome is A. In the contracting period, the farmer prefers that enforcement be present because case B is preferred to case A. The time inconsistency is not that the farmer would prefer to not produce the public good. It is rather that in the first period (when the provision contract is written) the farmer prefers to have an enforcement agency in place while in the production period he prefers not to have one in place.

5.4 Crowing-out of various policy instruments

Public good policy may consist of a number of instruments that can provide different incentives and constraints to the farmer. There might exist competing, complementary or joint relationship among these policy instruments in terms of the targeted public goods output.
In case of competition, a 'crowding-out' problem can arise when incentives provided by one policy instrument overrule those provided by other instruments and undermine its effect. This existence of 'crowding-out' problem requires better co-ordination of different policies. Co-ordination is also of importance when synergetic effect is possible among different policy instruments.

A specific example where crowding out may play a role is related to the competition of spending labor on-farm and off-farm employment. In the previous analysis (see chapter 4) it has already been shown that opportunity costs of providing public goods can be related to the off –farm labor remuneration (e.g. Table 7). However, there might be further issues influencing crowding out. For example, in order to realize the off-farm wage, it might be required to be available for the labor market for a minimum number of hours per week. If so this potentially will introduce further implications for the on-farm labor use, in particular when a farmer would like to combine on-farm and off-farm employment, or as he would like to keep the option to obtain off-farm employment open. Another issue is the difference in certainty. For example, an off-farm employment contract might be evaluated as a more certain source of income than on-farm employment, or labor remuneration for the provision of public goods.

6 Policy implications and practical lessons

This chapter summarizes the main lessons derived from this research, which will be presented in a non-technical language. The results of this study regard four themes:

1) concepts and production technology issues;
2) governance and optimality of policies, when looked at from a welfare maximization perspective;
3) insight into farmers' behavior, in particular in response to policies which would re-label the single farm payment to other payments aimed at stimulation the provision of green and blue services;
4) intertemporal issues considering the choices farmers make, in particular when participation in certain programs might affect the long term development perspective of farms. Also some other miscellaneous issues like information asymmetry, policy design and type of farmers that will be attracted, crowding-out phenomena, etc. are addressed under this heading.

The chapter closes with brief concluding paragraph, which highlights also some other contributions (e.g. significance of this project for the modeling of public good activities).

6.1 Concepts and production technology issues

- Green and blue services are typical examples of public goods, i.e. being non-rival and non-excludable. This has implications for their allocation. Markets will fail to ensure an optimal allocation. The level of public good provision will be in general too low and might even be zero.
- Green and blue services are often related to externalities (e.g. biodiversity, landscape) generated by agriculture. Many externalities partake of the character of public goods. The externalities might be depletable or non-depletable. In the first case the impacts of the externality have a slightly private character (e.g. trash dumping), whereas in the second case the impacts extend to the general public.
- Externality-effects are a wide-spread phenomenon in economics. However, most externalities can be characterized as so-called pecuniary externalities. Their impacts affect markets and also the market allocation, but the market can well handle these. So from a welfare optimization point of view on pecuniairy externalities no intervening government policies are justified.
- Agriculture produces both positive (e.g. nice landscape) and negative (e.g. Nitrate leaching to groundwater) externalities. When searching for the optimal policies both have to be taken into account simultaneously, implying a net public payment consisting of remunerative payments (for positive externalities) and punishing fines (for negative externalities). Note that in case an activity generates more negative than positive externalities the net payment may be negative (tax).
- Private and public outputs of agriculture might be connected in various ways. They might be jointly produced, in which case it is impossible to relate the costs of production to one specific output (e.g. open landscape and permanent pasture). They might be complementary and show a positive correlation (e.g. milk and beef when dual purpose cattle breeds are used; application of cover crop in winter time aimed at enhancing soil productivity will also reduce sensitivity to erosion and surface water contamination). They might be competing, where the supply of one output goes at the cost of the other (e.g. buffer zones compete with cultivated area). These characterizations are not absolute but

might only hold within certain ranges, beyond which the character switches to an alternative possibility.
- The interconnectedness of private and public goods have implications for the policy realm. If for example production has a joined character the optimal provision of the public good could be achieved by (private) output-related support.

6.2 Governance and optimality of policies

- In general positive and negative externalities lead to a suboptimal allocation because the market fails to take externalities properly into account.
- The mere existence of externalities related to agriculture is not sufficient to justify government interference. In case the impacts of the externalities spread to large numbers of victims or beneficiaries, government interference might in principle be relevant.
- The standard way to restore optimality in case of externalities is by introducing Pigovian taxes (negative externality) and subsidies (positive externality) and impose these with respect to the generator(s) of the externalities[11].
- Introducing price distortions (for example by creating import tariffs and export subsidies) is not an optimal solution in this case. This is because prices and price distortions treat supplies and demanders in a symmetric way, whereas in this case an asymmetric treatment is required for optimality.
- Within the WTO's trade negotiation framework, the issue of public goods should be recognized. This implies that member states should have freedom with respect to the Pigovian taxes and subsidies instrument. Note that the language might be a bit confusing here: a Pigovian subsidy, for example, is when properly targeted no subsidy in the strict sense of the word, but rather a compensation for services delivered (equivalent with normal prices).
- From a social welfare maximizing point of view it is in general not optimal to subsidize victims (of negative externalities) or tax beneficiaries (of positive externalities). Incentive policies should only focus on the generators of the externalities.
- As a consequence of the foregoing, using payment schemes, which let the beneficiaries of positive externalities (public goods) pay for their consumption or enjoyment of the benefits derived from the externality (for example to general money for compensating the farmers) is generally inefficient. It will reduce or inhibit the consumption of the public good to suboptimal levels (too few consumers might benefit from it).
- The foregoing result does not imply that voluntary private donations, aimed to ensuring or encouraging public good provision by agriculture, that are made to farmers conditionally on them taking certain actions generating the externality might be suboptimal. If there is no government interference private payment schemes are most likely to be welfare improving relative to the free market equilibrium. However, they in general will be insufficient to achieve a full welfare optimum. As such private schemes are no alternative for government interference.

6.3 Farmer's behavior

- When analyzing the farmers behavior with respect to the provision of public goods, it is recommendable to follow a utility maximization framework rather than a less-general profit maximization framework. The utility maximization framework allows better for the role of farmer attitudes and responsiveness to risk.

[11] Agri-environmental schemes (for nature, wildlife and landscape preservation) can be interpreted as operationalizations of the Pigovian subsidy principle.

- In a situation without policy intervention for public goods, farmers can still voluntarily provide public goods. The main reason then probably is because the public good is jointly produced with the private good or there the private and public good are characterized by complementarity (e.g. milk production and pasture grazing with dairy cows). Another possibility is that the public good enters into the utility function of the farmer and thus generates non-pecuniary benefits to the farmer (e.g. the farmer's appreciation of a nice homestead). A final possibility is that public goods not directly enter as an argument into the farmers utility function, but determine the shape of the utility function through 'moral' motives like altruism, responsibility for the countryside, stewardship, accepted good farming practice codes, etc. If so farmers can be said to be intrinsically motivated to supply public goods. This latter phenomenon might play a significant role (with maybe animal welfare in the dairy sector as an example).
- In case land is a not a binding factor a farmer will use land up to the point where the marginal product of the land equals the fixed costs per hectare. For value marginal products lower than the fixed costs we will get land abandonment.
- Scarcity of land occurs when the farmer would like to enroll more land for production than the land available, this can occur when for example the marginal productivity of land far exceeds the marginal costs (high profit margin). When land is scarce, at the extensive margin the opportunity cost of land is higher than its value marginal product. As a consequence compensation schemes based on the marginal productivity of land will not induce a farmer to refrain from commodity production.
- Opportunity cost**,** a key concept in economics, is the value of the next-best choice available to a decision maker who has to choose between several mutually exclusive choices. It has been described as expressing "the basic relationship between scarcity and choice". When making rational choices, it is important that the gains of the chosen alternative at least compensate the opportunity costs associated with the alternatives forgone. The opportunity costs of farmers depends on their marginal utility of income. This implies that for the same level of compensation farmers with already high incomes are more prone to accept the compensation than farmers with relatively low incomes. This holds even if the marginal productivity of land is the same for both farmers.
- An area payment can be interpreted as being equivalent to a reduction in a farmer's fixed costs (either per hectare or also at farm level). As such it creates an incentive to increase on-farm labor input.
- In order to induce farmers to participate in the provision of public goods, it follows from the participation constraint that farmers should be compensated for their inputs simply their opportunity costs (which are as a rule farmer specific).
- When a policy instrument aims at stimulating the provision of a public good, one should as a general rule identify to the changes the policy instrument would cause to commodity production and compensate them according to their opportunity costs (foregone net benefits principle).
- Heterogeneity in unobserved factors such as attitude explains some seemingly irrational behavior of farmers. From the point of view of targeting, compensation schemes should allow for the possibility to take into account these factors. This is in particular relevant when AES contracts are only offered to famers in certain zones, the characterization of which might differ from the general average.
- Empirical research is needed to obtain information on unobservable factors such as attitudes, which may be indirectly inferred from observed characteristics such as off-farm employment, family income and other factors.
- Characteristics of the policy instruments can greatly influence farmer's behavior. Empirical modeling should take into account these characteristics and put them into a coherent decision making framework.

6.4 Intertemporal and informational issues

- Who will participate? With a flat rate or general fixed payments, it is found that such payments led to a concentration of contracts on unproductive lands run by farmers with the lowest land use intensities (i.e. attracts farmers with the lowest opportunity costs).
- Who will participate? With uniform payment, not accounting for spatial heterogeneity, least 'polluting' farms (i.e. farms with relatively low intensity of production) are mostly likely to participate in public goods production since their opportunity costs are lower.
- Information asymmetry: Informational rents can be reduced by applying policies that: 1) gather more information on landowners in the form of costly-to-fake signals; 2) rely on screening contracts (self-selection mechanisms); or 3) harness competitive forces through procurement auctions.
- Long-term contracts: Decisions to participate in green and blue services have implications for future opportunities for farming. Taking into account of foregone future opportunities implies that compensation based only on foregone profits calculated from current profits are likely to be insufficient to induce participation.
- The participation in multiannual contracts involves expectations about future income derived from farming without participating in a contract (the opportunity costs of participation) and the expected remuneration implied in the contract. Increasing uncertainty can easily lead to a change in, or postponement of the participation decision.
- When the compensation for participating in the contract is updated over time, farmers will show a tendency to postpone participation decisions. Updating here implies that either the compensation amount is changed, or the rule according to which the compensation amounts are determinate is changed over time, or when the policy maker deviates from its own pre-specified rule (time inconsistency).
- Timing considerations: option values are important when voluntary participation decisions by farmers entail some irreversibility effects, such as for example restricting freely or costless return to other farming practices or farm strategies.
- A counterpart of 'irreversibility'-effects is that introducing flexibility in the obligations as specified in the contract can reduce its importance. For example, allowing for certain adjustments in the obligations farmers have to meet in case of for example extreme weather circumstances might reduce their estimate of income foregone, and by that lower the opportunity costs of participation into the contract. As it is known to be difficult to specify so-called complete contracts introducing such flexibility might be possible even without reducing the benefits (e.g. biodiversity benefits) the scheme aims for.
- Uncertainty might be related to the (feared or contested) ownership of the environmental assets that are generated financed from public funds. Farmers may fear that in the future restrictive designations might be introduced in order to protect the long term environmental or public good gains.
- Long-term contracts (e.g. multi-annual agri-environmental SAN schemes) are in general more complex than short term contracts and introduce additional elements in solving the decision problem. Among these are increasing uncertainty, and the role of risk perception and risk attitude.
- Long-term contracts also introduce the issue of time inconsistency (the policy maker changes its plans or the contract specifications while time is elapsing), which might affect the farmer's trust as well as current and future participation. In other words, longer term contracts have a higher policy risk than short-term contracts.
- "Crowding-out" among policies: In economics, "crowding-out" refers in general to the reduction in private consumption or investment that occurs because of an increase in government spending. In the policy arena, "crowing-out" effect can occur among policies if new or expanded policy to realize new policy goals has the effect of prompting those who are already participating in other policies to switch to the new policy, leaving the goals for the incumbent (other) policies unfulfilled. Policies for public good provision might introduce

crowding-out phenomena (non-smooth substitution between inputs, outputs and inputs and outputs) that are often neglected in the standard economic framework. This provides an argument to carefully think about coordination among policies (e.g. environmental, biodiversity, animal welfare, food safety policies). Realizing that this kind of phenomena may play a role, might also provide further insight into uncertainty, short-term – long-term trade-offs, and most-relevant opportunity cost determination.

6.5 Concluding remarks

This main contribution of this study is that it tries to disentangle the participation decision for participation in multifunctional agricultural activities (e.g. biodiversity and landscape preservation schemes, etc.). Often these activities have an externality or public good character, which implies that the market will fail to ensure an efficient allocation. In order to achieve an adequate provision of these multifunctional outputs and/or 'public goods' an active involvement of the policy maker is required. This study started to look at the peculiarities of this public good-management task. Also the interaction of such a public good policy with a country's other policies, notably its trade policy, was considered. It was argued that in general Pigovian taxes or subsidies would be the appropriate way to stimulate optimal public good provision (or reduction of public bad). It was concluded, that in general this provides no justification for (protective) trade policies. However, the public goods issue needs proper treatment in the WTO trade negotiation framework: countries should have autonomy in the way they use Pigovian taxes and subsidies, at least as far as these payments are properly targeted and the implied compensations (or punishments) are proportional with the efforts (or harm) made.

Significant attention was paid to concepts and production technology. With respect to the latter in particular the degree of jointness appeared to be crucial. Private and public outputs can be complementary, independent, or competing. Moreover, the trade-off between private and public outputs is most likely to be non-constant, but changing with changing private output levels. This may even lead to complementarity-competing-switches. As a general point, the results emphasize the need to carefully analyze how the public outputs are produced and their way of interaction with the private output. There is also a link from this to the determination of a proper remuneration of public good provision activities.

As regards the behavior of farmers, in contrast with many other studies, this study takes into account the role that farmers' attitudes, intrinsic motivations and moral convictions might play. Therewith also the potential impact of these factors on the participation decision could be analyzed. From the solution of the farmer's utility maximization problem, and some further comparative statics analysis, the role of these and other factors was clarified. Moreover, the specific issues involved in case of multi-annual contracts was separately discussed. There the crucial role of expectations, uncertainty and 'irreversibility' on the participation decision became clear. Also insight was gained in what factors might lead to postponement of participation decisions. This could have been further extended to lock in-effects and compliance issues.

It should be noted that this study has an analytical focus. As such it does not yet provide insight into the empirical importance of the various issues, and an empirical follow-up is recommended to create a more complete picture. However, this study provides valuable input about how to properly model public good activities. This is in particular useful, since the models used for policy analysis in this realm are still in need of further improvement, in particular with respect to the public good outputs. As the analysis showed, not only the regular variables explaining economic supply activities (such as output and input prices) are

important, but also the contract specification is crucial, since it is this that determines the opportunity costs of participation. It was argued that this relationship is complex. However, given that the basic mechanism is understood, the framework provides in this study might also be a guide to more simplified (or reduced form) approaches.

References

Arrow, K.J., Hahn, F.H. (1971). General competitive analysis. Holden-Day, San Francisco.

Bator, F.M. (1958). The Anatomy of Market Failure. The Quarterly Journal of Economics 72 (3), 351-379.

Baumol, W.J., Oates, W.E. (1988). The Theory of Environmental Policy. Cambridge University Press.

Becker, G.S. (1993). Nobel Lecture: The Economic Way of Looking at Behavior. The Journal of Political Economy 101 (3), 385-409.

Blandford, D., Brunstad, R.J., Ivar, G., Vårdal, E. (2000). Optimal agricultural policy and PSE measurement: an assessment and application to Norway. No 36769, 82nd Annual Conference, March 31 - April 2, 2008. Royal Agricultural College, Cirencester, UK

Brower, R. (2008). The potential role of stated preference methods in the Water Framework Directive to assess disproportionate costs. Journal of Environmental Planning and Management 51 (5), 597-614.

Carlson, S.A. (1939 (Reprinted 1969)). A Study on the Pure Theory of Production. M. Kelley. New York.

Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., Hyde, T. (2006). Valuing the diversity of biodiversity. Ecological economics 58, 304-317.

Coase, R.H. (1960). The Problem of Social Cost. Journal of Law and Economics III, 1-44.

Cornes, R., Sandler, T. (1996). The Theory of Externalities, Public Goods and Club Goods. Cambridge University Press. Cambridge.

Cubbage, F., Harou, P., Sills, E. (2007). Policy instruments to enhance multi-functional forest management. Forest Policy and Economics 9, 833-851.

Defrancesco, E., Gatto, P., Runge, F., Trestini, S. (2008). Factors affecting farmers' participation in agri-environmental measures: A Northern Italian perspective. Journal of Agricultural Economics 59, 114-131.

Dixit, A.K., Pindyck, R.S. (1994). Investment under Uncertainty. Princeton University Press. Princeton, New Jersey.

Dupraz, P., Vermersch, D., Henry de Fraham, B., Delvaux, L. (2003). The environmental supply of farm households: A flexible willingness to accept model. Environmental and Resource Economics 25, 171-189.

Ferraro, P.J. (2008). Asymmetric information and contract design for payments for environmental services. Ecological economics 65, 810-821.

Fraser, R. (2009). Land heterogeneity, agricultural income forgone and environmental benefit: An assessment of incentive compatibility problems in environmental stewardship schemes. Journal of Agricultural Economics 60, 190-201.

Hanley, N., Colombo, S., Mason, P., Johns, H. (2007). The Reform of Support Mechanisms for upland Farming; Paying for Public Goods in the Severely Disadvantaged Areas of England. Journal of Agricultural Economics 58 (3), 433-453.

Hanley, N., Kirkpatrick, H., Simpson, I., Oglethorpe, D. (1998). Principles for the Provision of Public Goods from Agriculture: Modeling Moorland Conservation in Scotland. Land Economics 74 (1), 102-113.

Hardaker, J.B., Huirne, R.B.M., Anderson, J.R., Lien, G. (2004). Coping with risk in agriculture. CABI Publishing. Cambridge.

Hausman, D.M. (2008). Market Failure, Government Failure, and the Hard Problems of Cooperation. Ethics and Economics 6 (1), 1-6.

Hennessy, D.A. (1998). The Production Effects of Agricultural Income Support Policies under Uncertainty. American Journal of Agricultural Economics 80, 46-57.

Hodge, I. (2001). Beyond agri-environmental policy: towards an alternative model of rural environmental governance. Land Use Policy 18, 99-111.

Holcombe, R.G. (1997). A Theory of the Theory of Public Goods. Review of Austrian Economics 10 (1), 1-22.

Hynes, S., Garvey, E. (2009). Modelling Farmers' Particpation in an Agri-environmental Scheme using Panel Data: An Application to the Rural Environment Protection Scheme in Ireland. Journal of Agricultural Economics 60 (3), 546-562.

Jongeneel, R.A., Polman, N.B.P., Slangen, L.H.G. (2008). Why are Dutch farmer going multifunctional? Land Use Policy 25, 81-94.

Jongeneel, R.A., Slangen, L.H.G., Polman, N.B.P. (2010) Groene en blauwe diensten; analyse van doelen, maatregelen en instrumenten. WOt-werkdocument 206. WOT Natuur & Milieu, Wageningen.

Kahneman, D., Tversky, A. (1979). Prospect theory: an analysis of decision under risk. Econometrica 47 (2), 263-290.

Keyzer, M., Merbis, M., Riet, M. van 't (2003) Will the proposed CAP reform reward green services? The hague: CPB Report 2003/2, pp.34-40.

Key, N., Roberts, M.J. (2009). Nonpecuniary benefits to farming: implications for supply response to decoupled payments. American Journal of Agricultural Economics 91 (1), 1-18.

Lau, L.J. (1972). Profit Functions of Technologies with Multiple Inputs and Outputs. Review of Economics and Statistics 54, 281-289.

Libecap, G.D. (2009). The tragedy of the commons; property rights and markets as solutions to resource and environmental problems. The Australian Journal of Agricultural and Resource Economics 53, 129-144.

LNV (2008). Houtskoolschets Europees Landbouwbeleid 2020.

Lynne, G.D. (1988). Allocatable Fixed Inputs and Jointness in Agricultural Production: Implications for Economic Modelling: Comment. American Journal of Agricultural Economics 70 (4), 947-949.

Lynne, G.D., Shonkwiler, J.S., Rola, L.R. (1988). Attitudes and Farmer Conservation Behavior. American Journal of Agricultural Economics 70 (1), 12-19.

Manner, M., Gowdy, J. (2008). The evolution of social and moral behavior: Evolutionary insights for public policy. Ecological economics In Press: doi: 10.1016/j.ecolecon.2008.04.021.

OECD (1979). OECD and the Environment. Paris.

OECD (2001). Multifunctionality: Towards an Analytical Framework. OECD (Organisation for Economic Co-operation and Development). Paris.

OECD (2006). Decoupling: Policy Implications. OECD (Organisation for Economic Co-operation and Development), Paris.

Osterberg, B. (1999). Agri-environmental programmes in Germany - implementation, acceptance and aspects of their evaluation. 1st Workshop on the management and Monitoring of Agri-Environment Schemes Joint Research Centre (JRC) Ispra, Italy.

Paarlberg, P.L., Bredahl, M., Lee, J.G. (2002). Multifunctionality and Agricultural Trade Negotiations. Review of Agricultural Economics 24 (2), 322-335.

Parks, P.J. (1995). Explaining "irrational" land use: risk aversion and marginal agricultural land. Journal of Environmental Economics and Management 28 (1), 34-47.

Potter, C., Tilzey, M. (2007). Agricultural multifunctionality, environmental sustainability and the WTO: Resistance or accommodation to the neoliberal project for agriculture. Geoforum 38, 1290-1303.

Reeson, A.F., Tisdell, J.G. (2008). Institutions, motivations and public goods: An experimental test of motivational crowding. Journal of Economic Behavior and Organization 68, 273-281.

RLG (2007). Publieke belangen centraal. Raad Landelijk Gebied (RLG).

Romstad, E. (2008). The informational role of prices. European Journal of Agricultural Economics 35 (3), 263-280.

Romstad, E., Vatn, A., Rørstad, P.K., Søyland, V. (2000). Multifunctional Agriculture: Implications for Policy Design. Report No. 21. Agricultural University of Norway, Department of Economics and Social Sciences, Norway.

Samuelson, P.A. (1954). The Pure Theory of Public Expenditure. The Review of Economics and Statistics 36 (4), 387-389.

Schram, A., van Winden, F. (1989). Revealed preferences for public goods: Applying a model of voter behavior. Public Choice 60, 259-282.

SER (2008). Waarden van de Landbouw. Sociaal-Economische Raad (SER).

Shumway, R.C., Pope, R.D., Nash, E.K. (1984). Allocatable Fixed Inputs and Jointness in Agricultural Production. American Journal of Agricultural Economics 66, 72-78.

Teulings, C.N., Bovenberg, A.L., van Dalen, H.P. (2003). De calculus van het publieke belang. Kenniscentrum voor Ordeningsvraagstukken.

Vanslembrouck, I., Van Huylenbroeck, G., Verbeke, W. (2002). Determinants of the Willingness of Belgian Farmers to Participate in Agri-environmental Measures. Journal of Agricultural Economics 53 (3), 489-511.

Vatn, A. (2002). Multifunctional agriculture: some consequences for international trade regimes. European Journal of Agricultural Economics 29 (3), 309-327.

Viner, J. (1931). Cost Curves and Supply Curves. Zeitschrift für Nationalökonomie 111, 23-46.

Willock, J., Deary, I., Edwards-Jones, G., McGregor, M.J., Sutherland, A., Dent, J.B., Gibson, G.J., Morgan, O., Grieve, R. (1999). The role of attitudes and objectives in farmer decision-making: Business and environmentally oriented behaviour in Scotland. Journal of Agricultural Economics 50, 286-303.

Wynn, G., Crabtree, B., Potts, J. (2001). Modelling farmer entry into the environmentally sensitive area schemes in Scotland. Journal of Agricultural Economics 52, 65-82.

Yano, Y., Blandford, D. (2009). Use of Compliance Rewards in Agri-Environmental Schemes. Journal of Agricultural Economics 60 (3), 530-545.

Zahrnt, V. (2009). A Blueprint from Reform of the WTO Agreement on Agriculture. ECIP Working Paper No.01/2009.

Appendix 1 Examples of production relationships for selected non-commodity outputs

Non-commodity Effects	Commodity production				Commercial non-food activities	Direct provision of public goods
	Fixed inputs	**Variable inputs**	**Farming technologies and practices**	**Commodity outputs**		
Landscape	Farmland area; Land use pattern; Farm buildings and structures		Silos, glass-houses, livestock housing, irrigation	Crop composition (structure and colour of the landscape)	Buildings and facilities for farm tourism	Maintaining farm buildings, flower meadows
Species and ecosystem diversity	Land use patterns	Use of agro-chemicals	Animal stockings density, soil cultivation and harvesting techniques	Crop composition	Leased access to specific eco-systems	Wetland and other habitat creation, wildlife feed and corridors
Rural viability	Demand for farm labor (in the short run)				Extra income on the farm	

Based on OECD (2001) P40.

Verschenen documenten in de reeks Werkdocumenten van de Wettelijke Onderzoekstaken Natuur & Milieu vanaf 2007

Werkdocumenten zijn verkrijgbaar bij het secretariaat van Unit Wettelijke Onderzoekstaken Natuur & Milieu, te Wageningen. T 0317 – 48 54 71; F 0317 – 41 90 00; E info.wnm@wur.nl
De werkdocumenten zijn ook te downloaden via de WOt-website www.wotnatuurenmilieu.wur.nl

2007

47 *Ten Berge, H.F.M., A.M. van Dam, B.H. Janssen & G.L. Velthof.* Mestbeleid en bodemvruchtbaarheid in de Duin- en Bollenstreek; Advies van de CDM-werkgroep Mestbeleid en Bodemvruchtbaarheid in de Duin- en Bollenstreek

48 *Kruit, J. & I.E. Salverda.* Spiegeltje, spiegeltje aan de muur, valt er iets te leren van een andere plannings-cultuur?

49 *Rijk, P.J., E.J. Bos & E.S. van Leeuwen.* Nieuwe activiteiten in het landelijk gebied. Een verkennende studie naar natuur en landschap als vestigingsfactor

50 *Ligthart, S.S.H.* Natuurbeleid met kwaliteit. Het Milieu- en Natuurplanbureau en natuurbeleids-evaluatie in de periode 1998-2006

51 *Kennismarkt 22 maart 2007; van onderbouwend onderzoek Wageningen UR naar producten MNP in 27 posters*

52 *Kuindersma, W., R.I. van Dam & J. Vreke.* Sturen op niveau. Perversies tussen nationaal natuurbeleid en besluitvorming op gebiedsniveau.

53.1 *Reijnen, M.J.S.M.* Indicators for the 'Convention on Biodiversity 2010'. National Capital Index version 2.0

53.3 *Windig, J.J., M.G.P. van Veller & S.J. Hiemstra.* Indicatoren voor 'Convention on Biodiversity 2010'. Biodiversiteit Nederlandse landbouwhuisdieren en gewassen

53.4 *Melman, Th.C.P. & J.P.M. Willemen.* Indicators for the 'Convention on Biodiversity 2010'. Coverage protected areas.

53.6 *Weijden, W.J. van der, R. Leewis & P. Bol.* Indicatoren voor 'Convention on Biodiversity 2010'. Indicatoren voor het invasieproces van exotische organismen in Nederland

53.7a *Nijhof, B.S.J., C.C. Vos & A.J. van Strien.* Indicators for the 'Convention on Biodiversity 2010'. Influence of climate change on biodiversity.

53.7b *Moraal, L.G.* Indicatoren voor 'Convention on Biodiversity 2010'. Effecten van klimaatverandering op insectenplagen bij bomen.

53.8 *Fey-Hofstede, F.E. & H.W.G. Meesters.* Indicators for the 'Convention on Biodiversity 2010'. Exploration of the usefulness of the Marine Trophic Index (MTI) as an indicator for sustainability of marine fisheries in the Dutch part of the North Sea.

53.9 *Reijnen, M.J.S.M.* Indicators for the 'Convention on Biodiversity 2010'. Connectivity/fragmentation of ecosystems: spatial conditions for sustainable biodiversity

53.11 *Gaaff, A. & R.W. Verburg.* Indicators for the 'Convention on Biodiversity 2010' Government expenditure on land acquisition and nature development for the National Ecological Network (EHS) and expenditure for international biodiversity projects

53.12 *Elands, B.H.M. & C.S.A. van Koppen.* Indicators for the 'Convention on Biodiversity 2010'. Public awareness and participation

54 *Broekmeyer, M.E.A. & E.P.A.G. Schouwenberg & M.E. Sanders & R. Pouwels.* Synergie Ecologische Hoofdstructuur en Natura 2000-gebieden. Wat stuurt het beheer?

55 *Bosch, F.J.P. van den.* Draagvlak voor het Natura 2000-gebiedenbeleid. Onder relevante betrokkenen op regionaal niveau

56 *Jong, J.J. & M.N. van Wijk, I.M. Bouwma.* Beheerskosten van Natura 2000-gebieden

57 *Pouwels, R. & M.J.S.M. Reijnen & M. van Adrichem & H. Kuipers.* Ruimtelijke condities voor VHR-soorten

58 Niet verschenen/ vervallen

59 *Schouwenberg, E.P.A.G.* Huidige en toekomstige stikstofbelasting op Natura 2000-gebieden

60 Niet verschenen/ vervallen

61 *Jaarrapportage 2006.* WOT-04-001 – ME-AVP

62 *Jaarrapportage 2006.* WOT-04-002 – Onderbouwend Onderzoek

63 *Jaarrapportage 2006.* WOT-04-003 – Advisering Natuur & Milieu

64 *Jaarrapportage 2006.* WOT-04-385 – Milieuplanbureaufunctie

65 *Jaarrapportage 2006.* WOT-04-394 – Natuurplanbureaufunctie

66 *Brasser E.A., M.F. van de Kerkhof, A.M.E. Groot, L. Bos-Gorter, M.H. Borgstein, H. Leneman* Verslag van de Dialogen over Duurzame Landbouw in 2006

67 *Hinssen, P.J.W.* Wettelijke Onderzoekstaken Natuur & Milieu. Werkplan 2007

68 *Nieuwenhuizen, W. & J. Roos Klein Lankhorst.* Landschap in Natuurbalans 2006; Landschap in verandering tussen 1990 en 2005; Achtergronddocument bij Natuurbalans 2006.

69 *Geelen, J. & H. Leneman.* Belangstelling, motieven en knelpunten van natuuraanleg door grondeigenaren. Uitkomsten van een marktonderzoek.

70 *Didderen, K., P.F.M. Verdonschot, M. Bleeker.* Basiskaart Natuur aquatisch. Deel 1: Beleidskaarten en prototype

71 *Boesten, J.J.T.I, A. Tiktak & R.C. van Leerdam.* Manual of PEARLNEQ v4

72 *Grashof-Bokdam, C.J., J. Frissel, H.A.M. Meeuwsen & M.J.S.M. Reijnen.* Aanpassing graadmeter natuurwaarde voor het agrarisch gebied

73 *Bosch, F.J.P. van den.* Functionele agrobiodiversiteit. Inventarisatie van nut, noodzaak en haalbaarheid van het ontwikkelen van een indicator voor het MNP

74 *Kistenkas, F.H. en M.E.A. Broekmeyer.* Natuur, landschap en de Wet algemene bepalingen omgevingsrecht

75 *Luttik, J., F.R. Veeneklaas, J. Vreke, T.A. de Boer, L.M. van den Berg & P. Luttik.* Investeren in landschapskwaliteit; De toekomstige vraag naar landschappen om in te wonen, te werken en te ontspannen

76 *Vreke, J.* Evaluatie van natuurbeleidsprocessen

77 *Apeldoorn, R.C. van,* Working with biodiversity goals in European directives. A comparison of the implementation of the Birds and Habitats Directives and the Water Framework Directive in the Netherlands, Belgium, France and Germany

78 *Hinssen, P.J.W.* Werkprogramma 2008; Unit Wettelijke Onderzoekstaken Natuur & Milieu (WOT-04). Onderdeel Planbureaufuncties Natuur en Milieu.

79 *Custers, M.H.G.* Betekenissen van Landschap in onderzoek voor het Milieu- en Natuurplanbureau; een bibliografisch overzicht

80 *Vreke,J., J.L.M. Donders, B.H.M. Elands, C.M. Goossen, F. Langers, R. de Niet & S. de Vries.* Natuur en landschap voor mensen Achtergronddocument bij Natuurbalans 2007

81 *Bakel, P.J.T. van, T. Kroon, J.G. Kroes, J. Hoogewoud, R. Pastoors, H.Th.L. Massop, D.J.J. Walvoort*. Reparatie Hydrologie voor STONE 2.1. Beschrijving reparatie-acties, analyse resultaten en beoordeling plausibiliteit.

2008

82 *Kistenkas, F.H. & W. Kuindersma..* Jurisprudentie-monitor natuur 2005-2007; Rechtsontwikkelingen Natura 2000 en Ecologische Hoofdstructuur

83 *Berg, F. van den, P.I. Adriaanse, J. A. te Roller, V.C. Vulto & J.G. Groenwold..* SWASH Manual 2.1; User's Guide version 2

84 *Smits, M.J., M.J. Bogaardt, D. Eaton, P. Roza & T. Selnes..* Tussen de bomen het geld zien. Programma Beheer en vergelijkbare regelingen in het buitenland (een quick-scan)

85 *Dijk, T.A. van, J.J.M. Driessen, P.A.I. Ehlert, P.H. Hotsma, M.H.M.M. Montforts, S.F. Plessius & O. Oenema..* Protocol beoordeling stoffen Meststoffenwet; versie 1.0

86 *Goossen, C.M., H.A.M. Meeuwsen, G.J. Franke & M.C. Kuyper. V*erkenning Europese versie van de website www.daarmoetikzijn.nl.

87 *Helming, J.F.M. & R.A.M. Schrijver.* Economische effecten van inzet van landbouwsubsidies voor milieu, natuur en landschap in Nederland; Achtergrond bij het MNP-rapport 'Opties voor Europese landbouw-subsidies

88 *Hinssen, P.J.W.* Werkprogramma 2008; Unit Wettelijke Onderzoekstaken Natuur & Milieu (WOT-04). Programma 001/003/005

90 *Kramer, H.* Geografisch Informatiesysteem Bestaande Natuur; Beschrijving IBN1990t en pilot ontwikkeling BN2004

92 *Jaarrapportage 2007.* WOT-04-001 – Koepel

93 *Jaarrapportage 2007.* WOT-04-002 – Onderbouwend Onderzoek

94 *Jaarrapportage 2007.* WOT-04-003 – Advisering Natuur & Milieu

95 *Jaarrapportage 2007.* WOT-04-005 – M-AVP

96 *Jaarrapportage 2007.* WOT-04-006 – Natuurplanbureaufunctie

97 *Jaarrapportage 2007.* WOT-04-007 – Milieuplanbureaufunctie

98 *Wamelink, G.W.W.* Gevoeligheids- en onzekerheids-analyse van SUMO

99 *Hoogeveen, M.W., H.H. Luesink, L.J. Mokveld & J.H. Wisman.* Ammoniakemissies uit de landbouw in Milieubalans 2006: uitgangspunten en berekeningen

100 *Kennismarkt 3 april 2008; Van onderbouwend onderzoek Wageningen UR naar producten MNP*

101 *Mansfeld, M.J.M. van & J.A. Klijn.* "Balansen op de weegschaal". Terugblik op acht jaar Natuurbalansen (1996-2005)

102 *Sollart, K.M. & J. Vreke.* Het faciliteren van natuur- en milieueducatie in het basisonderwijs; NME-ondersteuning in de provincies

103 *Berg, F. van den, A. Tiktak, J.G. Groenwold, D.W.G. van Kraalingen, A.M.A. van der Linden & J.J.T.I. Boesten*, Documentation update for GeoPEARL 3.3.3

104 *Wijk, M.N., van (redactie).* Aansturing en kosten van het natuurbeheer. Ecologische effectiviteit regelingen natuurbeheer

105 *Selnes, T. & P. van der Wielen.* Tot elkaar veroordeeld? Het belang van gebiedsprocessen voor de natuur

106 *Annual reports for 2007; Programme WOT-04*

107 *Pouwels, R. J.G.M. van der Greft, M.H.C. van Adrichem, H. Kuiper, R. Jochem & M.J.S.M. Reijnen.* LARCH Status A

108 *Wamelink, G.W.W.* Technical Documentation for SUMO2 v. 3.2.1,

109 *Wamelink, G.W.W., J.P. Mol-Dijkstra & G.J. Reinds.* Herprogrammeren van SUMO2. Verbetering in het kader van de modelkwaliteitsslag

110 *Salm, C. van der, T. Hoogland & D.J.J. Walvoort.* Verkenning van de mogelijkheden voor de ontwikkeling van een metamodel voor de uitspoeling van stikstof uit landbouwgronden

111 *Dobben H.F. van & R.M.A. Wegman.* Relatie tussen bodem, atmosfeer en vegetatie in het Landelijk Meetnet Flora (LMF)

112 *Smits, M.J.W. & M.J. Bogaardt.* Kennis over de effecten van EU-beleid op natuur en landschap

113 *Maas,G.J. & H. van Reuler.* Boomkwekerij en aardkunde in Nederland,

114 *Lindeboom, H.J., R. Witbaard, O.G. Bos & H.W.G. Meesters.* Gebiedsbescherming Noordzee, habitattypen, instandhoudingdoelen en beheermaatregelen

115 *Leneman, H., J. Vader, L.H.G. Slangen, K.H.M. Bommel, N.B.P. Polman, M.W.M. van der Elst & C. Mijnders.* Groene diensten in Nationale Landschappen- Potenties bij een veranderende landbouw,

116 *Groeneveld, R.A. & D.P. Rudrum.* Habitat Allocation to Maximize BiOdiversity, A technical description of the HAMBO model

117 *Kruit, J., M. Brinkhuijzen & H. van Blerck.* Ontwikkelen met kwaliteit. Indicatoren voor culturele vernieuwing en architectonische vormgeving

118 *Roos-Klein Lankhorst, J.* Beheers- en Ontwikkelingsplan 2007: Kennismodel Effecten Landschap Kwaliteit; Monitoring Schaal; BelevingsGIS

119 *Henkens, R.J.H.G.* Kwalitatieve analyse van knelpunten tussen Natura 2000-gebieden en waterrecreatie

120 *Verburg, R.W., I.M. Jorritsma & G.H.P. Dirkx.* Quick scan naar de processen bij het opstellen van beheerplannen van Natura 2000-gebieden. Een eerste verkenning bij provincies, Rijkswaterstaat en Dienst Landelijk Gebied

121 *Daamen, W.P.* Kaart van de oudste bossen in Nederland; Kansen op hot spots voor biodiversiteit

122 *Lange de, H.J., G.H.P. Arts & W.C.E.P. Verberk.* Verkenning CBD 2010-indicatoren zoetwater. Inventarisatie en uitwerking relevante indicatoren voor Nederland

123 *Vreke, J., N.Y. van der Wulp, J.L.M. Donders, C.M. Goossen, T.A. de Boer & R. Henkens.* Recreatief gebruik van water. Achtergronddocument Natuurbalans 2008

124 *Oenema, O. & J.W.H. van der Kolk.* Moet het eenvoudiger? Een essay over de complexiteit van het milieubeleid

125 *Oenema, O. & A. Tiktak.* Niets is zonder grond; Een essay over de manier waarop samenlevingen met hun grond omgaan

2009

126 *Kamphorst, D.A.* Keuzes in het internationale biodiversiteitsbeleid; Verkenning van de beleidstheorie achter de internationale aspecten van het Beleidsprogramma Biodiversiteit (2008-2011)

127 *Dirkx, G.H.P. & F.J.P. van den Bosch.* Quick scan gebruik Catalogus groenblauwe diensten

128 *Loeb, R. & P.F.M. Verdonschot.* Complexiteit van nutriëntenlimitaties in oppervlaktewateren

129 *Kruit, J. & P.M. Veer.* Herfotografie van landschappen; Landschapsfoto's van de 'Collectie de Boer' als uitgangspunt voor het in beeld brengen van ontwikkelingen in het landschap in de periode 1976-2008

130 *Oenema, O., A. Smit & J.W.H. van der Kolk.* Indicatoren Landelijk Gebied; werkwijze en eerste resultaten

131 *Agricola, H.J.A.J. van Strien, J.A. Boone, M.A. Dolman, C.M. Goossen, S. de Vries, N.Y. van der Wulp, L.M.G. Groenemeijer, W.F. Lukey & R.J. van Til.* Achtergrond-document Nulmeting Effectindicatoren Monitor Agenda Vitaal Platteland

132 *Jaarrapportage 2008.* WOT-04-001 – Koepel

133 *Jaarrapportage 2008.* WOT-04-002 – Onderbouwend Onderzoek

134 *Jaarrapportage 2008.* WOT-04-003 – Advisering Natuur & Milieu

135 *Jaarrapportage 2008.* WOT-04-005 – M-AVP

136 *Jaarrapportage 2008.* WOT-04-006 – Natuurplanbureaufunctie

137 *Jaarrapportage 2008.* WOT-04-007 – Milieuplanbureaufunctie

138 *Jong de, J.J., J. van Os & R.A. Smidt.* Inventarisatie en beheerskosten van landschapselementen

139 *Dirkx, G.H.P., R.W. Verburg & P. van der Wielen.* Tegenkrachten Natuur. Korte verkenning van de weerstand tegen aankopen van landbouwgrond voor natuur

140 *Annual reports for 2008; Programme WOT-04*

141 *Vullings, L.A.E., C. Blok, G. Vonk, M. van Heusden, A. Huisman, J.M. van Linge, S. Keijzer, J. Oldengarm & J.D. Bulens.* Omgaan met digitale nationale beleidskaarten

142 *Vreke, J.,A.L. Gerritsen, R.P. Kranendonk, M. Pleijte, P.H. Kersten & F.J.P. van den Bosch.* Maatlat Government – Governance

143 *Gerritsen, A.L., R.P. Kranendonk, J. Vreke, F.J.P. van den Bosch & M. Pleijte.* Verdrogingsbestrijding in het tijdperk van het Investeringsbudget Landelijk Gebied. Een verslag van casusonderzoek in de provincies Drenthe, Noord-Brabant en Noord-Holland.

144 *Luesink, H.H., P.W. Blokland, M.W. Hoogeveen & J.H. Wisman.* Ammoniakemissie uit de landbouw in 2006 en 2007

145 *Bakker de, H.C.M. & C.S.A. van Koppen.* Draagvlakonderzoek in de steigers. Een voorstudie naar indicatoren om maatschappelijk draagvlak voor natuur en landschap te meten

146 *Goossen, C.M.,* Monitoring recreatiegedrag van Nederlanders in landelijke gebieden. Jaar 2006/2007

147 *Hoefs, R.M.A., J. van Os & T.J.A. Gies.* Kavelruil en Landschap. Een korte verkenning naar ruimtelijke effecten van kavelruil.

148 *Klok, T.L., R. Hille Ris Lambers, P. de Vries, J.E. Tamis & J.W.M. Wijsman.* Quick scan model instruments for marine biodiversity policy.

149 *Spruijt, J., P. Spoorenberg & R. Schreuder.* Milieueffectiviteit en kosten van maatregelen gewasbescherming.

150 *Ehlert, P.A.I. (rapporteur).* Advies Bemonstering bodem voor differentiatie van fosfaatgebruiksnormen.

151 *Wulp van der, N.Y.* Storende elementen in het landschap: welke, waar en voor wie? Bijlage bij WOt-paper 1 – Krassen op het landschap

152 *Oltmer, K., K.H.M. van Bommel, J. Clement, J.J. de Jong, D.P. Rudrum & E.P.A.G. Schouwenberg.* Kosten voor habitattypen in Natura 2000-gebieden. Toepassing van de methode Kosteneffectiviteit natuurbeleid.

153 *Adrichem van, M.H.C., F.G. Wortelboer & G.W.W. Wamelink.* MOVE. Model for terrestrial Vegetation. Version 4.0

154 *Wamelink, G.W.W., R.M. Winkler & F.G. Wortelboer.* User documentation MOVE4 v 1.0

155 *Gies de, T.J.A., L.J.J. Jeurissen, I. Staritsky & A. Bleeker.* Leefomgevingsindicatoren Landelijk gebied. Inventarisatie naar stand van zaken over geurhinder, lichthinder en fijn stof.

156 *Tamminga, S., A.W. Jongbloed, P. Bikker, L. Sebek, C. van Bruggen & O. Oenema.* Actualisatie excretiecijfers landbouwhuisdieren voor forfaits regeling Meststoffenwet

157 *Van der Salm, C., L. .M. Boumans, G.B.M. Heuvelink & T.C. van Leeuwen.* Protocol voor validatie van het nutriëntenemissiemodel STONE op meetgegevens uit het Landelijk Meetnet effecten Mestbeleid

158 *Bouwma, I.M.* Quickscan Natura 2000 en Programma Beheer. Een vergelijking van Programma Beheer met de soorten en habitats van Natura 2000

159 *Gerritsen, A.L., D.A. Kamphorst, T.A. Selnes, M. van Veen, F.J.P.van den Bosch, L. van den Broek, M.E.A. Broekmeyer, J.L.M. Donders, R.J. Fontein, S. van Tol, G.W.W. Wamelink & P. van der Wielen.* Dilemma's en barrières in de praktijk van het natuur- en landschapsbeleid; Achtergronddocument bij Natuurbalans 2009.

160 *Fontein R.J, T.A. de Boer, B. Breman, C.M. Goossen, R.J.H.G. Henkens, J. Luttik & S. de Vries.* Relatie recreatie en natuur; Achtergronddocument bij Natuurbalans 2009

161 *Deneer, J.W. & R. Kruijne.* ***(2010).*** Atmosferische depositie van gewasbeschermingsmiddelen. Een verkenning van de literatuur verschenen na 2003.

162 *Verburg, R.W., M.E. Sanders, G.H.P. Dirkx, B. de Knegt & J.W. Kuhlman.* Natuur, landschap en landelijk gebied. Achtergronddocument bij

Natuurbalans 2009.

163 *Doorn van, A.M. & M.P.C.P. Paulissen.* Natuurgericht milieubeleid voor Natura 2000-gebieden in Europees perspectief: een verkenning.

164 *Smidt, R.A., J. van Os & I. Staritsky.* Samenstellen van landelijke kaarten met landschapselementen, grondeigendom en beheer. Technisch achtergronddocument bij de opgeleverde bestanden.

165 *Pouwels, R., R.P.B. Foppen, M.F. Wallis de Vries, R. Jochem, M.J.S.M. Reijnen & A. van Kleunen,* Verkenning LARCH: omgaan met kwaliteit binnen ecologische netwerken.

166 *Born van den, G.J., H.H. Luesink, H.A.C. Verkerk, H.J. Mulder, J.N. Bosma, M.J.C. de Bode & O. Oenema,* Protocol voor monitoring landelijke mestmarkt onder een stelsel van gebruiksnormen, versie 2009.

167 *Dijk, T.A. van, J.J.M. Driessen, P.A.I. Ehlert, P.H. Hotsma, M.H.M.M. Montforts, S.F. Plessius & O. Oenema.* Protocol beoordeling stoffen Meststoffenwet- Versie 2.1

168 *Smits, M.J., M.J. Bogaardt, D. Eaton, A. Karbauskas & P. Roza.* De vermaatschappelijking van het Gemeenschappelijk Landbouwbeleid. Een inventarisatie van visies in Brussel en diverse EU-lidstaten.

169 *Vreke, J. & I.E. Salverda.* Kwaliteit leefomgeving en stedelijk groen.

170 *Hengsdijk, H. & J.W.A. Langeveld.* Yield trends and yield gap analysis of major crops in the World.

171 *Horst, M.M.S. ter & J.G. Groenwold.* Tool to determine the coefficient of variation of DegT50 values of plant protection products in water-sediment systems for different values of the sorption coefficient

172 *Boons-Prins, E., P. Leffelaar, L. Bouman & E. Stehfest (2010)* Grassland simulation with the LPJmL model

173 *Smit, A., O. Oenema & J.W.H. van der Kolk.* Indicatoren Kwaliteit Landelijk Gebied

2010

174 *Boer de, S., M.J. Bogaardt, P.H. Kersten, F.H. Kistenkas, M.G.G. Neven & M. van der Zouwen.* Zoektocht naar nationale beleidsruimte in de EU-richtlijnen voor het milieu- en natuurbeleid. Een vergelijking van de implementatie van de Vogel- en Habitatrichtlijn, de Kaderrichtlijn Water en de Nitraatrichtlijn in Nederland, Engeland en Noordrijn-Westfalen

175 *Jaarrapportage 2009.* WOT-04-001 – Koepel

176 *Jaarrapportage 2009.* WOT-04-002 – Onderbouwend Onderzoek

177 *Jaarrapportage 2009.* WOT-04-003 – Advisering Natuur & Milieu

178 *Jaarrapportage 2009.* WOT-04-005 – M-AVP

179 *Jaarrapportage 2009.* WOT-04-006 – NPB-functie

180 *Jaarrapportage 2009.* WOT-04-007 – MPB-functie

181 *Annual reports for 2009; Programme WOT-04*

182 O*enema, O., P. Bikker, J. van Harn, E.A.A. Smolders, L.B. Sebek, M. van den Berg, E. Stehfest & H. Westhoek.* Quickscan opbrengsten en efficiëntie in de gangbare en biologische akkerbouw, melkveehouderij, varkenshouderij en pluimveehouderij. Deelstudie van project 'Duurzame Eiwitvoorziening'.

183 *Smits, M.J.W., N.B.P. Polman & J. Westerink.* Uitbreidingsmogelijkheden voor groene en blauwe diensten in Nederland; Ervaringen uit het buitenland

184 *Dirkx, G.H.P. (red.).* Quick responsefunctie 2009. Verslag van de werkzaamheden.

185 *Kuhlman, J.W., J. Luijt, J. van Dijk, A.D. Schouten & M.J. Voskuilen.* Grondprijskaarten 1998-2008

186 *Slangen, L.H.G., R.A. Jongeneel, N.B.P. Polman, E. Lianouridis, H. Leneman & M.P.W. Sonneveld.* Rol en betekenis van commissies voor gebiedsgericht beleid.

187 *Temme, A.J.A.M. & P.H. Verburg.* Modelling of intensive and extensive farming in CLUE

188 *Vreke, J.* Financieringsconstructies voor landschap

189 *Slangen, L.H.G.* Economische concepten voor beleidsanalyse van milieu, natuur en landschap

190 *Knotters, M., G.B.M. Heuvelink, T. Hoogland & D.J.J. Walvoort.* A disposition of interpolation techniques

191 *Hoogeveen, M.W., P.W. Blokland, H. van Kernebeek, H.H. Luesink & J.H. Wisman.* Ammoniakemissie uit de landbouw in 1990 en 2005-2008

192 *Beekman, V., A. Pronk & A. de Smet.* De consumptie van dierlijke producten. Ontwikkeling, determinanten, actoren en interventies.

193 *Polman, N.B.P., L.H.G. Slangen, A.T. de Blaeij, J. Vader & J. van Dijk.* Baten van de EHS; De locatie van recreatiebedrijven

194 *Veeneklaas, F.R. & J. Vader.* Demografie in de Natuurverkenning 2011; Bijlage bij WOt-paper 3

195 *Wascher, D.M., M. van Eupen, C.A. Mücher & I.R. Geijzendorffer,* Biodiversity of European Agricultural landscapes. Enhancing a High Nature Value Farmland Indicator

196 *Apeldoorn van, R.C., I.M. Bouwma, A.M. van Doorn, H.S.D. Naeff, R.M.A. Hoefs, B.S. Elbersen & B.J.R. van Rooij.* Natuurgebieden in Europa: bescherming en financiering

197 *Brus, D.J.,, R. Vasat, G. B. M. Heuvelink, M. Knotters, F. de Vries & D. J. J. Walvoort.* Towards a Soil Information System with quantified accuracy; A prototype for mapping continuous soil properties

198 *Groot, A.M.E.& A.L. Gerritsen, m.m.v. M.H. Borgstein, E.J. Bos & P. van der Wielen.* Verantwoording van de methodiek Achtergronddocument bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

199 *Bos, E.J. & M.H. Borgstein.* Monitoring Gesloten voer-mest kringlopen. Achtergronddocument bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

200 *Kennismarkt 27 april 2010;* Van onderbouwend onderzoek Wageningen UR naar producten Planbureau voor de Leefomgeving.

201 *Wielen van der, P.* Monitoring Integrale duurzame stallen. Achtergronddocument bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

202 *Groot, A.M.E.& A.L. Gerritsen.* Monitoring Functionele agrobiodiversiteit. Achtergrond-document bij 'Kwalitatieve monitor Systeeminnovaties verduurzaming landbouw'

203 *Jongeneel, R.A. & L. Ge.* Farmers' behavior and the provision of public goods: Towards an analytical framework.