

# **Distributive Aspects in the Design of Payments for Ecosystem Services and Agri-Environmental Schemes**

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## Abstract

Payments for ecosystem services (PES) and agri-environmental schemes (AES) (their counterpart in the EU and other developed countries) have been propagated as policy instruments to enhance environmental and nature conservation, and to reduce negative impacts of agriculture on the natural environment. These policies are often introduced with the goal to counteract overexploitation of natural habitats and biodiversity loss in forests and in agricultural landscapes. Their ecological effectiveness and cost-effectiveness have been, however, repeatedly questioned in the literature.

One of the proposed ways for increasing the cost-effectiveness of such schemes is through spatial differentiation of payments, which can reflect regional differences in both benefits and costs of conservation and thus maximize the ecological effect achieved with the available financial resources.

Another major critique for PES and AES is that they often pursue poverty alleviation and rural development objectives, which leads to compromising their cost-effectiveness. As the Tinbergen rule in economic theory suggests, separate policy goals require separate policy instruments.

However, as other policy instruments, PES and AES have distributional effects. Especially in developing countries, where governments are often weak and less able to successfully implement multiple policies, the distributional effects might not be adequately addressed. In developing as well as in developed countries, the distributional implications of PES and AES could even have an adverse effect on the cost-effectiveness of the schemes, if due to low acceptance and discontent among the potential ecosystem service (ES) providers, participation rates in these voluntary schemes are lower than optimal or if the transaction costs for scheme implementation are affected. From an economic perspective, if distributional goals are important for the design of PES and AES, the fairness preferences of potential ES buyers should be considered.

This thesis uses three case studies to address selected aspects of distribution and fairness in PES and AES from different perspectives. It provides insights into the preferences of potential ES buyers in Germany for distribution and other fairness aspects in PES and AES using two choice experiments and analyses possible distributional effects of cost-effective homogeneous and regionalized payments in AES.

The analysis of preferences among potential ES buyers suggests preferences for maximin distribution (favouring below-average income ES-providers) and equal distribution of payments, as well as preferences for animal welfare and biodiversity conservation (for local as well as for distant biodiversity), which could be directions for improvement of AES and PES.

Regarding distributional impacts of AES, in general, a trade-off between equality and cost-effectiveness is found. Equity generally increases with improved cost-effectiveness of homogeneous payments. Spatially differentiated payments improve the cost-effectiveness substantially, by aligning the payments to the regional costs and by aligning the measures to the regional specifics and the potential ecological benefits. However, regionalized payments have substantial redistribution effects, poorer regions are thereby adversely affected. This shows the importance of analyzing the distributional implications of cost-effective AES (and also PES) on different spatial levels and calls for a holistic approach in policy evaluation and implementation.

## **Zusammenfassung**

Zahlungen für Ökosystemleistungen (PES) und Agrarumweltprogramme (AUP) (das Äquivalent von PES in der EU und anderen Industrieländern) werden als politische Instrumente zur Verbesserung des Umwelt- und Naturschutzes und zur Verringerung der negativen Auswirkungen der Landwirtschaft auf die natürliche Umwelt propagiert.

Diese Maßnahmen werden häufig mit dem Ziel eingeführt der Übernutzung natürlicher Lebensräume und dem Verlust der biologischen Vielfalt in Wäldern und Agrarlandschaften entgegenzuwirken. Ihre ökologische Wirksamkeit und Kosteneffektivität wurden jedoch in der Literatur wiederholt in Frage gestellt.

Eine der vorgeschlagenen Möglichkeiten zur Steigerung der Kosteneffektivität solcher Systeme ist die räumliche Differenzierung der Zahlungen, welche regionale Unterschiede in Bezug auf Nutzen und Kosten der Maßnahmen widerspiegelt und somit den mit den verfügbaren Finanzmitteln erzielten ökologischen Effekt maximiert.

Eine weitere wichtige Kritik an PES und AUP ist, dass sie häufig auch Armutsbekämpfung und Entwicklung des ländlichen Raums als zusätzliche Ziele verfolgen, was zu einer Beeinträchtigung ihrer Kosteneffektivität führt. Wie die ökonomische Tinbergen-Regel vorschlägt, erfordern unterschiedliche politische Ziele unterschiedliche politische Instrumente.

Wie andere politische Instrumente haben auch PES und AUP jedoch Verteilungswirkungen. Insbesondere in Entwicklungsländern, in denen Regierungen häufig schwach sind und möglicherweise nicht in der Lage sind, mehrere politische Instrumente erfolgreich umzusetzen, werden die Verteilungseffekte möglicherweise nicht ausreichend berücksichtigt. Sowohl in Entwicklungs- als auch in Industrieländern könnten sich die Verteilungswirkungen von PES und AUP sogar nachteilig auf die Kosteneffektivität der Systeme auswirken, wenn aufgrund geringer Akzeptanz und Unzufriedenheit der potenziellen Anbieter von Ökosystemdienstleistungen (ES) die Beteiligung an diesen freiwilligen Systemen niedriger als erwünscht ist oder wenn die Transaktionskosten betroffen sind. Wenn Verteilungsziele für die Gestaltung von PES und AUP wichtig sind, sollten aus ökonomischer Sicht die Fairnesspräferenzen potenzieller ES-Käufer berücksichtigt werden.

Diese Arbeit verwendet drei Fallstudien, um ausgewählte Aspekte der Verteilung und Fairness in PES und AUP aus verschiedenen Perspektiven zu behandeln. Sie bietet Einblicke in die Präferenzen potenzieller ES-Käufer in Deutschland für Verteilungs- und andere Fairnessaspekte in PES und AUP anhand von zwei Choice-Experimenten und analysiert

mögliche Verteilungswirkungen kosteneffektiver homogener und regional-differenzierter Zahlungen in AUP.

Die Analyse der Präferenzen unter potenziellen ES-Käufern legt Präferenzen für eine maximin Verteilung (zugunsten von ES-Anbietern mit unterdurchschnittlichem Einkommen) und Gleichverteilung der Zahlungen, sowie Präferenzen für den Tierschutz und den Erhalt der biologischen Vielfalt, nahe (sowohl für die lokale als auch für die biologische Vielfalt in entfernten Regionen). In diese Richtungen könnten AUP und PES weiterentwickelt werden.

In Bezug auf die Verteilungseffekte von AUP wird im Allgemeinen ein Trade-off zwischen Gleichheit und Kostenwirkeffektivität festgestellt. Die Gerechtigkeit anhand der Verteilung der Produzentenrente steigt im Allgemeinen mit einer verbesserten Kosteneffektivität homogener Zahlungen. Räumlich differenzierte Zahlungen verbessern die Kosteneffektivität erheblich, durch Anpassung der Zahlungen an den unterschiedlichen regionalen Kosten, und auch durch Anpassung der Maßnahmen an den spezifischen regionalen Gegebenheiten und ökologischen Nutzen. Räumlich-differenzierte Zahlungen haben jedoch auch erhebliche Umverteilungseffekte, ärmere Regionen werden dadurch beeinträchtigt. Dies zeigt, wie wichtig es ist, die Verteilungswirkungen kosteneffektiver AUP (und auch PES) auf verschiedenen räumlichen Ebenen zu analysieren, und erfordert einen ganzheitlichen Ansatz bei der Bewertung und Umsetzung dieser Instrumente.

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## Abbreviations

AES	Agri-environmental schemes
AIC	Akaike information criterion
ASC	Alternative-specific constants
AI	Atkinson index
BIC	Bayesian information criterion
CAIC	Consistent Akaike information criterion
CAP	Common Agricultural Policy
CE	Choice experiments
CLM	Conditional logit model
CRP	Conservation Reserve Program
ES	Ecosystem Service
IIA	Independence from irrelevant alternatives
LCM	Latent class model
MLM	Mixed logit model
PES	Payments for ecosystem services
RPL	Random parameters logit model
SLCP	Sloping Land Conversion Program
WTP	Willingness to pay

# 1 Introduction

## 1.1 Background and motivation

Ecosystems all over the world are changing and deteriorating as a result of anthropogenic causes such as population growth, over-exploitation of natural resources, urbanisation, habitat conversion and intensive agricultural activities. Especially habitat conversion and intensive agricultural activities are two of the main factors driving biodiversity loss, one of the main threats to the global environment (IPBES, 2018). Biodiversity loss is especially pronounced in the tropics due to the decline in species rich tropical forests through overexploitation and conversion to agricultural land, but it is also important in non-tropic regions, as well (MEA, 2005).

The long-term success of agricultural activity depends, however, on the resources and ecosystems which it is actually undermining. On the other hand, certain landscapes and habitats, and also species, rely on specific agricultural activity for their sustenance (Poláková et al, 2011), e.g. certain grassland habitats are shaped through diverse and extensive grassland use and could be lost without human activities to maintain them which also negatively affects biodiversity in these habitats (Klimek et al., 2007). Thus agricultural ecosystems “are both providers and consumers of ecosystem services” (Power, 2010).

For conciliating this conflict between agricultural activities and environmental and nature protection different environmental policy instruments are being implemented, such as payments for ecosystem services (PES) and agri-environmental schemes (AES) (AES being a more narrow term to refer to a specific type of PES implemented on agricultural areas mainly in Europe and the USA). These policy instruments are widely used in practice and have received considerable attention in the literature (e.g. Batáry et al., 2015; Uehleke et al., 2019 for AES; and Kinzig et al., 2011; Salzman et al., 2018 for PES).

Some examples for PES are the PSA program in Costa Rica (Pagiola, 2008) and the Sloping Land Conversion Program (SLCP) in China (Lu and Yin, 2020) and for AES – the Conservation Reserve Program (CRP) in the US (Hellerstein, 2008) and the Agri-environmental, Climate Change and Animal Protection Program in Baden-Württemberg, Germany (Ministry of Rural Affairs, Food and Consumer Protection Baden-Wuerttemberg, 2016).

The main focus of research on PES and AES has been their ecological effectiveness and cost-effectiveness, i.e. to what extent they contribute to conservation/ environmental protection and

how the generated environmental results relate to the costs incurred by the policy (e.g. Kleijn, 2011; Jack et al., 2008; Wu and Yu, 2017).

A less well-researched and controversial topic, which is getting more attention in the literature in recent years, is the fairness of AES and PES, which can have different dimensions, such as distributive, procedural and contextual/ cultural issues (McDermott, Mahanty and Schreckenberg, 2013).

## 1.2 Literature overview

The economic term PES is formally defined by Engel (2016): "...as a positive economic incentive where environmental service (ES) providers can voluntarily apply for a payment that is conditional either on ES provision or on an activity clearly linked to ES provision."

The "ES providers" in PES and AES are either paid for a specific activity (land-use or no use) in action-related schemes or for a specific result attained (like (threatened) species occurrence, forest area preserved or another improvement in ES) in result-based schemes. There is often not a clear distinction between PES and AES, the two terms are however used in different contexts. The focus of AES are payments for conservation and environmental protection measures in agriculture and this term is used to refer to schemes implemented mostly in Europe and the USA (Engel et al., 2008), where the state finances and manages the schemes. The term PES is mostly used for schemes targeting different ecosystem services in developing countries, which are often financed by international donors and are either implemented by the state or international organizations like NGOs.

Whatever the source of financing for these instruments, there is the need to efficiently use the limited available resources. Thus, unsurprisingly, many studies have focused on the efficiency or cost-effectiveness of PES and AES. Already in 1996 Simpson and Sedjo propagated the use of direct payments (i.e. compensation of foregone benefits) for conservation of endangered ecosystems as an alternative to indirect payments (i.e. subsidies for "commercial activities that produce ecosystem services as joint products" (Ferraro and Simpson, 2000)). Ferraro and Simpson (2000) initiated a more in-depth discussion of the cost-effectiveness of conservation payments.

### **Cost-effectiveness in PES and AES**

Cost-effectiveness in PES and AES can in general be defined in two ways: maximizing the (conservation) output for given resources or reaching a certain conservation goal with minimum

resources (Wätzold and Schwerdtner, 2005). Here the first meaning of cost-effectiveness is used.

As Babrock et al. (1997) generalize: “maximization of environmental benefits obtained from a fixed budget is accomplished by purchasing those goods that offer the highest benefit to cost ratio until the budget limit is reached”. The application of this proposition in practice is not straightforward (e.g. due to difficulties in objectively measuring benefits (ES) and costs) and there have been different suggestions for the design and implementation of cost-effective PES and AES.

OECD (2010) gives detailed recommendations for improving the effectiveness and cost effectiveness of PES (including AES, no distinction is made there). The advice refers to specific design elements of the schemes, like baselines and additionality (ensuring that the environmental improvement or desirable actions would not have been undertaken even without the payments), and to the targeting of the schemes (choice of ES with high benefits and at high risk of degradation) and choice of ES providers (with low opportunity costs). A spatial differentiation of payments according to the opportunity costs of ES provision in combination with prioritizing high benefit areas for participation is seen as a straightforward way of increasing the cost-effectiveness of PES. Apart from spatial targeting and payment differentiation Wunder et al. (2018) also emphasize the importance of conditionality - “monitoring compliance and sanctioning detected non-compliance”, which in practice is rarely implemented, as it is costly and can be difficult.

Ansell et al. (2016) provide a review on the literature related to cost-effectiveness of AES in the context of biodiversity conservation which is also a focus of this thesis. One strand of the research on cost-effectiveness in AES relates to the different payment design, i.e. comparing fixed payments with auctions (e.g. Bamière et al., 2013) or with payment by result (e.g. White and Saddler, 2012). Fixed action-related payments are often found less cost-effective than results-based payments or auctions. However, taking into account different actual implementation conditions (Lundberg et al., 2018), potentially higher transaction costs (Klimek et al., 2008), or when multiple environmental objectives are set (Uthes et al., 2010), fixed payments could be more cost-effective.

Another main point of discussion on cost-effectiveness in AES is the spatial optimization of schemes (Hanley et al., 2012). Possible increases in cost-effectiveness are identified through spatial targeting of payments, e.g. by restricting participation to areas with highest benefit-cost ratio (van der Horst, 2007). Another suggested way of spatial optimization and improving cost-

effectiveness is through payment designs such as agglomeration bonus (a bonus payment for neighboring land patches on top of a baseline payment) and agglomeration payment (where payments are only received if contiguity of the participating land is established) (Drechsler et al., 2016; Lewis et al., 2011; Wätzold and Drechsler, 2014). To ensure cost-effectiveness the appropriate management scale for different types of species is also important (Ekroos et al., 2016). E.g. mobile species are better and less costly protected with a landscape-scale conservation management rather than farm-scale management (Cong et al., 2014). Spatially differentiated payments have also been alleged to increase the cost-effectiveness of schemes (compared to homogeneous payments) through better reflection of the often different cost and benefit functions among regions (Wätzold and Drechsler, 2005).

Together with the spatial variation, the timing of measures in AES is important in the case of biodiversity conservation schemes (Wätzold et al., 2016). Thereby, again, higher transaction costs can arise through the more sophisticated nature of differentiated schemes (Armsworth et al., 2012). Transaction costs are also relevant in the emerging research on possible more cost-effective collective PES (Jiangyi, Shiquan and Hmeimar, 2020), where payments are received by collectives or groups (instead of individuals) on the condition that they achieve a specific ecological outcome.

### **Distributional aspects in AES and PES**

There is a general consensus in the economic literature that increasing cost-effectiveness (or efficiency) normally means less equality, i.e. society faces an efficiency equality trade-off (cf. Okun, 1975). Consequently, for each separate policy target a separate policy instrument should be applied, i.e. one policy instrument should not strive to increase both efficiency and equality, as the “Tinbergen rule” of economic policy asserts (Tinbergen, 1952).

In line with this literature, but without revoking the importance of fairness considerations in PES and AES design, which is widely acknowledged, some scholars have repeatedly propagated that multiple side objectives like poverty alleviation or social equity can hinder the cost-effectiveness of these instruments (cf. Wunder et al., 2018). This issue is controversial and has led to a recent debate in Wells et al. (2020) and Wunder et al. (2020). As a reaction to the conclusions of Wunder et al. (2018) that simplified PES designs can impede their cost-effectiveness, Wells et al. (2020) defend the use of simplified PES designs (e.g. using undifferentiated payments and no targeting) to increase the “local transparency and acceptability” of the schemes, which can in practice be very important to ensure the cost-effectiveness of the schemes. And in response to this, the authors of the original article, Wunder



et al. (2020), provide more specific scientific evidence on the synergies between cost-effectiveness and equity. For example, assuring conditionality and paying landowners according to their opportunity costs could increase the fairness perception of the scheme.

Earlier literature has also questioned the explicit consideration of distributive impacts and setting poverty alleviation as a goal when implementing PES, since this could undermine the efficiency of conservation (Kinzig et al., 2011; TEEB, 2010). Instead, the use of separate policy instruments for achieving distribution objectives has been recommended. The prerequisite for successful policy implementation is, however, a functioning government and this is often not present in developing countries (Rice and Patrick, 2008), where PES are often implemented (often with the goal of conserving globally important ecosystem services). Governments in developing countries often do not sufficiently support policy implementation and enforcement (Engel and Palmer, 2008).

Therefore, as propagated by other authors (e.g. Corbera and Pascual, 2012; Pascual et al., 2014) consideration of equity issues, should be an integral part of PES design, especially in developing countries. In this way PES become more attractive for both the political agenda (Turpie et al., 2008) and also for those who participate in them (Narloch et al., 2012; Pascual et al., 2010). Not taking into account the fairness perceptions of the local communities in PES design can have an adverse effect on their implementation and goal attainment.

As AES are usually implemented in developed countries the argument of a weak government might not be strong in this context. This could be a reason why in the research on AES in particular distributional impacts have received less attention, exceptions include Claassen et al. (2001); Uthes et al. (2010); Wu, Zilberman, and Babcock (2001); and Wu and Yu (2017). Using a conceptual model Wu, Zilberman, and Babcock (2001) compare the environmental effectiveness and cost-effectiveness, and the distributional impacts of different conservation targeting strategies (benefit, cost, or benefit-cost targeting) for conservation funds (like CRP – an AES example from the USA) and conclude that the (agricultural) output price effect can have a strong influence on the cost-effectiveness of different targeting strategies. Wu and Yu (2017) demonstrate that improvement in both the efficiency and equity of the existing CRP is possible, whereas in their conceptual analyses Claassen et al. (2001) and Uthes et al. (2010) suggest that rural development goals impede the environmental goals of AES.

Since each scheme has its distributive effects, and they are important for the participants, the public and the policy makers, they should be considered and analyzed – at best already prior to implementation.

What is fair (in general, and in the context of PES and AES) is, however, also a point of discussion. In 2018 a systematic review by Friedman et al. on social equity in conservation research showed that the majority of research on social equity in conservation did not explicitly include an operational definition of equity.

Pascual et al. (2010) discuss several fairness criteria of PES programs and contribute to an operationalization of fairness in PES research and practice. A very widely and in general most commonly used fairness criterion is the equality or egalitarian principle (based on Konow, 2003; Leventhal, 1980) which stipulates equal treatment and distribution of rights, opportunities, outcomes etc. Translating this principle to PES and AES the payments should be distributed equally among the ES providers, e.g. per ha of participating land. This is also the way payments in PES and AES are normally implemented in reality. Since ES providers in PES are often poor the maximin principle can also be an important fairness criterion. Thereby, any social inequalities should be to “the greatest benefit of the least advantaged” (Rawls, 1999, p. 266). In the context of PES (or AES) this usually translates to higher payments for lower income participants. Since different ES providers have different costs of provision differentiating payments to reflect this difference can be seen as another fairness criterion (Pascual et al., 2010). This corresponds to the equity principle or accountability principle (Homans, 1974; Konow, 2003), where a fair output (payment or compensation) should be in proportion to an individual’s input (opportunity cost). The equity or accountability principle is thus also an efficiency oriented criterion, since it favors cost-effective distribution of payments.

This work focuses on the discussion of fairness based mainly on the aforementioned three fairness criteria, which all relate to the distributive dimension of fairness. Other fairness issues in PES (as suggested by McDermott, Mahanty and Schreckenberg, 2013) like procedural justice (the fairness of the processes involved in the implementation of the schemes) and contextual justice (the consideration of specific cultural and historical development related relevant social perceptions and fairness aspects) are beyond the scope of the thesis.

### 1.3 Research objectives and methods

Including distributional aspects, not only efficiency considerations already in the design of environmental policy instruments can, as already mentioned, facilitate their acceptance and implementation and the main research aim of this thesis is to contribute to an improved insight into the relationship between distributive aspects and cost-effectiveness in PES and AES, using three case studies and different approaches.

Since in the end taxpayers/ consumers pay for the implementation of these policy instruments (being through taxes, donations or fees, etc.), it is necessary to elucidate and analyse consumer preferences for different fairness aspects in PES and AES. From an economic perspective, the design of public policies should correspond to the public preferences (Page and Shapiro, 2010). The insights from this work can therefore be used to support the design of PES, AES and possibly other environmental policies.

For the analysis of consumer preferences two choice experiments (CE) were conducted. Choice experiments, or more generally, choice modelling is a stated-preference method for environmental valuation which was first applied in transportation economics and marketing. It is based on the proposition in Lancaster's theory of value (1976) that a consumer chooses and values a good based on its different characteristics and not based on the good as a whole. Thus CE provide valuation (willingness to pay) for different characteristics, or attributes, of a good. The good valued in Chapter 2 is a conservation fund for the dry spiny forest in Southeast Madagascar including the way (fairness) of payment distribution, and the good valued in Chapter 3 is milk with different ethical/ fairness attributes. From an economic perspective, AES design should take into account public preferences for public goods provided by agriculture (Hall et al., 2004). The CE study in Chapter 3 provides insights into the preferences of a large part of the population - conventional milk consumers (as taxpayers and potential ES buyers in state-administered AES) - for selected public goods related to milk production.

The discussion of fairness in this work is based mainly on the already mentioned three fairness criteria (equality, equity and maximin), which all relate to the distributive dimension of fairness. In addition, the choice experiments in Chapter 2 and 3 touch upon the public preferences for some other fairness issues related to environmental and social justice. The CE reveal preferences for: biodiversity protection, which is related to the responsibility to other species, the rights of the environment and to the responsibility to future generations (Clayton, 2000); preferences for animal welfare are also related to the responsibility to other species (Clayton, 2000); and the regional or national origin of milk production is related to the principle of social justice in the way that "the local food system is seen as one in which economic power, material resources, and profits are shared equitably among the people within a specific community" (Aprile et al., 2016).

Thus the CE in Chapters 2 and 3 look at the demand side for conservation and fairness in PES and AES, whereas Chapter 4 focuses on the supply side – how an AES can be optimized in its cost-effectiveness through regional payment differentiation and what implications for the

distributive fairness arise from this. For the analysis of cost-effectiveness in Chapter 4, an ecological-economic modelling procedure from Wätzold et al. (2016) is applied and modified. In the underlying ecological model for each spatial unit within a certain landscape the effect of different land use measures on the reproductive success of different pre-specified species (threatened meadow birds and butterflies) and habitats is assessed based on different landscape data and species-specific information. The costs arising from the different land use measures and the payments required for participation in AES are calculated using an agri-economic cost assessment model.

The modelling procedure is applied here to a case-study AES from Saxony, Germany, to simulate the ecological effects of the scheme and to show how it can be optimized. The cost-effectiveness of the AES is improved by choosing the most cost-effective set of measures for the species of interest under the predefined budget constraint. The timing and spatial allocation of the measures play a major role thereby. Additionally, the possible cost-effectiveness gains through regionally-differentiated payments in AES are analysed on two spatial scales (across regions – on state level, and within regions – on regional level) together with a discussion of the distributional effects of the schemes (based on the equality, equity and maximin criterion).

## 1.4 Thesis organization and outline

Cost-effectiveness and distributive issues in the context of PES and AES as environmental policy instruments in agricultural policy and species conservation are analysed from different perspectives in this thesis, based on two peer-reviewed articles (Chapter 2 and 3) and one working paper (Chapter 4). For the analysis of the demand side, i.e. the consumer preferences for distributive fairness, two choice experiment studies were conducted (Chapter 2 and 3).

The first choice experiment (Chapter 2) incorporates Markova-Nenova and Wätzold (2017) into this thesis and focuses on preferences of distant donors (potential ES buyers in Germany) for distributive fairness (equality and maximin principles) among local beneficiaries in developing countries, in the context of dry spiny forest conservation in Southeast Madagascar using a conservation fund (PES). The results reveal strong interest of potential distant donors in the way of payments distribution among local beneficiaries with preferences for maximin and equal distribution.

The second CE (Chapter 3) includes Markova-Nenova and Wätzold (2018) into the thesis and looks at preferences of a broad spectrum of consumers (as taxpayers and potential ES buyers in state-administered AES) on environmental and fairness issues in milk production using the case study of Germany. Thereby, animal welfare is the most highly valued ethical attribute. Fair

prices to poorer farmers (maximin principle) are supported in general, whereas fair prices to all farmers (equality principle) are supported only in the case of regional milk.

In addition, the two CE studies analyse preferences for biodiversity conservation. The first CE focuses on preferences for distant biodiversity (dry spiny forests in Madagascar) whereas the second CE focuses on preferences for local biodiversity (grassland biodiversity in Germany). Both studies show positive and substantial willingness to pay (WTP) for biodiversity conservation alongside with distributive fairness, thus indicating the relevance of these two issues and their importance in PES and AES design.

Biodiversity protection (in grassland) is also in the focus of the study in Chapter 4 on the cost-effectiveness and distributional aspects in AES, which includes Markova-Nenova, Wätzold and Sturm (2020) into the thesis. Here the supply side of AES is considered. Applying an ecological economic modelling procedure, the cost-effectiveness of a former AES from Saxony Germany is optimized on federal state and regional level. Trade-offs and synergies in improving the cost-effectiveness and the resulting distributive effects through homogeneous and regionally differentiated payments are identified. The results suggest in general large improvement in cost-effectiveness through regionalized payments, and a trade-off with equality, but an increase in equity through more cost-effectiveness. Thereby, the distributional effects from the schemes are different in the different regions, which calls for their thorough analysis and discussion.

The main results of the studies in Chapter 2, 3 and 4 are summarized and discussed in Chapter 5, where also an outlook with research gaps and policy recommendations are presented.

## Chapter 2

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### **PES for the poor? Preferences of potential buyers of forest ecosystem services for including distributive goals in the design of payments for conserving the dry spiny forest in Madagascar**

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The chapter includes a reprint of the published version  
with adapted cross-references and numbering  
to match the format of the thesis.

## **2 PES for the poor? Preferences of potential buyers of forest ecosystem services for including distributive goals in the design of payments for conserving the dry spiny forest in Madagascar**

### **Abstract**

Whether to consider distributive goals when designing the policy instrument of payments for ecosystem services is controversial. Opponents argue this may undermine the efficiency of ecosystem service provision and poverty reduction should be addressed with separate policies. However, many developing country governments are unable to implement such policies. In such cases, from an economic perspective, the preferences of buyers of ecosystem services should count. This paper addresses with a case study a particular group of buyers, citizens in developed countries, who pay to protect public environmental goods in developing countries through donations. Based on the case study of Malagasy spiny forest conservation, we conduct a choice experiment to elicit the preferences of citizens of Cottbus, Germany, for inclusion of distributive goals in PES design. We find that overall respondents have preferences for achieving distributive goals (equal or pro-poor distribution) with their donations and value information about the way of payments distribution among local beneficiaries.

### **2.1 Introduction**

The environmental policy instrument of payments for ecosystem services (PES) has received considerable attention in recent years (Corbera and Pascual, 2012; Kinzig et al., 2011; TEEB, 2010) including its application to preserve forest ecosystem services (Robert and Stenger, 2013). A contentious issue has been whether to consider distributive impacts when designing PES schemes. Some scholars argue that the consideration of equity issues, along with efficiency, should be an integral part of PES design (Corbera and Pascual, 2012; Pascual et al., 2014). A key argument for this view is that the support of local communities to implement a PES scheme can often only be achieved if their consideration of fairness is taken into account in PES design. Otherwise, local communities may ignore or even oppose the scheme, which is likely to make its implementation more costly and undermine its long-term success (Narloch et al., 2012; Pascual et al., 2010). Another argument is that considering equity issues increases the political attractiveness of PES, and hence a PES scheme that contributes to poverty alleviation is easier to implement (Turpie et al., 2008).

In contrast, other scholars argue that taking into account distributive impacts may undermine the main goal of PES, which is to improve the efficiency of natural resources management

(Kinzig et al., 2011; TEEB, 2010). While not disputing the relevance of distributive goals, those authors hold that it is more efficient overall to address distribution objectives with other, more suitable, policy instruments. As succinctly pointed out by Kinzig et al. (2011, p.604): “Poverty reduction is a laudable goal, but it should not prevent PES schemes from signaling the scarcity of ecosystem services. Every payment system has implications for equity; although these effects may be extremely important they should be addressed separately, not through payments made under the scheme”.

The argument put forward by Kinzig et al. (2011) and others relates to the “Tinbergen rule” of the classical theory of economic policy. This rule dates from the work of the Nobel Prize winner Jan Tinbergen (Tinbergen, 1952) and states, in summary, that in order to achieve a certain number of policy targets, an equal number of policy instruments should be applied. The implicit assumption behind the Tinbergen rule is that a functioning government exists and is able to formulate policy goals, design policies to achieve these goals, and successfully implement the policies. This assumption, however, does not hold in many developing countries (Rice and Patrick, 2008). In practice, governments in developing countries tend to be weak, and substantial policy implementation deficits exist (Engel and Palmer, 2008).

Establishing a PES scheme in countries with weak governments often proves difficult and may only be possible with the support of an international organization or donor (see as an example Sommerville et al., 2010). It is therefore unrealistic to expect that a weak government can or will implement a second policy focusing on distributive goals in the same area where the PES scheme is established. In such situations there are only two realistic alternatives: 1) to implement a PES scheme focusing solely on efficiency, or 2) to implement a PES scheme that also includes distributive goals.

From an economic perspective, a key factor to consider in the decision between these two alternatives are the preferences of the “buyers” of the ecosystem service. It is therefore important to understand to what extent distributive goals are relevant for these buyers. In the case of payments for ecosystem services there are different types of buyers (Engel, 2016). In this paper we are interested in a particular group of buyers, namely citizens in developed countries who pay to protect public environmental goods in developing countries. They pay through donations and taxes that are typically channeled through international NGOs and other international organizations such as the Global Environment Facility and used to finance or co-finance PES schemes aiming to conserve endangered biodiversity of global value or to preserve forests as carbon sinks (GEF, 2010; TEEB, 2010).



The aim of this paper is to contribute to answering the question of whether citizens in developed countries, as potential buyers of ecosystem services, have a preference for including distributive goals in the design of PES. For this purpose we carried out a case study with a choice experiment to elicit potential buyers' willingness-to-pay for an ecosystem service and for different distributive impacts of payments to preserve this ecosystem service. Our case study is the conservation of the dry spiny forest in the Mahafaly Plateau region in Madagascar, which is inhabited by many endangered endemic species and of high conservation value (Olson and Dinerstein, 2002). Hence, the ecosystem service we are interested in is maintenance of biological and genetic diversity (see de Groot et al., 2002), in this case - the preservation of the dry spiny forest as a habitat for endangered species. The forest is threatened by slash-and-burn agriculture from local inhabitants who are very poor (SULAMA, 2011). In Madagascar, the government is weak and policies are poorly developed and implemented (Rice and Patrick, 2008). In our choice experiment we asked inhabitants of the city of Cottbus, Germany, as potential "buyers", about their willingness to donate money to fund alternative PES schemes characterized by different levels of conservation and different distributive impacts.

Overall we find that respondents' willingness-to-pay for conservation is significantly affected by the distributive impacts of the payment to the inhabitants of the Mahafaly region. Respondents do have preferences for achieving distributive goals with their donations and prefer to be informed about the way payments are distributed among the local beneficiaries. Bearing in mind the limitations of a case study approach, our results suggest that citizens in developed countries do care about the distributive impact of PES schemes in poor countries. This adds from an economic perspective a strong argument that PES schemes which are financed by donations or taxes from developed countries and are implemented in poor countries with weak governments should include distribute goals.

## 2.2 Conservation problem

The dry spiny forest ecoregion extends across southern and southwestern Madagascar and is listed as one of the 200 most important ecological regions in the world (Olson and Dinerstein, 2002). It provides a habitat for numerous endemic species, such as the radiated tortoise and the giant-striped mongoose, and has the highest level of plant endemism in Madagascar (95% at the species level) (Ferguson et al., 2013, Ganzhorn et al., 2015). Deforestation has led to a decline in the area covered by spiny forest from 1973 to 2013 by 45% (Brinkmann et al., 2014). Brinkmann et al. (2014) identified the widely used practice of slash-and-burn agriculture as the main reason for deforestation and biodiversity loss in southwestern Madagascar (see Minten

2003 and Scales (2014) for the situation in Madagascar and Van Vliet et al. (2012) for a general discussion on slash-and-burn agriculture). Southwestern Madagascar is particularly vulnerable to deforestation as due to the dry climate the regrowth of forest is very slow (Sussman, 2003).

The Mahafaly Plateau, a rural area in the southwest of Madagascar, covers an area of approximately 8000 km<sup>2</sup>. The climate is semi-arid with an annual rainfall of between 300 and 600 mm, mainly occurring between November and April (SULAMA, 2011). There is no supply of electricity or tap water. Water for humans and livestock comes from wells and small ponds which, however, partly dry out during the dry season. There are only few unpaved roads. Goods are transported almost exclusively by ox cart. Education covers only primary school (SULAMA, 2011).

In the Mahafaly region, 87.7% of households are considered poor with an annual per capita income below 468,800 Ariary (around 200 US\$) (INSTAT, 2010; Neudert et al., 2015). Agriculture provides the main source of income for most inhabitants but many households also have other sources of income to complement their income from farming (Neudert et al., 2015). Cassava and maize are the main food crop and small-scale farming prevails with the median field size per household being 1.2 ha (INSTAT, 2010; SULAMA, 2011). Many households also keep livestock such as goats, sheep and chickens. Zebu (humped cattle typical for the region), however, are kept only by the wealthy households (Neudert et al., 2015). One way to gain more land for agriculture is slash-and-burn agriculture, a key driver of deforestation in the Mahafaly region (SULAMA, 2011).

In order to halt slash-and-burn agriculture, local communities could receive payments from international organizations for maintaining the dry spiny forest. Local communities could use these payments to buy food or increase the productivity of already cultivated agricultural land by, for example, applying manure (SULAMA, 2011). PES schemes in Madagascar are typically financed by international donors (Sommerville et al., 2010), and it is widely recognized that financial support from international organizations is essential for the conservation of endangered biodiversity in Madagascar (Richard and Ratsirarson, 2013).

In Madagascar, governmental structures are generally weak (Freudenberger, 2010; Rice and Patrick, 2008) and almost non-existent in the rural areas of the south and west (Bertelsmann Stiftung BTI, 2012). The government is therefore unlikely to be able to successfully implement measures to alleviate poverty in the Mahafaly Plateau. (Tucker et al., 2011 report some efforts of the Malagasy government to implement development programs in poor and remote regions of southwestern Madagascar, but are highly doubtful about the success of such policies.) This

argument is supported by the fact that transfer payments from the central government to the communities in Madagascar are usually paid with delay, and sometimes not at all (The World Bank, 2004). It is therefore unrealistic to assume that the government is able to design and implement poverty alleviation policies to complement possible payments to local communities to conserve the dry spiny forest in the Mahafaly region.

## 2.3 Methods

### 2.3.1 Choice experiment - survey

To study the preferences of potential buyers of ecosystem services for achieving specific distributive goals we used the stated-preference method of choice experiments. Based on Lancaster's (1966) characteristics theory of value, choice experiments (CE) are well-suited for analyzing the importance of different characteristics (attributes) of a good or a policy. In our case the most important choices for the analysis are between achieving and not achieving distributive goals by a donation for nature conservation through PES, and between different distributive goals. Thus, we designed a choice experiment with one of the attributes being the way payments are distributed among the providers of ecosystem services. We are especially interested in the relative importance of the levels of this attribute which reflect different distributive aspects.

The hypothetical scenario of our choice experiment is that a conservation NGO intends to conserve the dry spiny forest in the Mahafaly Plateau region through the distribution of payments among the local population. For this purpose, the NGO is to establish a conservation fund, to be funded by donations. The local communities are then to receive the donations and distribute them among the households.

In the choice experiment the respondents faced alternatives with three attributes (Table 2.1): (I) different levels of conservation as expressed by the area of forest conserved, (II) different (ways of) distribution of payments, and (III) different one-time payments in the form of a donation, which they would have to pay.

The different levels of conservation, as expressed by the area of forest conserved (attribute I), were defined based on literature research about the Mahafaly region. We decided to keep the number of alternative ways of distributing payments low to make the choice experiment easier and more understandable for the respondents. Thus the focus of the analysis was narrowed down to the relative importance of including either equality aspects, or pro-poor aspects or not including any distributive aspects in the payments distribution.

**Table 2.1 Attributes and attribute levels used**

Attributes	Levels
<b>Forest area conserved</b>	25 km <sup>2</sup> , 50 km <sup>2</sup> , 75 km <sup>2</sup>
<b>Distribution of payments</b> (depending on the communities where the project will be implemented)	(1) According to the communities' traditions → <b>everyone gets the same</b> <i>Corresponds to the equality/ egalitarian principle</i>
	(2) According to the communities' traditions → <b>low-income households get more</b> <i>Corresponds to the Rawlsian maximin principle</i>
	(3) No information available on the traditions in the communities → <b>distribution unknown</b> <i>Implies no consideration of distributive issues</i>
<b>Donation</b> (one-time payment in Euro)	2, 4, 10, 15, 20, 35, 55, 75, 100

In the hypothetical scenario of the experiment respondents were informed that the payments would go from the conservation fund to the village assemblies, as in the region the village assemblies always decide on important issues, including distribution of common goods and finances. Thus the decision on the distribution would always be community internal, but would depend on the communities' traditions. We stated that different local communities have different traditions in terms of the distribution of common goods, and that, therefore, there were three options for the distribution of the payments depending on which communities would be chosen to participate in the conservation project:

(1) *Everyone gets the same* – if only those communities are involved where according to tradition all households get equal amounts of common goods or of payments to the community. This corresponds to an equal distribution, i.e. to the egalitarian principle (Konow, 2003), where everyone gets the same amount. This is the traditional and most straightforward view on equity which Pascual et al. (2010) have also identified as one of the fairness criteria for PES programs.

(2) *Low-income households get more* – if only those communities are involved where according to tradition poorer households get higher amounts of common goods (we stated that approximately half of the payments go to the poorest one-third of the households). Following Pascual et al. (2010) for PES this corresponds to a pro-poor or “maximin” distribution, in accordance with Rawls (1971). Rawls' difference principle was translated to the respondents as “larger payments to low-income households”. This seemed the best and most direct way of conveying the idea that the payments can contribute to poverty alleviation.

(3) *Unknown distribution* – the way payments are distributed is not predictable when the communities involved have no prevailing traditions due to intensified migration and

resettlement from other regions. Thus, it might be that all households get the same payments, or that low-income households get more, or that wealthier households get more. This distribution level was included in order to be able to better assess whether distributive issues matter to respondents.

Voluntary donation (attribute III) to a conservation fund managed by an NGO was chosen as a payment vehicle, because this is the usual way of financing the kind of project in question. We decided to use a one-off donation, since the effect on a respondent's budget is easier to understand than in the case of an annual payment over several years. To allow respondents to choose between different low, middle and high amounts of payment the donation attribute was set at nine levels between €2 and €100.

For the purpose of the experiment a balanced orthogonal fractional factorial design with 27 profiles was generated using SPSS® Conjoint software. The profiles which represented the first (A) alternative in every choice set were blocked into 3 blocks. The B alternative was constructed from the A alternative by shifting. The C alternative that was included in the choice sets corresponded to a status quo, where no fund is established, no forest is conserved, and no donation is made by the respondent. Each respondent was presented with nine choice cards. A sample choice card is presented in Figure 2.1. The optimal number of choice situations in a CE is reported to be about 9 or 10 (see Caussade et al., 2005 or Vecchiato and Tempesta, 2013).

**Figure 2.1 Sample choice card**

<b><i>Which alternative would you choose, if you were asked to donate to the establishment of a conservation fund for the spiny forest?</i></b>			
	<i>Alternative A</i>	<i>Alternative B</i>	<i>Alternative C: no donation</i>
<b>Spiny forest area conserved</b>	<b>75 km<sup>2</sup></b>	<b>25 km<sup>2</sup></b>	<b>0 km<sup>2</sup></b>
<b>Distribution of payments. Who gets the payments?</b>	<b>“distribution unknown”</b>	<b>“low income households get more”</b>	<b>X</b>
<b>One-time donation</b>	<b>15 €</b>	<b>20 €</b>	<b>No donation</b>
<b>I choose: Please, check only one box!</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*X means no distribution of payments, no conservation fund established.*

### 2.3.2 Choice modeling

We tested three different choice models for predicting the choice probabilities of respondents, namely the conditional logit model (CLM), the random parameters logit (RPL) model, and the latent class model (LCM). In general, choice models employ random utility theory, according to which the utility derived from an alternative consists of an observable part ( $V$ ) and a stochastic element ( $\varepsilon$ ). In line with this, the probability of individual  $n$  choosing an alternative  $i$  over  $j$  depends on some observable and unobservable characteristics of the alternative or the respondent (equation 2.1 below). Different choice models rely on different assumptions about the distribution of the error term  $\varepsilon$  that captures the unobservable characteristics.

$$P_{ni} = (V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}, \forall i \neq j) \quad (2.1)$$

In the simplest and most widely used conditional logit model, as formulated by McFadden (1974), the error term is an independently and identically distributed (IID) extreme value Type I. The parameters estimated are fixed for all the respondents, i.e. no heterogeneity of preferences is assumed. Further, the ratios of choice probabilities of the alternatives are considered to be independent of including new alternatives into the choice set or of excluding alternatives (independence from irrelevant alternatives – IIA assumption). This assumption is strong and should be tested (Hausman and McFadden, 1984).

To test the validity of the IIA assumption in our experiment we conducted a generalized Hausman test suggested by Weesie (1999) using the statistical package Stata. The Weesie test led to rejection of the IIA assumption for each of the three alternatives at the 1% level. Morrison et al. (1998) suggest the presence of close substitutes in a choice set or the existence of preference heterogeneity among respondents as possible reasons for violation of the IIA assumption. In our experiment the A and B alternatives as defined can be regarded as close substitutes, which might explain the violation of the IIA assumption. We accordingly only present the results of an RPL model and an LCM.

A more sophisticated model, which relaxes the strong assumptions of the CLM, is the RPL model (McFadden and Train, 2000), where parameter coefficients are assumed to vary across respondents. The probability of choosing an alternative is specified as:

$$P_{ni} = \frac{\exp(\beta' x_{ni})}{\sum_{j=1}^J \exp(\beta' x_{nj})} \quad (2.2)$$

where  $x$  stands for the characteristics of an alternative and/or of respondents and  $\beta'$  is a vector of parameter estimates.

The probability distributions of the random parameters in an RPL model have to be specified by the analyst. The normal distribution, which is often preferred, has the disadvantages of being unbounded and symmetrical. Thus it is not well suited for estimating coefficients which are presumed to be either only negative (e.g. cost coefficients) or only positive. A triangular distribution, which can be asymmetric, is better for deriving behaviorally meaningful individual-level outputs (Hensher et al., 2005). Therefore in our analysis in the RPL model, we specify a triangular distribution for the donation attribute and for the forest area conserved, whereas for the distributive attribute levels (effects-coded variable in our experiment) we use a normal distribution. For the calculation of marginal willingness to pay (WTP) we restrict the spread of the donation attribute to be equal to the mean to ensure only positive WTP values, as suggested by Hensher et al. (2005).

$$WTP = -\frac{\beta_{attribute}}{\beta_{cost}} \quad (2.3)$$

Another way to relax the assumptions of the CLM is by using an LCM (Greene and Hensher, 2003), which can potentially give some interesting insights into the preferences of respondents according to their socio-demographic characteristics. In an LCM preferences are assumed to vary between classes of respondents. The sample is implicitly divided into a small number of classes based on different individual characteristics or attitudes. Membership of a class is probabilistic and not known a priori to the analyst. The parameters are estimated based on a logit model for each class of respondents. The number of classes has to be defined by the analyst, which might pose a difficulty, but the disadvantage of an RPL model of having to make assumptions about the distribution of parameters is obviated. All choice models were estimated using NLOGIT 5/LIMDEP 10 econometric software.

### 2.3.3 Data collection

As a result of a pretest with 18 individuals, the presentation, which was a part of each survey session, was slightly modified to include some additional information respondents were interested in, such as the total area covered by dry spiny forests and alternative livelihoods of locals apart from slash-and-burn agriculture.

The survey respondents were recruited via announcements in the local newspaper and by word of mouth in the city of Cottbus. Quota sampling based on age and gender was used. The survey topic was not revealed to the respondents in order to reduce sample selection bias. Each respondent received €15 compensation for participating in the survey (cf. Ahlheim et al., 2013).

The surveys were conducted in groups with a size of approximately 15 to 20 respondents by one of the authors.

Since the scenario was hypothetical and the topic not well known in the general public, each choice experiment survey session started with a presentation by the interviewer on the conservation problem, the Mahafaly region and the proposed hypothetical solution through payments. In the presentation we avoided the scientific term “ecosystem service” as respondents were most likely not familiar with this term and it would have unnecessarily complicated the description of the conservation problem. Guidelines on filling out the choice cards were also given. The goal was to ensure that the respondents have a good understanding of the problem, and to help in filling out the questionnaire. Several stated-preference studies show that the amount and kind of information provided to respondents has a significant effect on their preferences and WTP (e.g. Czajkowski and Hanley, 2012; Upton et al., 2012), especially if respondents are not familiar with the good being valued (Lienhoop and Völker, 2016; MacMillan et al., 2006).

At the end of the presentation the interviewer urged the respondents to answer according to their own preferences and budget/financial situation, as they would in a real-life situation. The interviewer also informed the respondents that similar studies have shown that participants tend to exaggerate their stated willingness to pay. The purpose of this “cheap talk” was to reduce the hypothetical bias to which the participants’ responses are subject to having in mind the theoretical nature of the survey scenario. Cheap talk (an explanation of the bias problem to respondents and a request not to overstate their WTP) has been successfully used in contingent valuation studies (e.g. Murphy et al., 2005) and choice experiments (Carlsson et al., 2005) to reduce the effects of hypothetical bias.

After the presentation the respondents had the opportunity to ask questions concerning the experiment and the project. The interviewer ensured that the same answers were given to similar questions in different survey sessions to avoid any bias. Eventually every respondent completed the questionnaire on their own without any group discussion to avoid any social pressure arising from the group setting of the experiment.

The questionnaire itself consisted of some “warm-up” questions, the choice cards plus instructions for filling them out, and some debriefing and socio-economic questions. Some of the debriefing questions were included to help identify protest responses. Some attitudinal questions and questions on the perceived complexity of the experiment for respondents were



included too. The questionnaire ended with an appendix with the information on the project and the problem as presented in the oral presentation which respondents could refer to, if needed.

Altogether 298 individuals from the city of Cottbus participated in 16 survey sessions. Overall the sample is fairly representative of the population, especially in terms of income and gender (Table 2.2). However, the age class 20-44 years is slightly underrepresented in the sample, whereas the age class 45-64 years is slightly overrepresented.

Out of the 298 respondents, the data from 245 respondents was used in the choice model estimation. Sixteen respondents were dropped because of missing values for the choice variable. In addition, the answers of 37 respondents were identified as protest responses and excluded from the model estimation. The protest respondents in this study were defined as respondents who object to or reject some parts of the hypothetical scenario of the stated-preferences survey and allocate non-true zero values to the program valued. Thus the protest responses were identified among the respondents with no WTP, i.e. among those who chose not to donate on each choice card. To distinguish between protest responses and real zeros we asked respondents to give their reasons in case they chose not to donate on each choice card. For this purpose, a closed-ended question with an option for stating “reasons for not donating” was included in the questionnaire, in the debriefing part after the choice cards. After analyzing the answers to this question, the protest responses were identified based on protest beliefs (cf. Meyerhoff and Liebe, 2008 and Strazzera et al., 2003). Three respondents (out of the 37 identified as protests) gave no reason for not donating and left many questions unanswered. They were classified as protest responses too.

**Table 2.2 Sample statistics compared to the population of Cottbus**

	Sample in % (count)		Population of Cottbus in % (31.12.2011)
Gender			
Female	52.7	(156)	50.7
male	47.3	(140)	49.3
Age (years)			
15-19	4.8	(14)	3.1
20-44	29.2	(85)	37.1
45-64	42.3	(123)	34.5
>=65	23.7	(69)	25.2
Income			

	<b>Sample in % (count)</b>	<b>Population of Cottbus in % (31.12.2011)</b>
< 900 €	21.9 (61)	22.4
900 € to under 1300 €	17.3 (48)	19.1
1300 € to under 2600 €	41.4 (115)	38.5
>=2600 €	19.4 (41)	20.0
Size (count)	298	102,129

## 2.4 Results

### 2.4.1 Main Results

In the choice model estimations, we used effects coding for the levels of the distribution attribute to be able to analyze trade-offs between different alternative ways of distributing payments. Continuous variables were defined for the forest area conserved and the donation amount.

Table 2.3 shows the results of the RPL model estimated only using the attributes. The RPL model was estimated once with an unconstrained triangular (t-)distribution for the donation attribute and then with a constrained t-distribution. The standard deviation parameter estimate was constrained to that of the mean of the random parameter, as suggested by Hensher et al. (2005). This ensures no change of sign in the parameter estimates for donation and is therefore useful for WTP calculations.

Both estimations of the RPL model result in statistically significant coefficients for all attributes used. The coefficient for forest area conserved is significant at the 1% level and with a positive sign. As expected, the larger the forest area conserved, the higher the utility of an alternative. The coefficient for donation is negative and significant at the 1% level, showing that utility decreases with higher donations. The positive and statistically significant coefficients for “equal distribution” and “pro-poor distribution” suggest that respondents have preferences for achieving distributive goals with their donations. This is also confirmed by the negative and significant coefficient for “unknown distribution”. Respondents seem to prefer to donate to a program involving some distributive goals and prefer to have information on the way the donations are distributed.

**Table 2.3 RPL model estimates of preferences (standard errors in parentheses)**

Variable	RPL (unconstrained)		RPL (constrained)	
	Mean	Std. Dev./ Spread	Mean	Std. Dev./ Spread
Forest area conserved	0.034*** (0.009)	0.062** (0.028)	0.027*** (0.003)	0.052*** (0.014)
Equal distribution	0.555** (0.245)	0.889 (0.610)	0.391*** (0.076)	0.277 (0.574)
Pro-poor distribution	1.188*** (0.399)	1.201** (0.519)	0.876*** (0.105)	0.752*** (0.268)
Unknown distribution	-0.789*** (0.197)	0.466 (0.949)	-0.823*** (0.086)	0.049 (0.315)
Donation	-0.056*** (0.018)	0.107** (0.040)	-0.037*** (0.004)	0.037*** (0.004)
Number of respondents	245		245	
Number of observations	2205		2205	
Log-likelihood	-1963.283		-1973.356	
AIC (normalized)	1.790		1.798	
Pseudo-R2	19.0%		18.5%	
*** significant at 1%, ** significant at 5%, * significant at 10%				

Following the procedure suggested by Hensher et al. (2005), we use the common-choice-specific conditional parameter estimates of the constrained RPL model shown in **Table 2.3** to calculate the implicit prices (marginal WTP) for the different attributes and levels. The comparison of implicit prices gives us a better insight into respondents' preferences, especially into the preferences for different ways of distribution. The implicit price or marginal WTP for any attribute is equal to the ratio between the coefficient for that attribute and the coefficient for cost or price.

Table 2.4 shows that respondents are willing to pay on average €0.74 for one km<sup>2</sup> forest area conserved. A conservation program involving higher payments to lower income households ("pro-poor" distribution) is valued higher than a program with equal distribution of payments. The WTP to have a "pro-poor" distribution equals €24.41, whereas "equal" distribution is valued at €10.76. The negative WTP value of -22.54 for unknown distribution can be interpreted as the WTP not to have an unknown distribution, implying that it is desirable for respondents to have information on the distribution of the payments. Apparently, not knowing how payments are distributed decreases the utility of a conservation program for respondents.

A useful comparison of the preferences for different ways of distribution can be based on the part-worths of changes in the distribution (calculated as the difference in marginal WTP). Changing the distribution from “unknown” to “equal” is worth €33.30; changing the distribution from “unknown” to “pro-poor” is worth €46.95; a change from “equal” to “pro-poor” distribution is worth €13.65.

**Table 2.4 Implicit prices (marginal WTP) using conditional constrained parameter estimates from RPL**

Attributes	Marginal WTP (in Euro)			
	Forest area conserved (per km <sup>2</sup> )	Equal distribution	Pro-poor distribution	Unknown distribution
<i>Mean</i>	0.74	10.76	24.41	-22.54
<i>St. Dev.</i>	0.27	1.99	8.94	2.57
<i>MAX</i>	1.53	23.53	50.96	-19.01
<i>MIN</i>	0.19	7.50	5.76	-42.98

#### 2.4.2 Sources of preference heterogeneity

The estimated simple RPL models show the existence of preference heterogeneity, but do not give information on the sources of heterogeneity. To analyze the influence of socio-demographic characteristics and attitudes on preferences we employ an LCM and an RPL model including interactions between attributes and socio-demographic and attitudinal variables. We thereby test the following hypotheses for the determinants of preferences.

It is likely that respondents who have already donated to environmental or nature protection causes are more likely to choose alternatives with greater forest area conserved and higher donation payment. To test these hypotheses a question on previous donations to an environmental or nature protection organization (in the previous two years) was included in the questionnaire and coded as the dummy “Donation for Environment”.

Similarly, respondents who have already donated to poverty alleviation causes might tend to choose programs which help the poor. To test this, we include an interaction between the “pro-poor” donation attribute with the variable “Donation for Poverty”. The latter accounts for respondents’ donations to development aid or poverty alleviation causes in the previous two years.

Respondents who think it is important that low-income households get higher payments for implementing nature conservation measures in developing countries might be more likely to choose to donate to a program involving a “pro-poor” distribution. To test this hypothesis, we

include a respective debriefing question in the choice experiment questionnaire. We then create a dummy variable “Poor Important”, which is equal to 1 if respondents stated that low income households getting more is important or very important and 0 otherwise, and let it interact with the “pro-poor” attribute. This is to some extent a consistency check, too.

To test how income influences respondents’ choices, we create two dummy variables - “Low-Income” respondents, which equals 1, if the net monthly household income is below €900 and 0 otherwise, and “High-Income” respondents, which equals 1, if the net monthly household income is above €2600 and 0 otherwise. We let the two income variables interact with all three random parameters in the RPL model (“forest area conserved”, “pro-poor” and “donation”) to check the effect of income on preferences.

Respondents with low income are expected to prefer to donate to a program where low income households get higher payments, out of empathy. We check this by including an interaction between the “Low-Income” variable and the “pro-poor” distribution attribute in the model. It is also likely that low-income respondents have higher disutility of donation payments and prefer lower payment amounts, due to their higher marginal utility of income (money) compared to wealthier households. We therefore let the donation attribute interact with the “Low-Income” variable. The opposite effect on the utility of donation is expected for “High-Income” respondents, since the amount of donation and the share of donors increases with increasing income. For Germany this trend has been empirically confirmed by e.g. Priller and Sommerfeld (2005) and by Priller and Schupp (2011).

Available donation statistics show that the proportion of donors in the population increases also with age. The donation rate (as a percentage of money donors) is especially high in the age class of 65 and above (TNS Infratest, 2011). To account for the higher willingness to donate of the elderly, we create a dummy variable “Age 65 and above”, which is equal to 1, if a respondent is 65 years old or above and 0 otherwise and estimate an interaction between this variable and the donation attribute.

Apart from analyzing the interaction of age and the donation attribute, we test the influence of age on the choice of a program which supports the poor. There is some evidence in the literature that altruistic behavior becomes more likely with age (List, 2004). Thus, it might be that elderly respondents are more likely to choose a program involving “pro-poor” distribution.

To test the above hypotheses, we run an RPL model including the estimation of fixed interactions between the attributes and the dummy variables “Poor Important”, “Low-Income”, “High-Income”, “Donation for Environment”, “Donation for Poverty”, and “Age 65 and

above”. Thereby we set the distribution attribute levels “equal distribution” and “unknown distribution” as non-random parameters, as suggested by the results of the simple constrained RPL model (see Table 2.3), where the standard deviation estimates of these variables are insignificant.

The results of the RPL model including sources of preference heterogeneity are presented in Table 2.5. The coefficients for all attributes, displayed in the first section of the table, are of the expected sign and significant, except for the coefficient for the mean of the “pro-poor” distribution, which is insignificant. However, its significant standard variation shows that there is high heterogeneity of preferences for this distribution option. The coefficients for the interaction effects are shown in the second section of the table.

Elderly respondents and respondents who have already donated for poverty alleviation tend to choose the “pro-poor” distribution of payments, where the low-income households get more. Here the coefficients for the interaction effects are positive and significant at the 5% and 10% level, respectively. The interaction effect between “pro-poor” and “Poor Important” is also positive and significant (at the 1% level) – in line with expectations. Respondents who expressed support for pro-poor distribution show lower interest in forest area conserved. The coefficient of the corresponding interaction term is negative and significant at the 5% level.

The insignificant coefficient for the interaction effect between “forest area conserved” and “Donation for Environment” implies that previous donations to environmental and nature protection causes do not increase the likelihood of choosing an alternative with higher forest area conserved in the experiment. A possible explanation might be that in the case of donations for the poor Mahafaly region respondents focused more on the distributive aspects than on the level of forest conservation.

**Table 2.5 RPL preference estimates including the influence of respondents' characteristics and attitude (standard errors in parentheses)**

Variable	Mean/Parameter		St. dev.
Forest area conserved	0.031***	(0.005)	0.065*** (0.015)
Equal distribution	0.492***	(0.096)	-- (non-random parameter)
Pro-poor distribution	0.167	(0.177)	0.865*** (0.287)
Unknown distribution	-0.800***	(0.088)	-- (non-random parameter)
Donation	-0.053***	(0.007)	0.081*** (0.014)
<i>Interaction terms</i>			
Forest Area: Poor important	-0.010**	(0.004)	
Forest Area: Low-Income	0.006	(0.005)	
Forest Area: High-Income	0.013**	(0.005)	
Forest Area: Age 65 and above	-0.001	(0.004)	
Forest Area: Donation for Environment	0.002	(0.004)	
Forest Area: Donation for Poverty	0.003	(0.004)	
Pro-poor: Poor Important	0.978***	(0.184)	
Pro-poor: Low-Income	0.042	(0.173)	
Pro-poor: High-Income	-0.173	(0.186)	
Pro-poor: Age 65 and above	0.382**	(0.170)	
Pro-poor: Donation for Environment	-0.131	(0.146)	
Pro-poor: Donation for Poverty	0.287*	(0.152)	
Donation: Poor Important	-0.003	(0.006)	
Donation: Low-Income	-0.019***	(0.007)	
Donation: High-Income	0.007	(0.007)	
Donation: Age 65 and above	0.028***	(0.007)	
Donation: Donation for Environment	0.007	(0.006)	
Donation: Donation for Poverty	0.003	(0.006)	
Number of respondents	242		
Number of observations	2178		
Log-likelihood	-1870.225		
AIC(normalized)	1.741		
Pseudo-R2	21.8%		

\*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%

Surprisingly, there is no significant link between low-income respondents and a “pro-poor” distribution, the coefficient of this interaction term is positive but insignificant. It seems that low-income respondents are not more likely to choose a “pro-poor” distribution than middle-income respondents. This might be due to the relatively high number of university students in Cottbus and consequently in our sample. Students usually have low income, but also prospects of having high income in the future. Therefore, they might not perceive themselves as poor and therefore might not be inclined to choose a pro-poor distribution.

The model also shows no significant influence of high income on respondents’ preferences for “pro-poor” distribution, since the interaction is insignificant. The negative sign of the coefficient, however, suggests, that some high-income individuals tend to value pro-poor distribution less than middle-income individuals (which is set as the base income category). The only significant interaction term including the effect of high-income is with the forest area conserved. Thus, high-income individuals put more value on conservation than middle income individuals.

For the donation attribute, only the interaction effects with low-income and elderly respondents are significant (at the 1% level). As expected, low-income respondents have higher disutility of donation due to higher marginal utility of income. The hypothesis that elderly respondents have higher willingness to donate and thus higher utility of donation is also supported. However, the expectations that previous donations to environmental or poverty alleviation causes might have an effect on the willingness to donate and thus on the likelihood of choosing higher payments are not confirmed. The coefficients for the interactions between the donation amount and “Donation for Environment” and “Donation for Poverty” are insignificant.

We also tested the hypotheses listed above using an LCM. As already mentioned, an LCM divides the sample into classes of respondents with different preferences based on some individual characteristics and can thus give interesting insights into the heterogeneity of preferences in the sample. We use a model with two classes as increasing the number of classes to more than two led to a decrease in model fit. For the division into classes, i.e. for the class-membership function, we employ the determinants of preferences already used in the RPL model above (“Poor Important”, “Low-Income”, “High-Income”, “Donation for Environment”, “Donation for Poverty”, “Age 65 and above”). The first section of Table 2.6 presents the parameter estimates for the attributes and the second section displays the coefficients for the class-membership function. The coefficients of the class-membership function are set to zero



for Class 2 and the coefficients for Class 1 show the probability of membership of Class 1 relative to Class 2 for each variable.

**Table 2.6 Preference estimates using a latent class model (standard errors in parentheses)**

Variable	Class 1		Class 2	
Forest area conserved	0.026***	(0.004)	0.025***	(0.004)
Equal distribution	0.766	(0.770)	0.326***	(0.115)
Pro-poor distribution	1.818**	(0.787)	0.140	(0.132)
Unknown distribution	-0.357	(0.757)	-0.725***	(0.131)
Donation	-0.014***	(0.003)	-0.054***	(0.009)
<i>Class membership</i>				
Constant	-1.164***	(0.370)		
Poor Important	0.916***	(0.229)		
Low-Income	-0.512**	(0.229)		
High-Income	0.381*	(0.216)		
Age 65 and above	1.339***	(0.239)		
Donation for Environment	-0.279*	(0.143)		
Donation for Poverty	0.277*	(0.143)		
Number of respondents	245			
Number of observations	2205			
Log-likelihood	-1910.580			
AIC(normalized)	1.748			
Pseudo-R2	21.1%			

\*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%

As Table 2.6 shows, the coefficients for all variables used for the class-membership function are significant, however at different significance levels. Among these variables, “Age 65 and above”, “Poor Important” and the constant term are the strongest determinants of class membership. Elderly respondents, high-income respondents, respondents who support higher payments for low-income households and respondents who have already donated to poverty alleviation causes belong to Class 1. They show preferences for a “pro-poor” distribution and seem not to be influenced in their choices by an “equal” or “unknown” distribution. The coefficients for “equal” and “unknown” distribution are of the expected signs but insignificant for Class 1. Low-income respondents and those who have already donated to environmental causes belong to Class 2. In contrast to Class 1 they show a preference for “equal” distribution, no significant preferences for the “pro-poor” distribution and avoid choosing “unknown

distribution”. In sum, lower income respondents tend to choose an “equal” distribution, whereas elderly, higher income individuals prefer a “pro-poor” distribution.

## 2.5 Discussion and conclusions

Many scholars argue against incorporating distributive goals in PES schemes as this may undermine the main goal of PES which is the improvement of natural resources management efficiency (TEEB, 2010; Kinzig et al., 2011). Their arguments are in line with the Tinbergen rule which states that in order to achieve different goals the same number of different policy instruments should be implemented. Such an approach, however, requires the existence of a functioning government. In many developing countries governments are weak, and a successful implementation of separate policies for separate goals is unlikely. From an economic perspective in such a setting the preferences of buyers of ecosystem services should count. In this paper, we are interested in a particular group of buyers, namely citizens in developed countries who pay to preserve global environmental goods in developing countries.

In a case study, we investigate the preferences of inhabitants of the German city of Cottbus – as an example of potential donors from a developed country – to conserve the endangered dry spiny forest in a very poor rural area in Madagascar. We find that respondents have a positive willingness-to-pay for forest conservation and for a pro-poor or equal distribution of payments among local beneficiaries compared to an unknown distribution. In general, the participants in our survey dislike alternatives where the distributive effects are unclear and there is the possibility that wealthier locals would benefit more from the payments. Our results suggest that overall citizens in developed countries have preferences for achieving distributive goals with their donations and prefer to be informed about the way payments are distributed among local beneficiaries. However, since our analysis is based on a case study for the conservation of a particular environmental good and uses a sample from one city, there are limitations to generalizing the results. We leave it to future research to conduct a survey with greater coverage to gain general insights for including distributive goals in PES design.

A further limitation of our study is that we look at the preferences of only one type of potential buyers of ecosystem services in developing countries, namely citizens in developed countries. There are many other types of buyers (cf. TEEB, 2010), for example, local beneficiaries from ecosystem services. From an economic perspective, the preferences of these buyers are important regarding whether distributive aspects should be included in PES design. To what extent different types of buyers have preferences for including distributive goals in PES schemes is also a matter for future research.

In our study we focused on two distributive justice criteria, namely the egalitarian and the maximin principle. We did not use other important fairness criteria, such as the accountability principle (rewards according to merit in Konow 2003), because it would have been rather unrealistic (and possibly creating additional biases) to explain to respondents how exactly each household's contributions to conservation would be assessed, e.g. based on the household's opportunity costs. Assessing the preferences of buyers of ecosystem services for other fairness criteria for PES, suggested by among others Pascual et al. (2010), is therefore another topic for future research.

Moreover, here we only discuss distributional aspects, which represent just one dimension of equity. McDermott *et al.* (2013) suggest that other aspects, such as procedural equity and local beneficiaries' cultural understanding of fairness have to be taken into consideration as well when implementing PES schemes. Therefore, further research on the preferences of potential buyers of ecosystem services for such equity considerations can provide interesting insights, and contribute to the design of "tailor-made" PES programs, which correspond to the preferences and expectations of providers and buyers of ecosystem services. This might positively influence the acceptance of PES schemes and their implementation both in developed and developing countries (Palmer and Di Falco, 2012).

In our study, the hypothetical bias, which is often present in choice experiment surveys, might have been magnified for some respondents due to the framing of donating money to a developing country. Some respondents might have had doubts about whether the payments would really go to the community members, if the community assemblies decide on the distribution. This is a limitation of the study, which however applies in general to the context of donations to developing countries and is not limited to our research question.

Another source of bias stemming from the framing of the choice experiment may have been the definition of unknown distribution of payments due to high migration rates in communities. Some respondents might have not associated negative value to this distribution level, but rather addressed this just as another option in which (similarly to the other two distributional options) the indigenous people decide on the payments distribution, whereby the distribution only remains unknown to the donors and researchers. This could explain the insignificant parameter estimate for unknown distribution in the first class of the estimated latent class model. Most probably, due to different interpretations of the definition of this option, some respondents have ascribed positive values to it.

A further limitation of our choice experiment is the focus on the ecosystem service of habitat provision for endangered species whereas the dry spiny forest provides also other ecosystem services such as carbon storage to the international community and some direct benefits to the local population (Neudert et al. 2017). This implies that a possible PES scheme would not only target one but a bundle of ecosystem services. We focused on the valuation of the dry spiny forests as habitat for endangered species for two reasons. First, the endangered and endemic biodiversity of Madagascar has a high value for distant donors. Biodiversity is, for example, the forest ecosystem service with highest value for the international public in the cost-benefit-analysis of Hockley et al. (2006) on conserving the Ranomafana–Andringitra–Pic d’Ivohibe Corridor in Madagascar. Second, the dry spiny forest contains relatively little carbon as the mean aboveground carbon density of the dry-spiny forests is rather low (Vieilledent et al. 2013). Therefore, we think that our focus on habitat provision and the negligence of other ecosystem services is justified.

Our findings indicate that buyers in developed countries have a positive willingness to pay when there is an equal or pro-poor distribution of payments for ecosystem services. Since an equal distribution also corresponds to a widespread view of fairness among local beneficiaries (Narloch et al., 2011; Gross-Camp et al., 2012), payments that lead to an equal distribution of benefits to providers of ecosystem services might be a good option for incorporating equity concerns in a PES program.

Finally, the aim of our study is not to reject the notion that efficiency and equity issues should be treated separately in environmental policy design. We merely argue that the institutional preconditions needed for a separate treatment of efficiency and equity frequently do not exist in developing countries, and that in such cases the preferences of buyers should be considered. If, on the other hand, the institutional preconditions do exist we agree that the goals of poverty alleviation and environmental improvement can be better achieved if they are dealt with separately.

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## Chapter 3

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### **Fair to the cow or fair to the farmer? The preferences of conventional milk buyers for ethical attributes of milk**

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with adapted cross-references and numbering  
to match the format of the thesis.

### **3 Fair to the cow or fair to the farmer? The preferences of conventional milk buyers for ethical attributes of milk**

#### **Abstract**

Conventional dairy farming has been under pressure for lacking animal welfare, biodiversity loss through abandonment and intensification of grassland, and low milk prices during the 2015/16 milk price crisis. The relatively stable organic milk prices during the milk price crisis indicate that consumers have preferences for product characteristics besides the price. We investigate through a choice experiment the willingness-to-pay (WTP) of German conventional milk buyers for ethical attributes of milk production that address the above-mentioned concerns. Respondents have the highest WTP for animal welfare – free-stall plus summer pasture – followed by biodiversity conservation, support for small, below-average income farms, and regional milk production. Respondents also have a positive WTP to support all farms but only in combination with regional production. We further find a positive WTP to support small farms in combination with tethering. This implies animal-welfare concerns are somewhat counterbalanced by fairness aspects. Our insights may support developing labels and agri-environmental policies concerning ethical aspects of conventional milk production.

#### **3.1 Introduction**

Dairy farming in the EU has been recently under pressure for several reasons. From an animal welfare point of view, the keeping of cows in tie-stalls (where they are tethered and cannot move freely) and their frequent lack of access to pasture has been criticized (Algers et al., 2009; Kikou, 2015).

Moreover, an important part of European biodiversity depends on the existence of grassland and its management and hence on how the production system of dairy farming is organised (Klimek et al., 2007). Diverse and extensive grassland management supports a high level of biodiversity (Wätzold et al., 2016; Young et al., 2007) whereas intensively managed pasture leads to less biodiversity (Plieninger et al., 2012). However, extensive grassland management with low economic yield is not economically viable today (Hodgson et al., 2005). Even intensively managed grassland is under growing pressure to convert to arable land as grazed-herbage is increasingly replaced by maize silage and concentrated feed, resulting in even more adverse effects on biodiversity (IEEP, 2007).

Conventional dairy farmers have also been under pressure in terms of profitability. During the recent EU milk price crisis, producer prices dropped from around 0.38 €/kg in 2014 to less than

0.27 €/kg in 2016 for conventional milk in Germany (Bioland, 2017). These low milk prices led to the closure of many small farms and contributed to the trend of conversion to more intensive, large-scale milk production (Ilchmann, 2017; Sauer, 2016). Similar milk price developments took place in other European countries (see BLE, 2017 for Germany, France, and Austria). Only at the end of 2016, after public intervention by the EU (buying up and storage of skimmed milk powder) and the provision of financial support to dairy farms, milk prices returned to levels seen prior to the milk price crisis (EU Milk Market Observatory, 2017).

Interestingly, during the milk price crisis, producer prices for organic milk remained rather stable in Germany at around 0.48 €/kg, (Bioland, 2017). This is unusual as previously the price of organic milk typically followed conventional milk price fluctuations. However, a similar widening of the gap between organic and conventional milk prices could be observed in France during the milk price crisis (CLAL, 2017). This, together with an increasing share of organically produced agricultural goods, including milk, over the past 10 years (Meredith and Willer, 2016), suggests that consumers are increasingly willing to pay more for what they perceive are higher-value agricultural products.

Yet organic milk does not offer much product and price differentiation, which suggests that the product and price segment between conventional and organic milk has not yet been fully utilized. So, besides organic farming, another marketing strategy for more stable milk prices, which may also address the challenges of dairy farming mentioned above, could be value creation and product differentiation through the introduction and marketing of different ethical attributes of production. Ethical attributes are associated with social and environmental issues (Luchs, 2010).

Several economic studies on preferences for ethical milk attributes have been conducted in Europe applying either choice experiments (CE) or other willingness-to-pay (WTP) approaches. Previous CE studies have focused on preferences for organic and local milk (Illichmann and Abdulai 2013), partly in combination with other attributes (Hasselbach and Roosen, 2015 with brand names; Klein, 2011 with fair prices for producers; Wägeli et al., 2016 with exclusion of GMO production). Some studies analysed preferences for ethical milk attributes on a more general level but have not involved a monetary valuation of specific attributes (e.g. Stolz et al., 2011; Zander and Hamm, 2010). Others directly asked respondents about their WTP for certain ethical attributes (Hellberg-Bahr et al., 2012 and Weinrich et al., 2014 for pasture milk; Ellis et al., 2009 for animal welfare; Emberger-Klein et al., 2016 for regional milk).

We contribute to this literature by conducting a CE among German milk buyers to elicit their WTP for ethical attributes of milk production. Our study is novel as we focus on conventional milk buyers and include a comprehensive list of ethical milk attributes which enables us to rank the relevance of the ethical attributes for the conventional milk buyers. These attributes are: animal welfare, the support of biodiversity through milk production, financial support for small farms with below-average income or for all farms, and production in one's own region. Furthermore, the ethical attributes in our experiment are not linked to the explicit use of labels, certifications or brands, as in previous studies (Hasselbach and Roosen, 2015; Illichmann and Abdulai, 2013; Klein, 2011; Wägeli et al., 2016). This is because there is no existing label for these ethical attributes (except for regional origin) in Germany and they have not been covered in valuation studies. Our study also provides novel insights in other respects. Previous valuation studies focused on fair prices to all farmers (Klein, 2011). We introduce another dimension of farmers' equity by including fairness to small, below-average income farms. To our knowledge, this is also the first study to provide a monetary valuation for biodiversity conservation in the context of milk production.

The aforementioned studies on milk preferences focused on values, attitudes, socio-demographic variables and norms to explain variation in preferences for ethical milk attributes (e.g. Emberger-Klein et al., 2016). In addition to socio-demographic factors, we use stated buying behaviour towards milk to explain heterogeneity in consumers' preferences for ethical milk attributes. The explanatory variables we use are: gender, frequency of organic milk purchase, currently paid milk price, having donated to animal protection and having a farmer as a friend or family member.

Moreover, we investigate respondents' preferences for some combinations of ethical attributes (four interaction effects) which, to our knowledge, have not been addressed in the literature.

- (1) Fairness for dairy cows vs. equity for small, poor farms. How do milk buyers value support for small, below-average income farms that use tethering of dairy cows (1a) with pasture and (1b) without pasture?
- (2) Influence of product origin on preferences for fairness to milk producers. Do buyers prefer to support (2a) small, below-average-income farms only or (2b) all farms in their region?

Our results can inform the development of labels for milk products which reflect customers' preferences and are also relevant for the development of agri-environment policies in general. From an economic perspective, the design of agri-environment policies and in particular agri-



environment payments should be based on the population's preferences for public goods provided by agriculture (Hall et al., 2004). Our study provides information on the preferences of a substantial part of the population – conventional milk buyers – for selected public goods related to milk production.

### 3.2 Choice modelling

To investigate the trade-offs in milk preferences we use the stated-preference method choice experiments. Appendix A provides an overview of the basic methodological approach whereas here we focus on specific aspects needed to understand our analysis. We employ a mixed logit model (MLM) with a panel specification for calculating overall mean WTP values over the whole sample. To ensure meaningful WTP estimates with correct signs, the utility parameter for price is assumed to be fixed, whereas the other parameters are normally distributed. In the MLM the probability of observing a sequence of choices under the assumption of a certain parameter distribution  $f(\beta)$ , e.g. normal distribution, is specified as (cf. Train, 2009 for general considerations and for an example see Kuhfuss et al., 2016):

$$P_n = \int \prod_s \left( \frac{\exp(\beta' x_{nsi})}{\sum_{j=1}^J \exp(\beta' x_{nsj})} \right) f(\beta) d(\beta) \quad (3.1)$$

WTP values are calculated as the negative ratio of the marginal utility estimates for the attributes ( $\beta_{attribute}$ ) and the marginal utility estimate for price ( $\beta_{price}$ ). The confidence intervals of the WTP are computed based on the delta method (Bliemer and Rose, 2013).

$$WTP = - \frac{\beta_{attribute}}{\beta_{price}} \quad (3.2)$$

Alternative-specific constants (ASC) are included for the A-alternative, the lowest-price fixed alternative and the ‘no-buy’ option and are assumed to be fixed. We selected the model with A-ASC, since including this constant improved the model fit and the constant turned out to be significant. As Hensher et al. (2015, p. 52) note: “Treating constants as generic parameters...should only be done if, empirically, the ASCs for two or more alternatives are found to be statistically equivalent.” Furthermore, an ASC can be used to test for systematic bias, where respondents might tend to select the first alternative in a choice set (Hasselbach and Roosen, 2015).”

We use a latent class model (LCM) with class membership function to analyse the preferences of different milk consumer groups. It allows for separate estimation of WTP values for each estimated latent class of consumers. Since we are interested in the preferences of milk buyers

who usually buy the cheapest milk, using an LCM is more appropriate than using MLM with heterogeneity. We identify the cheapest milk buyers by including a question on the currently paid price for milk in the survey questionnaire and use the currently paid price as one determinant of preferences. Thereby, respondents' currently paid milk price serves as an indicator of price consciousness, which we expect to have an influence on the WTP for ethical milk attributes.

In the LCM employed here the utility parameter estimates are assumed to vary between classes of respondents and are fixed within the classes (cf. Boxall and Adamowicz, 2002). The number of classes in an LCM is specified by the analyst and is usually determined after estimation of models with all possible and plausible number of classes based on the resulting values of information criteria such as the Bayesian information criterion (BIC) or the Akaike information criterion (AIC) (Swait, 2007). In our analysis we used the BIC and the consistent Akaike information criterion (CAIC).

### 3.3 Background information and survey

#### 3.3.1 German milk sector

Dairy milk production is the most important agricultural activity in Germany and the dairy industry is the biggest sector in the country's food industry (MIV, 2017a). In 2016, 32,672,000 t cow's milk were produced in Germany in total, 5,182,000 t of which as drinking milk (MIV, 2017b). The drinking milk consumption was 4,350,800 t overall and 52.6 kg per capita (MIV, 2017b). Thus, Germany is by far the biggest producer of cow's milk in the EU, followed by France, and the second-biggest consumer of drinking milk behind the UK (Eurostat, 2017). Since 1950, due to intensification and increased productivity, cow's milk production has steadily increased, whereas the number of dairy farms and cows kept has decreased. In 1950 1.6 million dairy farms existed in Germany, whereas their number was only 67,319 in 2017 (MIV, 2017a). Especially the number of small farms has drastically decreased and there is a clear trend to large-scale dairy farming.

According to the latest available detailed agricultural report of the Federal Statistical Office Germany (2010), in 2009, only 6% of the dairy cows in Germany were kept in smallest farms, with up to 19 cows; 24.9% were kept in small farms with 20-49 cows; about 48.8% were in medium-sized farms with 50-199 cows and 20.4% - in large farms with 200 cows or more (see Table B. 1). Overall, more than one fourth of the dairy cows (27.3%) were kept in tie-stall (tethering) systems and 72% in free-stall barns; 42% of the dairy cows in Germany had access

to pasture. Thereby, pasture is relatively widely used in small and medium farms, but only rarely used in large farms (see Table B. 1).

Grassland is highly important for biodiversity conservation as it contains more than half of all species occurring in Germany (Federal Environmental Agency, 2015). Especially extensive, high nature value grassland, which contains a large number of endangered species, is highly threatened. It has declined by 7.4% between 2009 and 2013 in Germany (BfN 2014), and continues to decline in recent years (Länderinitiative Kernindikatoren, 2018).

In sum, in Germany small farms predominantly use tie stalls, often in combination with pasture, whereas large farms rarely use tie stalls, but also rarely provide for pasture access (Table B. 1). For small farms tethering is even allowed in organic milk production, provided that summer pasture is used and if in winter the cows have access to open air at least twice a week.<sup>1</sup> A general complete ban of cattle tethering has been a topic of political discussion in Germany in recent years, but has not met enough political support, due to the fact that especially small farms would be affected by it, since they usually cannot afford big investments in equipment. Small farms are also more susceptible to milk price changes and have suffered more during the milk price crisis in 2015 and 2016 (Ilchmann, 2017).

Organic milk prices were less affected by the latest milk price crisis. However, in Germany organic milk accounted for only 2.5% of the milk delivered to dairy factories in 2016 (MIV, 2017b). Similarly, the production share of organic milk in the EU as a whole is still low - at about 2.6% of the total EU cow's milk production in 2014 (Meredith and Willer, 2016). Even in Germany and France - the largest organic milk markets in the EU - the market share of organic milk (based on sales value) remains low - 8.1% and 10.8% respectively. In Austria and Switzerland the share is higher - 15.7 and 18.9% respectively (Meredith and Willer, 2016).

### 3.3.2 Survey

To investigate preferences for ethical milk attributes, in February 2017, we conducted an online CE survey of 1,040 conventional milk buyers (individuals who occasionally or frequently buy conventional milk for themselves or their families) in Germany with the help of the survey company Respondi. Respondents who only rarely or never buy conventional milk (as opposed to organic milk) were excluded from the survey. Individuals, who frequently or occasionally

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<sup>1</sup> as stipulated in Article 39 of Commission Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control

buy conventional milk and in addition to this frequently or occasionally buy organic milk were allowed to participate. Respondents were screened for gender, education, age and size of their place of residence to ensure representativeness. Quota sampling was based on data for German milk buyers aged 18-95 years in the past 12 months from the German marketing study best4planning 2016. Table B. 2 provides an overview of sample statistics based on the quota sampling procedure. The proportion of females in the sample is greater than that of males, as more often women are responsible for shopping.

### 3.3.3 Experimental design

Respondents had to choose between four hypothetical milk alternatives – two alternatives with changing attributes ('milk A' and 'milk B'), one fixed lowest-price milk alternative with all ethical attributes at their lowest levels ('milk C'), and one 'no-buy' alternative. We decided to include a 'no-buy' alternative instead of a real opt-out 'none-of-these' option, because we were particularly interested in how often and why customers would choose the lowest-price milk, even though it involved the lowest levels for all ethical attributes. The definition of the opt-out as a 'no-buy' alternative also reduces the attractiveness of the opt-out alternative and therefore is likely to amplify the trade-off between price and the ethical attributes of milk. By defining a fixed alternative and a 'no-buy' alternative we were able to check what portion of the milk buyers are only interested in price or can only afford the lowest price and would not dispense with milk. An example of a choice card used in the experiment is provided in Figure 3.1.

The attributes and levels for the experiment were chosen based on the research aims, literature review and focus group discussion. For the animal welfare attribute we focus on particular aspects of animal welfare, namely housing system and pasture access. We distinguish between four different housing systems: tie-stall, tie-stall with summer pasture, free-stall, and free-stall with summer pasture. Other housing systems do exist, e.g. free-stall with outdoor exercise area, but we included only the main housing systems to keep the complexity of the trade-offs at an acceptable level.

*Please choose one of the three products below. In all eight decision situations you also have the option not to buy milk. Please be honest in your choices and always take into account your financial situation.*

	Milk A	Milk B	Milk C
Animal welfare/ Housing system of dairy cows	free-stall	free-stall + summer pasture	tie-stall
Biodiversity conservation	good for biodiversity conservation	no special biodiversity conservation	no special biodiversity conservation
Support for milk farms	small milk farms with below- average income	no support	no support
Origin of the milk	from your region	from your region	from Germany
Price per litre	1.32 €	0.78 €	0.60 €

☐ I buy milk A      ☐ I buy milk B      ☐ I buy milk C      ☐ I buy no milk

**Figure 3.1** Example of a choice card used in the survey.

We considered fairness to farmers as support for dairy farms by providing “fair prices”, whereby a specific part of the consumer milk price goes to a special fund for the support of either all milk farms or only small milk farms with below-average income. This leads to three options: no support, support for all farms, and support for small, below-average income farms. Support for small, below-average income farms is related to Rawls’ (1971) maximin principle, which postulates that inequalities (in our case in financial support) should be ‘to the benefit of the least advantaged’, and the needs principle (Miller, 1976; Dobson, 1998), which postulates that those in need should get higher support.

As already mentioned, in Germany, small dairy farms predominantly use tie-stalls, often in combination with pasture, whereas large farms rarely use tie-stalls, but also rarely provide pasture access. So, whether milk buyers gain utility from supporting small farms despite cow tethering<sup>2</sup> is an interesting question. To analyse this trade-off between animal welfare and fairness to small, below-average income farms we estimate two interaction effects: support for small, below-average income farms with tethering and summer pasture; and support for small, below-average income farms (henceforth small farms) with tethering.

<sup>2</sup> For small farms, tethering is allowed in organic milk production, provided that summer pasture is used and the cows have access to open air at least twice a week in winter (Article 39 of Commission Regulation (EC) No 889/2008).

We are also concerned with milk buyers' preferences for biodiversity conservation through milk production practices. Traditional extensive dairy farming supports biodiversity, whereas the intensification of milk production leads to a decline in grassland species diversity (CEAS Consultants, 2000). Thus, depending on the type of production, dairy farming can have a negative or positive effect on grassland biodiversity. In the CE the biodiversity-conservation attribute has two levels – 'good for biodiversity conservation' with the conservation of many endangered species, and 'no special biodiversity conservation', whereby loss of grassland biodiversity is not mitigated due to intensification. We explicitly stated that especially meadow birds and butterflies can profit from extensive grassland management by dairy farmers. As Lienhoop and Brouwer (2015) conclude, information on the type of species protected is instrumental for valuing biodiversity by respondents in stated-preference studies.

For the origin of milk we set two levels – regional and national origin – to keep the complexity of trade-offs within acceptable limits. In Germany, consumer milk is rarely imported; in recent years imports account for only about 7% of the total milk production in dairy factories (MIV, 2017). To analyse preferences for fairness to farmers when buying regional milk, we estimate two interaction effects: between regional origin and support for either small farms or all farms.

The questionnaire included questions on respondents' milk purchases, the importance of/ attitude towards different ethical aspects in buying decisions in general, and information on the CE, the different milk attributes, and the choice cards. Debriefing questions on the choice of the fixed and 'no-buy' alternatives and on the importance of cows' welfare and support to dairy farms to respondents, as well as an explicit question on individual WTP for milk with additional ethical attributes, and socio-demographic questions were also included.

Table 3.1 provides an overview of the attributes and levels included in the CE and Table B. 3 includes a complete description of attributes and levels from the survey questionnaire.

**Table 3.1 Attributes and levels included in the CE**

Attributes	Levels
Animal welfare/ Housing system of dairy cows	<ul style="list-style-type: none"> <li>- <b>Tie-stall</b></li> <li>- Tie-stall with summer pasture</li> <li>- Free-stall</li> <li>- Free-stall with summer pasture</li> </ul>
Biodiversity conservation	<ul style="list-style-type: none"> <li>- Good for biodiversity conservation – many endangered species protected</li> <li>- <b>No special biodiversity conservation – loss of biodiversity not mitigated</b></li> </ul>
Support for milk farms – fair prices to producers	<ul style="list-style-type: none"> <li>- Support for all milk farms</li> <li>- Support for small milk farms with below-average income</li> <li>- <b>No support</b></li> </ul>
Origin of the milk	<ul style="list-style-type: none"> <li>- From your region (within a radius of max. 40 km)</li> <li>- <b>From Germany</b></li> </ul>
Price per litre	<b>0.60 €; 0.78 €; 0.96 €; 1.14 €; 1.32€</b>

*Note: Reference levels (of the fixed milk alternative) in bold type.*

*The different price levels were based on real consumer prices in Germany in February 2017.*

Ngene software was used to create a Bayesian D-efficient design (Bliemer et al., 2008) with a fixed alternative and a ‘no-buy’ alternative for the estimation of main effects and the four interaction effects mentioned. Ignoring any interaction effect by assuming its insignificance can lead to loss of information and confounding, whereas including many interaction effects leads to larger designs (Hensher et al., 2015). We only estimate the interaction effects of interest and acknowledge this as a limitation of the design.

The design included a requirement for combining levels of the fixed C-alternative and a constraint for excluding alternatives with all attributes equal to the fixed C-alternative in the A- and B-alternatives. Alternative-specific constants were included for the fixed and ‘no-buy’ alternatives. The attribute levels were effects-coded, except for price, which was coded as a continuous variable.

A pretest consisting of two consecutive parts, with separate D-efficient Bayesian designs and 50 respondents each, was conducted online by the survey company. In the first pretest no regional-production attribute was included, but a three-level biodiversity-conservation attribute (high, medium and no biodiversity conservation level). In the second pretest the choices

included regionality of milk production and a two-level biodiversity conservation attribute. Since the estimated two parameters for the three effects-coded levels of biodiversity conservation in the first pretest - without regionality - were insignificant, whereas the parameter for the one effects-coded biodiversity-conservation variable in the second pretest was highly significant, we decided to use two biodiversity conservation levels in the main survey. With three levels for biodiversity conservation, it might have been difficult for respondents to distinguish between them, since limiting information load is important in eliciting preferences (Hensher, 2006).

In the main survey, normally distributed Bayesian priors based on the results of the pretest were used to generate an MNL D-efficient Bayesian design with 24 choice sets in three blocks with 8 choice sets each. Respondents were randomly assigned to blocks and the order of choice cards was randomized between respondents. The priors of the price and the ‘no-buy’ constant were fixed to facilitate the design procedure.

## 3.4 Results

### 3.4.1 Overall results

Only five respondents chose the ‘no-buy’ alternative on each choice card, the answers to the debriefing questions showed no protest responses. 11.8%, or 123 respondents chose the fixed lowest-price alternative on all cards: 107 of them because for them price is the most important factor in the buying decision; 10 of them, because the decision was difficult due to too much information; six of them chose other reasons, which however also do not show protest responses. 106 (or 86%) of the 123 ‘only lowest-price-alternative choosers’ currently pay the lowest milk price - 0.60 € to 0.69 €. Overall, the lowest-price alternative accounted for 20% of all the choices made.

An overview of the estimated utility parameters in the choice models and goodness-of-fit indicators is provided in Table B. 5 and Table B. 6. The LCM with heterogeneity in preferences leads to a substantial improvement in goodness of fit. Especially the choice of the fixed option can be much better modelled with it.

In the process of LCM specification we tested different buying behaviour variables and socio-demographic characteristics as predictors of preference heterogeneity in the class membership function and selected only the significant ones. The estimated LCM with significant covariates and best fit (see section 0), includes a class membership function based on gender, frequent organic milk purchasing, lowest currently paid price - 0.60 € to 0.69 € per litre (in the following



referred to as cheapest-milk buyers), currently paid price between 0.70 and 0.79 €/litre, high currently paid price (above 1 €/litre), having a farmer as friend or family member and having donated to animal protection in the last two years (see list of variables used in Table B. 4).

The LCM was estimated with up to six classes. The five-class LCM showed lowest values for the information criteria BIC and CAIC and highest Pseudo  $R^2$  and was therefore selected for further analysis. Another possible criterion for LCM model selection is the posterior probability of segment membership (see Beharry-Borg et al., 2012 for an application). Increasing the number of segments to five leads to higher number of respondents with posterior probabilities of membership less than 90%, but it also results in considerable improvement in model-fit (lower BIC and CAIC and higher Pseudo  $R^2$  values). The six-class model is inferior regarding both selection criteria.

We also investigated whether heterogeneity of preferences was present depending on the socio-demographic characteristics income, education, age, having children, and rural or urban residents (differentiated according to data on district type from BBSR, 2015). However, the influence of these characteristics was insignificant. Stated buying behaviour variables which were tested and also had no significant influence on heterogeneity of preferences were: frequently buying pasture milk, frequently buying regional milk, and having donated to environmental protection in the last two years.

By including the variable ‘cheapest-milk buyers’ in the class membership function of the LCM we can show which attributes appeal most to many members of this group of buyers and are also able to derive corresponding WTP values. In the sample, the group of ‘cheapest-milk buyers’ is represented by individuals from all income classes, not only the lowest income classes, and also all LCM classes include some respondents from the group of the ‘cheapest-milk buyers’.

### 3.4.2 WTP estimation

The coefficients derived from the MLM were used in the estimation of overall mean WTP values over all respondents. MLM estimation with fixed price and all other parameters being random and normally distributed leads to significant standard deviation values, except for the last, fourth, interaction effect (support for all farms in one’s own region). Here we present the results from the estimation with fixed fourth interaction effect.

The WTP resulting from the MLM is highest for the highest level of animal welfare (free-stall plus summer pasture) and equals 24 cents/litre (Table 3.2). Biodiversity conservation is valued

at 9 cents/litre. The second most preferred housing system (tie-stall plus summer pasture) and support for small farms are similarly valued at 7 cents/litre. Regional production is valued less than the aforementioned ethical attributes, at 3 cents/litre. The WTP as well as the marginal utility estimate for free-stall from the MLM are negative and significant.

The combinations of tethering (with and without pasture) and support for small farms are positively valued by respondents, at 8 cents/litre. The WTP for the interaction between support for all farms and regional milk is 13 cents/litre, which is the second highest estimated WTP from the MLM.

As expected, support for small farms is in general valued more than support for all farms. Surprisingly, respondents' marginal utility for supporting all farms in general is negative and insignificant (Table B. 5), whereas in case of regional milk, respondents show positive WTP for supporting all farms and insignificant utility and WTP for supporting only small farms.

**Table 3.2 WTP from mixed logit model (MLM).**

<b>Attributes/ Interactions</b>	<b>WTP (€)</b>	<b>95% Confidence interval</b>	
Free-stall+pasture	0.24***	0.21	0.27
Free-stall	-0.02**	-0.05	0.00
Tie-stall+pasture	0.07***	0.05	0.10
Tie-stall <sup>a</sup>	-0.29		
Biodiversity conservation	0.09***	0.07	0.11
No special biodiversity conservation <sup>a</sup>	-0.09		
Support small farms	0.07***	0.03	0.10
Support all farms	-0.02	-0.05	0.01
No support <sup>a</sup>	-0.05		
Regional milk	0.03**	0.01	0.05
From Germany <sup>a</sup>	-0.03		
<b>Interactions</b>			
Tie-stall+pasture*Support for small farms	0.08***	0.02	0.15
Tie-stall*Support for small farms	0.08***	0.02	0.15
Regional milk*Support for small farms	-0.03	-0.08	0.03
Regional milk*Support for all farms	0.13***	0.07	0.19

*Note: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%*  
<sup>a</sup>The WTP for the effects-coded base levels is calculated as the negative sum of the WTP for the other levels (Cooper et al., 2012).

### 3.4.3 Heterogeneity in preferences – LCM class differences

Since the model fit of the estimated LCM is much better and it captures heterogeneity in preferences among different consumer groups, the WTP values resulting from it are more indicative (Table 3.3). The five LCM classes are differentiated according to socio-demographic characteristics, attitudes and buying behaviour. The comparison is based on the estimates for the class membership function from the LCM and tests on statistical significance (Pearson Chi-square, Mann-Whitney and Kruskal-Wallis tests) of differences between the classes.

Cheapest-milk buyers are more likely to belong to classes 3 and 4, whereas high-price milk buyers are more likely to belong to classes 1 and 2. Class 5 has a higher proportion of buyers with currently paid prices in the mid-range (0.70 – 1 €/litre).

We do not find a significant WTP for ethical milk attributes among respondents in class 4, since the utility parameter estimates for this class are all insignificant, including the price parameter. Therefore WTP of class 4 is not reported in Table 3.3. All respondents who chose the fixed lowest-price alternative on all cards are members of class 4 and make up 88.5% of it. The other 16 (11.5%) of the 139 assigned members in class 4 have chosen the fixed alternative seven times and another alternative only on one card. Members of this class are on average highly price sensitive, with lower mean income and lower mean education level. There are no statistically significant differences in mean education among the other classes 1, 2, 3 and 5. Mean age is also not significantly different between the LCM classes.

Respondents in class 3 also tend to be highly price-sensitive, with lower currently paid milk prices, and lower mean income, but show WTP for highest animal welfare (free-stall with summer pasture) and support for small farms with tethering (with and without summer pasture).

Members in class 1 show overall highest WTP values and would support small farms (also in combination with tethering and summer pasture), but not all farms. Class 1 includes many higher income, mainly female (69%), organic and regional milk buyers, who currently pay higher milk prices. 71% of the frequent organic milk buyers and half of the frequent pasture milk buyers in the sample are members of this class (Table B. 7).

Class 2, with the second highest WTP values, also has higher female representation (67%), and a higher proportion of members who currently pay higher milk prices. Overall, respondents in this class show preferences for highest animal welfare (free-stall plus summer pasture), biodiversity conservation and regional production and would support small farms who use tethering with summer pasture.

Class 5 respondents have in general significant WTP for animal welfare, biodiversity conservation and small farmers' support, and for supporting all farms within their region.

Paired-classes income comparisons show that the mean income in class 1 is higher than in class 3 and 4, but not higher than that of class 2, and only on the 10% significance level higher than the mean income of class 5. The higher income classes (above 3,000 €/month household net income) are most represented in class 1 and class 5 and less in class 2, but all the other (lower) income classes are also represented in these LCM classes (Figure B. 1). The class with no significant WTP values, class 4, has the highest proportion of low-income individuals (below 1,000 €/ month household net income), and the lowest proportion of high-income individuals together with class 3. Thus, income seems to play a role in milk preferences, but not always.

All respondents who chose the fixed lowest-price alternative on all cards are members of class 4 and make up 88.5% of it. 86.3% of this class also currently pay the lowest milk price (Figure B. 2). In class 3 these respondents account for 71.8% of the members. Thus, class 3 and 4 are the classes with highest proportion of cheapest-milk buyers, one third of them are members of class 4. Cheapest-milk buyers are, however, represented in all LCM classes and account for about one third of the members of class 5 and one fourth of the members in class 2.

Cheapest-milk buyers are also represented in all income classes – they account for almost 50% of the members of the lowest income class and for almost 20% of the highest income class (Figure B. 3). 76% of all cheapest-milk buyers stated higher WTP for ethical milk attributes than their currently paid milk price.

The class with no significant WTP values (class 4) has higher mean milk consumption than the other classes and the two classes with highest WTP values (1 and 2) have lower mean meat consumption (Table B. 8).

Individuals who have donated to animal protection and those having donated to environmental protection are most represented in class 1 (Table B. 7). Respondents in class 1, with the highest WTP values, also have on average the most positive attitude to agriculture followed by class 2 and 5; class 4 respondents have the least positive attitude.

Table 3.3 WTP from LCM panel model

	Class 1 - 'organic, regional, animal and farmer fairness milk buyers'			Class 2 - 'highest animal welfare, biodiversity and regional milk buyers'			Class 3 - 'lower income, price-sensitive milk buyers with preferences for animal and farmer fairness'			Class 4 - 'lower income, cheapest-milk buyers with no WTP for ethical attributes'			Class 5 - 'animal and farmer fairness milk buyers'		
Attributes/ interactions	WTP	95% Confidence interval		WTP	95% Confidence interval		WTP	95% Confidence interval		WTP	95% Confidence interval		WTP	95% Confidence interval	
Free-stall+pasture	1.71***	0.79	2.63	0.45***	0.37	0.52	0.06***	0.02	0.10	-	-	-	0.10***	0.07	0.13
Free-stall	-0.38***	-0.64	-0.13	0.04	-0.02	0.11	0.00	-0.04	0.03	-	-	-	-0.01	-0.04	0.01
Tie-stall+pasture	0.49***	0.18	0.80	0.04	-0.03	0.12	0.01	-0.02	0.04	-	-	-	0.04***	0.02	0.07
Tie-stall	-1.82			-0.53			-0.07			-	-	-	-0.13		
Biodiversity conservation	0.70***	0.37	1.03	0.16***	0.13	0.19	0.01	0.00	0.03	-	-	-	0.06***	0.05	0.07
No special biodiversity conservation	-0.70			-0.16			-0.01			-	-	-	-0.06		
Support small farms	0.58***	0.17	0.98	0.06	-0.01	0.13	-0.02	-0.07	0.03	-	-	-	0.05***	0.02	0.08
Support all farms	0.00	-0.21	0.22	0.00	-0.08	0.07	0.03	-0.01	0.06	-	-	-	-0.03**	-0.06	0.00
No support	-0.58			-0.06			-0.01			-	-	-	-0.02		
Regional milk	0.30**	0.07	0.53	0.06*	-0.01	0.12	0.01	-0.01	0.03	-	-	-	0.01	-0.02	0.03
From Germany	-0.30			-0.06			-0.01			-	-	-	-0.01		
Tie-stall+pasture* Support small farms	0.54**	0.08	0.99	0.21***	0.06	0.36	0.10**	0.01	0.18	-	-	-	0.00	-0.06	0.07
Tie-stall* Support small farms	0.35	-0.08	0.77	-0.02	-0.31	0.28	0.09*	0.00	0.18	-	-	-	0.08**	0.02	0.15
Regional milk* Support small farms	0.26	-0.15	0.66	-0.10	-0.26	0.06	0.01	-0.05	0.08	-	-	-	0.00	-0.06	0.06
Regional milk* Support all farms	0.22	-0.33	0.76	0.15	-0.04	0.34	-0.01	-0.09	0.06	-	-	-	0.09**	0.01	0.18
Members as % of all respondents		34.0			13.6			10.6			13.4			28.5	

Note: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%; - No WTP calculated for class 4 due to insignificant price parameter.

<sup>a</sup>The WTP for the effects-coded base levels is calculated as the negative sum of the WTP for the other levels (Cooper et al., 2012).

### 3.5 Discussion and conclusions

We analyse preferences and WTP for ethical attributes of milk among conventional milk buyers in Germany. Based on the mean WTP values over all respondents, the ethical attributes from our experiment can be ranked as follows: animal welfare, regional milk plus fair prices for all farms in the region, biodiversity conservation, support for small, below-average income farms (with and without tethering and in general), regional milk, fair prices to all farms. These results are in line with insights by Zander and Hamm (2010) into the preferences of regular and occasional consumers of organic food in five European countries for ethical attributes of organic milk. However, in their study WTP values were not elicited and the focus was exclusively on the preferences of organic milk buyers.

We employed different buying and socio-demographic variables in the analysis of preference heterogeneity among buyers, and found price-consciousness, gender and frequency of organic milk consumption to be the most important determinants of respondents' ethical preferences for milk production. In line with our results, Emberger-Klein et al. (2016) identified price-consciousness as the most important determinant of WTP for fairly produced, local milk.

Similarly to our study, Illichmann and Abdulai (2013) found significant differences in preferences between males and females with women having lower WTP values for organic milk than men. By contrast, in our experiment women represent two thirds of the buyers with highest WTP values for ethical milk. This is in line with other research, which suggests that women are more likely to buy organic products (Gil et al., 2000) and place higher value on local origin (Weatherell et al., 2003).

Income also partly plays a role as a determinant of WTP for ethical milk with lower income respondents showing lower WTP. However, we also find that cheapest-milk buyers are represented in all income classes and many of them show a willingness to spend more (than what they currently pay) to buy milk with ethical attributes, in particular, if it concerns animal welfare – free-stall plus summer pasture. This result is consistent with insights of a recent survey (Eurobarometer, 2016) on animal welfare attitudes of EU citizens, where the majority of respondents (94%) shows high concern about animal welfare and 59% of respondents also state WTP a premium for animal friendly products.

The observed change in price sensitivity regarding milk in our CE could have been triggered by the provision of information on ethical milk attributes through the CE. Feedback provided by respondents at the end of the online survey supports this conclusion. The importance of

information for raising awareness and building consumers' preferences for ethical milk is also confirmed by Wägeli et al. (2016). Therefore, better information provision with respect to dairy production practices, for example credible and accountable statements on housing and pasture access displayed on packaging, could change the price sensitivity of buyers.

Interestingly, in Illichmann and Abdulai (2013), respondents were willing to pay a much higher premium for organic milk from their region - 0.58 € more. One reason for the higher premium for regional origin might be that their study focused on organic milk. Another reason could be the so-called embedding effect. In our CE respondents faced trade-offs between several ethical attributes. As Waldrop et al. (2017) suggest, adding multiple sustainability claims or certifications to a product may result in lower price premiums for the additional claims.

The more detailed and differentiated definition of fairness to farmers in our study leads to some interesting results, too. Overall, respondents would support small, below-average income farms, but not all farms. This is in contrast to previous studies which find WTP for fair production - defined as all farmers getting back a fixed amount of the price per litre (e.g. Klein 2011). Our experiment, however, includes an additional level of fairness – fairness to small, poorer farmers – which is valued higher by consumers. Interestingly, when buyers buy regional milk, they prefer support to all farms. Possible explanations for this result might be a willingness to support dairy production as a whole in one's own region and consumers' different viewpoints concerning fairness to farmers on the national and regional level. In general, respondents show greater support for small, below-average income farms. Apart from contributing to environmental protection, by buying regional products, consumers typically want to support the local economy (Hasselbach and Roosen, 2015; Menapace and Raffaelli, 2016) and thus may focus more on supporting all farms in their region. Another possible reason for this result might be confounding of dropped interaction effects, which as mentioned earlier might be a limitation of the experimental design.

The existing WTP for a combination of tethering (with and without pasture) and support for small, below-average income farms among milk buyers suggests that to many consumers fairness to farmers is more important than animal welfare, when it comes to small, below-average income farms. This argument to some extent supports those who still reject a complete ban on tie-stalls in Germany, as it would affect mainly small farms where investment in free-stalls is often not economically viable. However, this might change, if consumers support animal-friendly housing practices through higher milk prices. The presence of preferences among respondents for fairness to weak income groups has also been found in other contexts

in CE (e.g. see Markova-Nenova and Wätzold, 2017 for donations for forest conservation in developing countries).

From an economic perspective, the design of public policies should follow citizens' preferences (Page and Shapiro, 2010) and our survey captures the preferences of a substantial portion of citizens with respect to ethical attributes of dairy production. Hence, the insights from our study can be used to support the design of labels and other agri-environmental policies.

We found that many conventional milk buyers are willing to pay a premium for ethical milk attributes. However, consumers typically only pay this premium, if they have trustworthy information that the ethical standards are met in the production process (Ibanez and Stenger, 2000). Credible and traceable labels are needed for this purpose.

Since the highest WTP was elicited for the highest level of animal welfare – free-stall plus summer pasture – developing a nationwide pasture milk label seems appropriate, similar to the pasture milk label in the Netherlands (Stichting Weidegang, 2017). The significant WTP for support for small, below-average income farms in combination with tie-stall and pasture indicates that a pasture label could be attractive to customers even without a complete restriction on tethering, as is the newly developed pasture milk label for the German federal state of Lower Saxony. Here, tethering is allowed under the condition of more pasture days per year than for free-stall cows and if outdoor access is provided every two days for at least one hour (Lower Saxony ML, 2017).

The substantial WTP for biodiversity conservation suggests that this could also be an attractive characteristic for a milk label. A possible difficulty involved in marketing such a label could be to convey to customers how milk production impacts on biodiversity conservation. Moreover, biodiversity conservation can have different meanings for different individuals (Lienhoop and Brouwer 2015). Therefore, more research is needed to address the challenges in designing a milk label for biodiversity conservation.

Two further aspects need to be considered in this context. (1) There are already a few labels related to dairy farming, for example the labels on organic farming and on regional production. If there are too many different labels, customers might get confused and might refrain from buying labelled milk products. Research is needed to understand how many labels are tolerable and how milk labels should be designed to help customers understand the ethical impacts of their buying decisions. (2) Through the introduction of ethical attributes, the costs of milk production increase, e.g. due to specific production restrictions. Additional costs also arise in the processing of milk, e.g. milk collection trucks need to have different tank compartments for



different types of milk instead of one compartment for conventional milk. Research is needed to compare these costs with the WTP of consumers for ethical milk attributes.

The insights from our study can be used to support the design of agri-environmental policies other than labelling. We find that, generally, citizens support measures directed at animal welfare, biodiversity conservation and small, below-average income farms. Notably, citizens have preferences for a general farm support only if they see a link to their own region. This suggests that the policies adopted by governments in the recent EU milk price crisis (buying up and storage of skimmed milk powder, providing financial support to dairy farms) are inconsistent with public preferences.

Other agri-environmental policies that can address the challenges of dairy farming in terms of biodiversity conservation and animal welfare are mandatory production standards and agri-environment schemes (AES). From an economic perspective, the choice of policy instrument is a matter of the allocation of property rights (Bromley and Hodge 1990). If society is given the right to decide how farmers should treat their animals, mandatory production standards are the appropriate policy instrument. If farmers are given the right to treat their animals as they wish, they should be compensated for measures to increase animal welfare through AES. A discussion of the appropriate allocation of property rights is beyond the scope of this paper. However, our results indicate that citizens do care about animal welfare, small, below-average income farms and biodiversity conservation related to dairy farming. Hence, further developing agri-environmental policies in these directions seems appropriate. Whereas this is often straightforward for production standards, designing effective and cost-effective AES can be a complex challenge and requires further research, e.g. because spatial and temporal considerations need to be included in the design (Wätzold et al. 2016).

WTP for regional products suggests that policies directed at local and regional cooperation among farmers are in line with public preferences. Support for cooperation among farmers is debated in the current discussion on the CAP (Common Agricultural Policy) reform beyond 2020 (e.g. Feindt et al. 2018). Cooperation among local farmers and actors in the agricultural sector is expected to bring substantial benefits and cost reductions. The German Federal State of Hesse, for example, has introduced a public support programme for cooperation in short supply chains and local markets among farmers, local actors from the agricultural and silvicultural sector, and research and development institutions (Regional Council of Giessen, 2018). An example of a public programme directed at cooperation of farmers in the context of biodiversity conservation is the Swiss ‘network bonus’ where farmers receive an additional

payment on top of a base payment for conservation measures, if they coordinate these measures on a local level (Krämer and Wätzold 2018). However, there is little knowledge on how to design public incentive programmes for local and regional cooperation that not only lead to improvements of the economic situation of small, below-average income farmers but also address the other challenges that dairy farming is facing, such as grassland biodiversity loss and animal welfare concerns. We conclude that further research is also needed in this context.

### Acknowledgements

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# Chapter 4

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## **Distributional Impacts of Cost-effective Spatially Homogeneous and Regionalized Agri-Environment Payments.**

### **A case study of a Grassland Scheme in Saxony, Germany**

*This chapter has been submitted as a working paper:*

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The chapter includes a reprint of the submitted version  
with adapted cross-references and numbering  
to match the format of the thesis.

## **4 Distributional Impacts of Cost-effective Spatially Homogeneous and Regionalized Agri-Environment Payments. A case study of a Grassland Scheme in Saxony, Germany**

### **Abstract**

Economic analysis of agri-environment schemes (AES) has focused mainly on improving their cost-effectiveness. In contrast, the distributional impacts of AES have received less attention in the economic literature, even though the implementation of cost-effective policies can receive much more support, if their distributional impacts are desirable. We combine cost-effectiveness and distributional considerations and investigate empirically for a case study (a grassland program in Saxony, Germany), if trade-offs or synergies exist between improving the cost-effectiveness of an AES and its distributional impacts. We apply an ecological-economic modelling procedure to design two cost-effective AES - one scheme with spatially homogeneous payments and one with regionally differentiated payments. To compare the distributional impacts of the schemes we use the criteria of equality, equity and Rawls' maximin criterion. Our results suggest that substantial cost-effectiveness improvements can be achieved with the spatially differentiated AES. Regarding distributional impacts, on the federal state level and within the largest region, we find a trade-off between equality and cost-effectiveness, whereas equity generally increases with improved cost-effectiveness of the AES, except in the largest region. On Rawls' maximin criterion the spatially homogeneous payments are preferred, as they lead to the highest net benefits in the poorest region. This shows the importance of analyzing the distributional implications of cost-effective AES on different spatial levels.

### **4.1 Introduction**

Agri-environment schemes (AES) aim to support land use measures of farmers that are costly to them but beneficial to biodiversity, the environment or the landscape. AES can be found in most developed countries. Examples of AES include the Conservation Reserve Program (CRP) in the US (Claassen et al., 2008), the Agri-environmental Grassland Premium in France (Buller and Brives, 2017), the Agri-environmental, Climate Change and Animal Protection Program in Baden-Württemberg, Germany (Ministry of Rural Affairs, Food and Consumer Protection Baden-Wuerttemberg, 2016), and the Australian National Landcare Program (Robins, 2018). AES exist also in some developing countries (e.g. the Sloping Land Conversion Program (SLCP) in China (Lu and Yin, 2020) where they are usually referred to as Payments for Ecosystem Services (PES).

A large part of the economic analysis of AES has focused on how to improve their cost-effectiveness (Ansell et al., 2016), here understood as how to design AES so that for available financial resources environmental aims are achieved to the greatest possible extent (Wätzold and Schwertner, 2005). Regarding the design of cost-effective AES, the spatial optimization of schemes has become a key concern (Engel, 2015), especially with respect to schemes targeted at the conservation of biodiversity (Hanley et al., 2012). Four main threads of discussion can be distinguished: The first thread analyzes possible improvement in cost-effectiveness through ‘benefit-cost targeting’ which is normally superior to only (environmental) benefit or cost targeting strategies (Babcock et al. 1996), but can be less cost-effective when there is a considerable output price effect (Wu et al., 2001). The second thread investigates incentives to provide spatially aggregated (Parkhurst et al., 2002) or evenly allocated conservation areas (Bamière et al., 2011). A focus has been on analyzing the cost-effectiveness of payment designs such as the agglomeration bonus and the agglomeration payment schemes to provide spatially aggregated habitats (Drechsler et al., 2016; Lewis et al., 2011; Wätzold and Drechsler, 2014). The third line of discourse focuses on the spatial scale of habitat conservation in general. It is suggested that depending on the different types of species the appropriate management scale differs (Ekroos et al., 2016), e.g. landscape-scale conservation management is considered more cost-effective than farm-scale management in the case of ecosystem services provided by mobile species, which require a spatial habitat pattern on larger scale (Cong et al., 2014). The fourth thread is based on the idea of spatially differentiated payments. If cost and benefit functions differ among regions, a payment scheme that includes regionally differentiated payments is likely to be more cost-effective than a scheme with homogeneous payments across regions (Wätzold and Drechsler, 2005). In an empirical analysis of different hypothetical AES to conserve birds in the Peak District in England, Armsworth et al. (2012) identified substantial cost-effectiveness gains of a spatially differentiated payment scheme albeit at the expense of substantial transaction costs.

In contrast to cost-effectiveness considerations, the distributional impacts of AES have received less attention. Wu and Yu (2017) investigate cost-effectiveness equity trade-offs using the CRP as a case study. They find that the CRP is quite cost-effective, but not very equitable on most indicators used, even though large part of the fund goes to lower-income counties. Claassen et al. (2001) also analyze trade-offs in the design of AES. Using hypothetical scenarios, they investigate spatial distribution of gains and losses from the implementation of a policy for reducing water quality damage due to sediments. They conclude that reaching two goals, e.g. environmental improvement and farm income improvement, with one policy is hardly possible.

This finding is in line with Uthes et al. (2010) who suggest that having rural development as a goal undermines achieving environmental benefits and cost-effectiveness of AES. By contrast, Gauvin et al. (2010) demonstrate that for the SLCP targeting parcels, which maximize jointly the environmental and poverty alleviation benefits is only slightly less cost-effective than the most cost-effective strategy of selecting parcels with the highest benefit–cost ratio. Similarly, Mouysset (2014) finds that when ecological objectives are low or high grassland management subsidies in France can reach simultaneously ecological and social objectives (increasing minimum farmer income) and at the same time minimize welfare losses.

This paper investigates cost-effectiveness gains from a hypothetical regional differentiation of an AES in Saxony, Germany, and the resulting distributional impacts. By this, we contribute to the above-mentioned discussions in two ways. (1) Similarly to Armsworth et al. (2012), we empirically investigate the cost-effectiveness gains of spatially differentiated payments over spatially homogeneous payments. In contrast to Armsworth et al. (2012), however, the additional transaction costs of our proposed differentiated scheme are negligible as we do not suggest introducing a different scheme but just to pay farmers in different Saxon regions differently for the same measures. (2) By analyzing the distributional impacts of the spatial differentiation of the Saxon AES, we also contribute to the debate on trade-offs and synergies between cost-effectiveness and distributional impacts of AES.

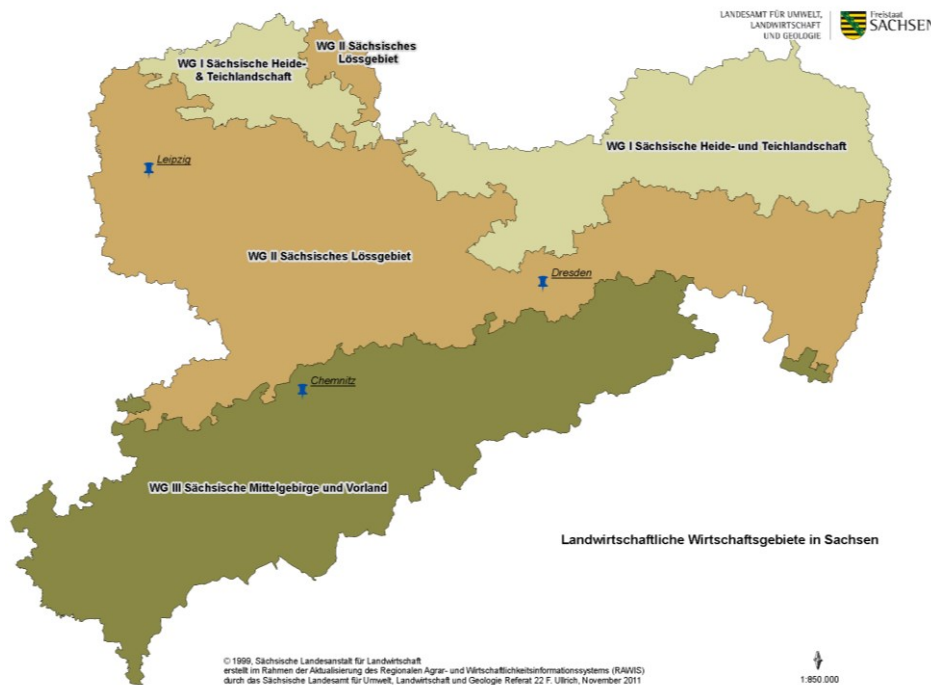
Our case study is an AES focused on grassland biodiversity in the federal state of Saxony, Germany (in the following referred to as Saxon AES). We modify the ecological-economic modelling procedure from Wätzold et al. (2016) in order to design a cost-effective regionalized scheme and take into account distributional impacts of AES. We investigate the cost-effectiveness gains (measured in habitat improvements for 13 bird species, 14 butterfly species and 7 habitat types for given budgets) of an optimized AES with homogeneous payments for the whole of Saxony and an optimized AES with payments differentiated according to three Saxon agri-economic regions in comparison to the Saxon AES. Finally, we analyse the distributional impacts of the Saxon AES with the distributional impacts of the two cost-effective alternatives, based on the principles of equality and equity/accountability (Ohl et al., 2008) and Rawls' (1999) maximin criterion.

## 4.2 Case study

### 4.2.1 Agriculture in Saxony

About half of the total area of the German federal state of Saxony (49.2%=9,066 km<sup>2</sup>) is used for agriculture with approximately 20% (1,850 km<sup>2</sup>) of the overall agricultural area being

grassland (Saxon State Ministry of the Environment and Agriculture, 2014b). Saxony is divided into three agri-economic regions (**Figure 4.1**), each of which covers areas with similar physiogeographic characteristics.



**Figure 4.1 Agri-economic regions in Saxony. 1 = WG I Sächsisches Heide- und Teichlandschaft (Saxon Heath and Pond Landscape), 2 = WG II Sächsisches Lößgebiet (Saxon Loess Region), 3 = WG III Sächsisches Mittelgebirge und Vorland (Saxon Uplands and Foothills). Source: modified representation based on data and with the permission of the Saxon State Office for the Environment, Agriculture and Geology (2014).**

These agri-economic regions include the Saxon Heath and Pond Landscape (Sächsisches Heide- und Teichlandschaft), the Saxon Loess Region (Sächsisches Lößgebiet) and the Saxon Uplands and Foothills (Sächsisches Mittelgebirge und Vorland), referred to as region 1, region 2 and region 3 in the following. Starting from 100 m above sea level in the north lowland, the altitude continually rises to the south and east to approximately 900 m. Altitude is the main factor that leads to differences in climatic conditions and vegetation types in the different regions (Saxon State Institute for Agriculture, 1999). The soil productivity (expressed as grassland number<sup>3</sup>) is on average best in region 2 (**Table 4.1**). Regions 1 and 2 include much less grassland area than region 3 (Corine Land Cover, CLC, 2000, see Mewes et al., 2012).

<sup>3</sup> The grassland number (GZ) (ranging from 1 to 100) is a measure of the productivity of grassland in Germany and indicates the percentage yield ratio of a certain grassland area to the best soil. It depends on many different factors, such as soil type, climate, moisture, and relief (Soil Estimation Act, 2007, Germany).

For our analysis we consider farms with a relatively high percentage of grassland area which are likely to participate in a grassland AES (e.g. cattle and dairy farms, see Appendix D or relevant farms according to the Farm Accountancy Data Network).

**Table 4.1 Comparison of the analyzed grassland farms in the three agri-economic regions of Saxony.**

Region	Region 1	Region 2	Region 3
Number of farms <sup>a</sup>	33	131	197
Average grassland number <sup>b</sup>	38	48	35
Range grassland number <sup>b</sup>	17-56	32-71	13-62
Grassland area used for modelling in ha <sup>c</sup>	47,844	69,206	121,088
<b>Mean operating income in €/ ha<sup>a</sup></b>	<b>812</b>	<b>1,149</b>	<b>910</b>
Mean operating income in €/ ha as percent of region 1 <sup>a</sup>	100.00%	141.50%	112.07%
<b>(gross operating surplus+ personnel costs in €/ full time worker<sup>a</sup></b>	<b>31,300</b>	<b>38,293</b>	<b>32,231</b>
(gross operating surplus + personnel costs in €/ full time worker as percent of region 1 <sup>a</sup>	100.00%	122.34%	102.97%

Sources: <sup>a</sup> Source: Saxon State Ministry of the Environment and Agriculture (2014a), own calculation based on surveyed farms.

<sup>b</sup> Source: Representation based on data and with the permission of the Saxon State Office for the Environment, Agriculture and Geology (2014), own calculation.

<sup>c</sup> Source: based on Corine Land Cover, CLC, 2000 (see Mewes et al. 2012).

In data provided by the Saxon State Ministry of the Environment and Agriculture (2014a), we find altogether 33 relevant farms in region 1, 131 farms in region 2 and 197 farms in region 3 (Table 4.1). The actual number of farms is higher, since not all farms participated in the agricultural data collection survey. However, the data provided in Table 4.1 can be considered representative in terms of differences between regions 1-3.

To identify the poorest region, we would ideally use individual farm income data. However, due to a lack of data on the farm level, we compare only the mean incomes of the three regions and define the region with the lowest mean income as the poorest region. A key indicator for the regional comparison of income is “gross operating surplus plus personnel costs per full time worker”. This indicator is used in official statistics to indicate the sustainable disposable income per full time worker and is not directly dependent on the number, size, and legal forms of farms in the regions (Saxon State Ministry of the Environment and Agriculture, 2014a). On this factor, the income in region 2 is 22% higher than the income in region 1 and the income in region 3 is only slightly higher than in region 1 (3%). The mean operating income per hectare in region 2



is even 42% higher than that in region 1, which corresponds to the high soil productivity in region 2. The mean operating income per hectare in region 3 is 12% higher compared to region 1. In sum, both indicators suggest that income is substantially higher in region 2 than in the other two regions and it is only slightly higher in region 3 than in region 1.

#### 4.2.2 Conservation challenge and Saxon grassland scheme

As in many other parts of Europe, since the 1970s agricultural intensification and amelioration has led to a loss of grassland types resulting in uniform grasslands in Saxony (Bastian et al., 2002, Klimek et al., 2007). This has resulted in a general loss of biodiversity and the endangerment of many grassland species such as meadow birds and butterflies (Bastian et al., 2002, Wätzold et al., 2016). To reverse this trend and support extensive grassland management, the federal state of Saxony has implemented AES for grassland.

Between 2007 and 2014 the AES pertaining to grassland in Saxony was the programme “Extensive grassland use, nature conforming grassland management and conservation” (“Extensive Grünlandwirtschaft, Naturschutzgerechte Grünlandbewirtschaftung und Pflege” - Saxon State Ministry of the Environment and Agriculture, 2015). The scheme comprised eight different mowing and grazing measures and four other measures (e.g. transformation of arable land into grassland and the impoverishment of grassland soils). We focus on the mowing and grazing measures (Table C. 1 provides details of these measures) because they can be analyzed by the ecological-economic modelling procedure applied in our analysis. The payments per hectare, the size of participating area and the total budget spent on the measures in 2013 are used as inputs for the simulation of the Saxon grassland AES with the ecological-economic modelling procedure.

#### 4.3 Ecological-economic modelling procedure

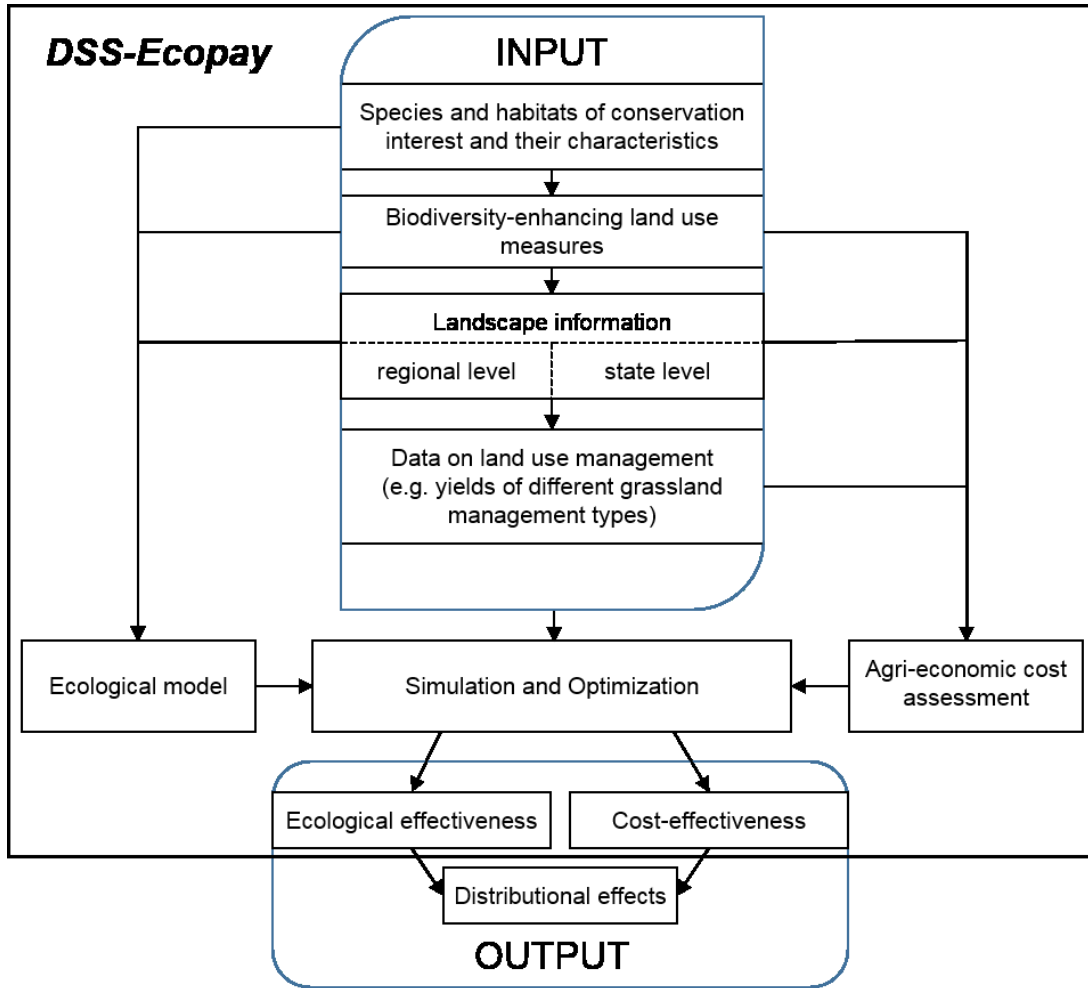
For our analysis, we apply the ecological-economic modelling procedure from Wätzold et al. (2016) to analyze the effectiveness and cost-effectiveness of grassland AES and modify it in order to analyze cost-effectiveness gains from regionalization and its distributional impacts. The following section provides a brief overview of the modelling procedure. For a detailed description, we refer to Wätzold et al. (2016). The ecological-economic modelling procedure consists of several components, which are depicted in **Figure 4.2**. Different species and grassland measures with their characteristics as well as landscape parameters are used as inputs for the calculation of the costs of different grassland measures (in the agri-economic cost assessment) and their ecological effects on the selected species (in the ecological model). These

results can be used for simulation or optimization of an AES. We further modified the modelling procedure to employ the results of the simulation and optimization for the analysis of the regionalization and the distributional aspects. The next sections provide an overview of the modelling procedure, which is implemented in the decision support software *DSS-Ecopay* (see Sturm et al., 2018 for details on the software).

#### 4.3.1 Conservation aims, land-use measures and landscape information

For Saxony, the procedure considers altogether 13 bird species, 14 butterfly species and 7 habitat types (Table C. 2) all of which are threatened or endangered. Information about certain characteristics of the species and habitat types related to the impact of grassland measures is available which is used as input in the ecological model. Altogether 475 different mowing regimes, grazing regimes and combinations of mowing and grazing regimes are included as land-use measures in the procedure. Mowing regimes differ in terms of the frequency and timing of mowing, restrictions regarding N-fertilizer input and the existence of mowing strips. Grazing regimes differ in terms of the beginning and length of the grazing period, the livestock density and the type of livestock. Regime combinations of mowing and grazing vary in terms of timing of mowing, start of grazing, stocking rate and type of livestock (see Wätzold et al., 2016 for details).

Landscape information (e.g. altitude, land use, land productivity, soil moisture) is available on the level of grid cells (pixels) with a resolution of 250m x 250m=6.25 ha and is used as input in the ecological model and the agri-economic cost assessment.



**Figure 4.2 Components of the ecological-economic modelling procedure. Source: modified from Wätzold et al. (2016).**

#### 4.3.2 Ecological model

The ecological model evaluates the impacts of the different measures on the different species and habitat types in a spatially differentiated manner, i.e. differentiated for each grid cell (Johst et al., 2015 provides a detailed description of the ecological model). The effect of land use measures on species and habitat types is measured in terms of the habitat quality on each grid cell. This local habitat quality shows the suitability of the habitat for the reproduction of the species and can take values between 0 (reproduction is not feasible on a grid cell) and 1 (maximum habitat quality for the reproduction of a species on a grid cell). The ecological model estimates for each grid cell  $l$  the local habitat quality  $q_j^{l,m}$  resulting from a measure  $m$  at timing  $t_m$  and the overall achieved effective habitat area  $A_j^{eff}$  for a species  $j$  (see Eq. 1).

The  $A_j^{eff}$  is calculated by summing up the area of all grid cells in the landscape multiplied with their local habitat quality  $q_j^{l,m}$ , under the condition that the measure  $m$  results in a habitat quality

higher than a predefined minimum habitat quality  $q_j^{min}$  for a species, which is set to 0.1 for butterflies and 0.3 for birds and habitat types based on expert knowledge (cf. Wätzold et al., 2016).

$$A_j^{eff} = \sum_{l(r_j; q_j^{l,m}(t_m) > q_j^{min})} A^l \cdot q_j^{l,m}(t_m) \quad \text{Eq. 1}$$

where  $A^l = 6.25$  ha represents a grid cell.

The occurrence and dispersal rate of a species are accounted for in the calculation of habitat quality by summing up only grid cells that contain a species or are within a certain radius of dispersal ( $r_j$ ). For birds this radius is assumed to be infinite, due to their good dispersal ability, whereas for butterflies  $r_j$  is specified for each species based on expert knowledge. In the ecological-economic modeling procedure, the effective habitat area  $A_j^{eff}$  is the indicator for the ecological effect of a land use measure  $m$  on a species  $j$  on the regional scale and is used to assess the ecological effectiveness of a measure. The higher the effective habitat area  $A_j^{eff}$ , the more effective is the measure.

#### 4.3.3 Agri-economic cost assessment

The agri-economic cost assessment estimates the costs of the different measures spatially differentiated for each grid cell. Due to data access restrictions, the ecological-economic modelling procedure does not rely on individual farm data, but considers grid cells instead. That is, in the modelling procedure, one grid cell stands for one virtual farmer. Farmers are assumed to maximize their profits. Thus, a farmer (grid cell  $l$ ) participates in an AES and adopts a measure  $m$ , if the payment  $p_m$  at least covers his costs of participating in the scheme.

$$p_m \geq c^{l,m}(t_m) + tc \quad \text{Eq. 2}$$

where  $tc$  represents the transaction costs of the farmer to participate in a scheme, arising from e.g. paperwork and communication with authorities, and  $c^{l,m}(t_m)$  the opportunity costs of the farmer for not being able to carry out the profit-maximizing grassland use. The opportunity costs depend on the yield loss as well as changes in variable and labor costs, which, in turn, depend on the timing  $t_m$  of the land use measure  $m$ . Mewes et al. (2015) provides a thorough explanation of the agri-economic cost assessment.

#### 4.3.4 Simulation of an AES

The ecological-economic modeling procedure can simulate the effects of an AES on species and habitat types. In the procedure, an AES is defined by a single or a combination of land use measures  $m$ , a corresponding payment  $p_m$  (per year and ha) for each measure, and a maximum area of implementation  $A_m^{max}$  for each measure. For the simulation of the Saxon AES the  $A_m^{max}$  was defined as the size of the area on which a specific measure was applied in 2013 (Table C. 1).

If a farmer can select between different measures, the farmer (grid cell) is assumed to adopt the measure with the highest difference between payment and participation costs, i.e. the measure with the highest producer surplus  $PS^{l,m}$ , as long as it is positive ( $PS^{l,m} > 0$ ) and the maximum participating area  $A_m^{max}$  for the measure has not been reached.

$$\max: PS^{l,m} = p_m - (c^{l,m}(t_m) + tc) \quad \text{Eq. 3}$$

For technical details of the simulation we refer to Wätzold et al. (2016). The result of the simulation is a particular land use pattern characterized by measures and payments assigned to grid cells and habitat quality for each species in each participating grid cell. The ecological effectiveness of an AES is assessed by calculating  $A_j^{eff}$  for each species and grassland type. The total budget  $B$  for an AES is the sum of the products of the payments  $p_m$  for each measure with the size  $A_l = 6.25$  ha and number  $N_m$  of grid cells where this measure is applied:

$$B = \sum_m p_m N_m A_l \quad \text{Eq. 4}$$

#### 4.3.5 Cost-effectiveness analysis

The cost-effectiveness analysis in the modelling procedure can be done in two ways; minimization of a budget for given conservation goals and maximization of goal attainment under a budget constraint,  $B_0$ . Here, we focus on the latter option, i.e. to maximize the total effective habitat area  $A_{tot}^{eff}$  for a number of predefined species with a given budget.

$$A_{tot}^{eff} = \sum_j w_j A_j^{eff} \rightarrow \max \quad \text{subject to } B \leq B_0 \quad \text{Eq. 5}$$

The formula above can reflect a decision-maker's preferences for the protection of certain species through the insertion of weights  $w_j$ . Here, we give equal weights to all 34 species and habitat types identified for Saxony as they are all protected.

Since the core topic of the paper is the cost-effectiveness gain of regional differentiation of an AES and related distributional impacts, in the optimization we consider only the land use measures from the Saxon AES (by contrast Wätzold et al. (2016) use a pool of 58 best-candidate measures). The optimization is carried out with simulated annealing and maximizes the ecological effectiveness of the Saxon AES under the given overall budget constraint from the simulation. The result of the optimization is a cost-effective AES, i.e. a set of land use measures with the corresponding payments per ha, the area covered by each measure, the budget required, as well as the effect on the different species and habitat types  $A_j^{eff}$ .

To compare the cost-effectiveness of the different schemes, we use  $Eff_{type}$ , which is the effective habitat area  $A_{type}^{eff}$  for each species *type* (i.e. for *birds*, *butterflies*, *habitat types* or *all species*) per Euro budget  $B_{type}$  spent:

$$Eff_{type} = \frac{A_{type}^{eff}}{B_{type}} \quad \text{Eq. 6}$$

This indicator taken for all species together  $Eff_{all}$ , i.e. based on the total effective habitat area  $A_{tot}^{eff}$ , should be discussed with caution, since due to their much higher dispersal radius the conserved areas for bird species ( $A_{birds}^{eff}$ ) tend to be much higher than for butterflies ( $A_{butterflies}^{eff}$ ). We therefore make some general comparisons based on all species, but also point to the differences in cost-effectiveness for the different species types.

#### 4.3.6 Regionalization

To investigate the cost-effectiveness of regionalization, the modelling procedure is modified in the following way. GIS data on the spatial distribution of agri-economic regions (from Saxon State Office for the Environment, Agriculture and Geology, 2014) has been added as an input to the model. Thus, the existing pixels are attributed to the three regions (pixels which cross the border between two regions are excluded). For each region, we calculate the budget spent in the simulation of the Saxon AES. The resulting regional budgets are then used in separate optimizations of the payments for the three regions to ensure comparability with the simulation results. For each region, the ecologic-economic modelling procedure maximizes the ecological benefit under the given budget constraint.

#### 4.3.7 Distributional impacts analysis

We use the results of the modelling procedure to compare the distributional impacts of the Saxon AES, the optimized and the regionally optimized AES. The comparison is based on three fairness principles: equality, equity and maximin.

According to the equality principle (based on Konow, 2003; Leventhal, 1980) individual opportunities, rights, proportions etc. should be equal. In the case of AES, we concentrate on the egalitarian view of equality of outcomes (Pascual et al., 2010), i.e. compensations in AES should be equal for all farmers. This corresponds to the distribution of equal payments ( $P$ ).

The equity principle or accountability principle (Homans, 1974; Konow, 2003) stipulates that a fair output distribution should be in proportion to an individual's input or effort. In AES equity translates to compensations that are in accordance to the individual conservation efforts of the farmers, i.e. to their opportunity costs (Ohl et al., 2008). This relates to the distribution of producer surplus ( $PS$ ), which is the difference between the received payments and the incurred opportunity costs. Therefore, we associate higher equity with a more equal distribution of  $PS$ .

The maximin principle introduced by Rawls (1999, p. 266) states that: "Social and economic inequalities are to be arranged so that they are ... to the greatest benefit of the least advantaged". In the context of PES, this principle has been interpreted by Pascual et al. (2010) as maximizing "the net benefit to the poorest landholders". As we are unable to identify single farm income, we assume that a farmer in region 1 - the region with the lowest income expressed as "gross operating surplus plus personnel costs per full time worker" - is "poorest". The net benefit in our case corresponds to the  $PS$  of the farmers. When comparing the schemes based on the maximin principle we investigate in which scheme the  $PS_{min}$ ,  $PS_{mean}$  and  $PS_{sum}$  in the "poorest region" - region 1 - are highest. Due to data limitations and asymmetric information between the farmers and the regulator about the farmers' costs, in practice a pro-poor scheme may not concentrate explicitly on the  $PS$  of the poorest farmers, but just try to allocate higher payments to poorer participants. Therefore, in our analysis based on the maximin principle, in addition to the comparison of  $PS$ , we also investigate in which scheme the payments (i.e.  $P_{min}$ ,  $P_{mean}$  and  $P_{sum}$ ) in the "poorest" region 1 are highest.

In order to analyze the equality of the simulated and optimized AES for Saxony on a federal state and regional level, we compare the payment distributions, and for analyzing the equity of the schemes we compare the producer surplus distributions among pixels as a proxy for farmers. Both comparisons are based on the Atkinson index (Atkinson 1970), with Whitehouse (1995) defining the Atkinson index (AI) as a measure of income inequality as follows:

$$AI(\varepsilon) = 1 - \left( \frac{1}{n} \sum_{i=1}^n \left( \frac{y_i}{\bar{y}} \right)^{(1-\varepsilon)} \right)^{\frac{1}{1-\varepsilon}}, \quad \text{for } \varepsilon \neq 1 \quad \text{Eq. 7}$$

$$AI(1) = 1 - \prod_{i=1}^n \left( \frac{y_i}{\bar{y}} \right)^{1/n}, \quad \text{for } \varepsilon = 1 \quad \text{Eq. 8}$$

where  $y_i$  refers to the individual income and  $\bar{y}$  refers to the average income of individuals in a population of size  $n$ .

In our case,  $y_i$  stands for payment ( $P$ ) respectively producer surplus ( $PS$ ), and  $\bar{y}$  corresponds to the average payment or producer surplus. The Atkinson index takes values from 0 to 1, the lower the value, the more equal (or in our case equitable) the distribution, whereby perfect equality/equity corresponds to a value of 0 for the Atkinson index.

The calculation of the Atkinson index is based on a parameter epsilon ( $\varepsilon$ ), which can reflect different levels of inequality/inequity aversion and thus different social welfare preferences. The higher the value of  $\varepsilon$ , the stronger the inequality/inequity aversion, with  $\varepsilon = 0$  corresponding to no interest in the distribution and high values of  $\varepsilon$  corresponding to high inequality/inequity aversion and Rawlsian preferences. In accordance with Schlör et al. (2013) the  $\varepsilon$  parameter can reflect preferences for equality (in our case also equity) and efficiency and can be defined as a ratio between an equality/equity parameter  $\alpha$  and an efficiency parameter  $\beta$ , where these parameters can each take values between 1 and 5:

$$\varepsilon = \frac{\text{equality/equity}}{\text{efficiency}} = \frac{\alpha(1,2,3,4,5)}{\beta(1,2,3,4,5)} \quad \text{Eq. 9}$$

Thus,  $\varepsilon$  ranges from 0.2 with low inequality/inequity aversion and strong efficiency preferences to 5 with high inequality/inequity aversion and Rawlsian preferences. With higher values of  $\varepsilon$  the Atkinson index becomes more sensitive to income inequalities, in our case – to payment or producer surplus inequalities. The special case of  $\varepsilon = 1$  refers to social preferences attributing equal weights to equality (in our case also equity) and efficiency and we employ this assumption in our calculations.

We transform the values of the Atkinson (AI) index by defining  $EP$  as a measure of equality and  $EPS$  as a measure of equity with higher values indicating more equal/equitable distributions, where:

$$EP = 1 - AIP(\varepsilon = 1) = 1 - \prod_{i=1}^n \left( \frac{P_i}{\bar{P}} \right)^{1/n} \quad \text{Eq. 10}$$



$$EPS = 1 - AIPS(\varepsilon = 1) = 1 - \prod_{i=1}^n \left( \frac{PS_i}{PS} \right)^{1/n} \quad \text{Eq. 11}$$

Here  $i$  refers to pixels instead of individuals or farmers, due to the mentioned limitations of data accessibility. Using these measures of equality/ equity we compare the Saxon AES and the optimized schemes based on the equality and equity principles.

## 4.4 Cost-effectiveness results and analysis

### 4.4.1 Overview of results

#### *Simulation*

We find that the Saxon AES contributes considerably to the conservation of endangered grassland birds, but fails to protect most of the butterfly species and habitat types (**Figure 4.3** and Table C. 2). All bird species, except the crested lark, are conserved to some extent, whereas this applies only to five out of 14 butterfly species and four out of seven habitat types. All 10 measures from the Saxon AES are to some extent applied in regions 2 and 3, whereas in region 1 only nine measures are applied (an overview of the regionally differentiated results from the simulation and optimizations is found in Table C. 3)

#### *Statewide optimization*

Only seven out of the 10 measures in the Saxon AES are included in the statewide optimized scheme – five in region 1, three in region 2 and seven in region 3. Compared to the Saxon AES, the cost-effective AES leads to about 33% more  $A_{birds}^{eff}$  and  $A_{habitats}^{eff}$  (**Table 4.2**) whereas  $A_{butterflies}^{eff}$  is a bit (16%) lower. The conservation levels of the optimized AES are higher for eight bird species, two habitat types, and one butterfly species. Overall, the optimized scheme generates effective habitat area for 11 birds, two butterflies and four habitat types.

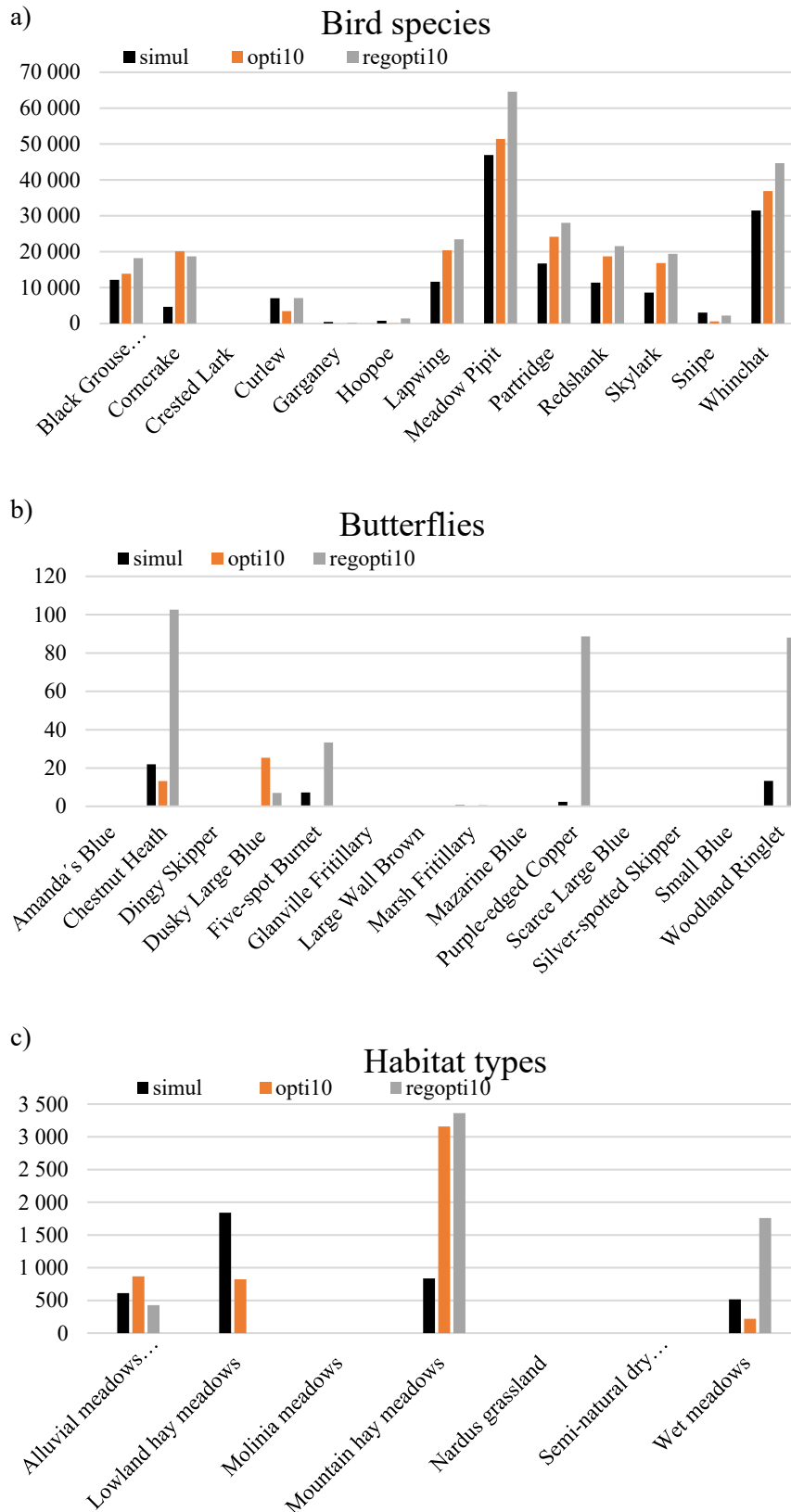
#### *Regional optimization*

The regionalized cost-effective AES conserves overall 12 out of 13 bird species, six out of 14 butterfly species and three out of seven habitat types and includes all 10 measures from the Saxon AES (four measures in region 1, six measures in region 2 and all 10 measures in region 3). Despite a 13% lower budget, it leads for the whole of Saxony to a 61.23% larger  $A_{birds}^{eff}$ , 596.46% more  $A_{butterflies}^{eff}$ , and a 45.86% larger  $A_{habitats}^{eff}$  than the Saxon AES (**Table 4.2**). The conservation levels are higher for most species and habitat types, except for the Garganey, the Snipe, alluvial meadows and lowland hay meadows. In comparison to the statewide cost-

effective payment scheme, the effective habitat areas are 21% ( $A_{birds}^{eff}$ ), 729% ( $A_{butterflies}^{eff}$ ), and 10% higher ( $A_{habitats}^{eff}$ ) and the regionalized payments perform better for most species and habitat types, except the Corncrake, the Five-spot Burnet, alluvial meadows and lowland hay meadows (Table C. 2 and **Figure 4.3**).

**Table 4.2 Regional comparison of the (cost-)effectiveness of the Saxon AES, the statewide and the regional optimizations.**

Run	Regions	$A_{birds}^{eff}$ in ha	$A_{butterflies}^{eff}$ in ha	$A_{habitats}^{eff}$ in ha	$A_{tot}^{eff}$ in ha	Budget ( $P_{sum}$ ) in Euro	Producer surplus ( $PS_{sum}$ ) in Euro
<b>Saxon AES</b>	region 1	28 755	0.65	1 225	29 981	2 104 425	1 258 621
	region 2	47 273	15.26	816	48 105	2 905 838	1 498 020
	region 3	78 702	29.66	1 763	80 495	6 129 313	4 467 608
	<b>Saxony</b>	<b>154 731</b>	<b>45.58</b>	<b>3 805</b>	<b>158 581</b>	<b>11 139 575</b>	<b>7 224 249</b>
<b>as percent difference to simulation:</b>							
<b>statewide optimization</b>	region 1	96.63%	-100.00%	5.86%	92.92%	11.40%	74.97%
	region 2	66.92%	-13.31%	-100.00%	64.06%	-3.30%	105.73%
	region 3	-9.93%	-14.42%	113.77%	-7.22%	-5.03%	-34.95%
	<b>Saxony</b>	<b>33.36%</b>	<b>-16.05%</b>	<b>33.14%</b>	<b>33.34%</b>	<b>-1.48%</b>	<b>13.37%</b>
<b>regional optimization</b>	region 1	110.90%	-0.28%	-100.00%	102.28%	-60.65%	-53.56%
	region 2	65.06%	-100.00%	-72.74%	62.66%	-0.48%	96.33%
	region 3	40.78%	977.90%	202.12%	44.66%	-2.35%	-80.09%
	<b>Saxony</b>	<b>61.23%</b>	<b>596.46%</b>	<b>45.86%</b>	<b>61.02%</b>	<b>-12.88%</b>	<b>-38.89%</b>



**Figure 4.3** Comparison of the cost-effectiveness of the simulation (simul) with the statewide optimization (opti10) and regional optimization (regopti10) for birds (a), habitat types (b) and butterflies (c). The y-axis indicates the effective habitat area  $A_j^{eff}$  achieved for each species in ha.

#### 4.4.2 Analysis of results

In the analysis of the results, we focus on an explanation of why a regionalized payment scheme leads to cost-effectiveness improvements compared to the Saxon AES and the optimized Saxon AES with homogeneous payments. Generally, the optimization is able to identify cost-effective measures and induce their (increased) uptake for both optimized schemes. In both optimizations the participating area of the general mowing measures is reduced compared to the Saxon AES, due to their much lower benefit-cost ratios, whereas the participating area for ‘mowing strips’ and ‘rotational grazing’, the best-performing and lowest-cost measures, is increased. This mechanism can explain very well the increase in cost-effectiveness in the statewide optimization (33% more  $A_{tot}^{eff}$  with nearly the same budget).

The regional optimization increases the overall cost-effectiveness further by taking advantage of cost differences between the three regions (Wätzold and Drechsler 2005). Payments are set lower in regions 1 and 3 with low opportunity costs than in region 2 with high opportunity costs (Table C. 3). By contrast, in the statewide optimization the payments are defined over the whole of Saxony and cannot take into account cost differences among regions. The rise in cost-effectiveness through regionalization comes only from the two regions with low opportunity costs (region 1 and 3); for region 2 with high opportunity costs, the regional optimization does not improve overall cost-effectiveness ( $Eff_{all}$  in **Table 4.3**) further than the statewide optimized scheme. In this region both optimizations reduce substantially the number of measures and are therefore less effective and cost-effective for butterflies and habitat types than the Saxon AES. Thus, there are regional differences and the optimizations do not improve the cost-effectiveness for all different species types in all regions. However, on the federal state level the regional optimization is most cost-effective for all species types (highest  $Eff_{type}$  values over Saxony for all species types in Table C. 4 in the appendix).

Additional cost-effectiveness improvements can arise in regionalization from the possibility to spatially focus payments relevant for the conservation of specific species, which occur only or mainly in one or several specific regions. In our study, this is particularly relevant for butterflies. The regional optimization generates substantially higher  $A_{butterflies}^{eff}$ , but only in region 3, which has the largest grassland area, low opportunity costs and in general most butterfly occurrence. In the regional optimization, all ten measures from the Saxon AES are applied in this region (Table C. 3) generating the diversity of grassland use needed to conserve different butterfly species (Johst et al. 2015, Wätzold et al. 2016). By contrast, in the statewide optimization due

to the lower number of measures with mostly higher payments in all regions the cost-effectiveness for butterflies is even lower than in the Saxon AES.

In the other low-cost region 1 the overall cost-effectiveness is increased to a very high extent in the regional optimization by setting much lower payments and focusing only on four high benefit-cost measures. Thus, by aligning the payments and measures to the regional specifics, and offering much lower payments, the regional optimization is able to significantly improve the overall performance of the scheme in the two low-cost regions.

Interestingly, the resulting budgets in the regional optimizations are close to the budget constraints derived from the simulations in regions 2 and 3, but about 60% below the constraint in region 1. This large reduction in the budget results from lower payments, which lead to a situation where the available grassland area for mowing measures is utilized completely without reaching the budget constraint. The lower payments are feasible due to the lower land productivity in region 1 and the resulting lower cost of AES participation.

#### 4.5 Distributional impacts and their relation with cost-effectiveness

In the analysis of distributional impacts, we use the measures introduced in section 3.7, the calculated values for which are presented in (Table 4.3). When we refer to the cost-effectiveness of the schemes in this section we consider the overall cost-effectiveness ( $Eff_{all}$  in Table 4.3).

##### 4.5.1 Comparison based on equality and equity principles

The Saxon AES has similar payment levels for all ten measures, the statewide optimization results in less measures with quite different payment levels, and the regional optimization leads to even more unequal payment distribution, due to the different levels of opportunity costs used as basis for the payments in the different regions. Thus, as expected, on the federal state level  $P$  are most equally distributed in the Saxon AES and least equally distributed in the regional optimization.

The statewide optimization is, in general, most equitable. There the  $PS$  is most homogeneously distributed, as the scheme includes less measures and aligns the homogeneous payments to the high opportunity costs in region 2 so that for each measure  $P$  are the same and the  $PS$  levels are similar for most of the measures (and pixels) involved. The regionally differentiated optimization leads to a less homogeneous distribution of  $PS$  than the statewide optimization and the Saxon AES because it reduces substantially the  $P$  and thus  $PS$  for measures in regions 1 and 3 with low opportunity costs, but the  $P$  and  $PS$  in region 2 with high opportunity costs remain higher. As in the regional optimization the farmers in region 2 do not compete with

farmers with lower opportunity costs from the other regions, some of the less cost-effective mowing measures with high  $P$  and  $PS$  are included in the regionalized scheme in region 2, whereas these measures are not applied in this region in the statewide optimization.

Thus, on the federal state level optimized statewide payments lead to a trade-off between cost-effectiveness and equality ( $EP$ ), but a synergy of cost-effectiveness and equity ( $EPS$ ), whereas the further overall rise in cost-effectiveness through regionalization leads to less equality and less equity.

**Table 4.3 Comparison over Saxony and for each region of the cost-effectiveness measures ( $Eff_{all}$  in Eq. 6), the equality measures ( $EP$  in Eq. 10) and equity measures ( $EPS$  in Eq. 11)**

Comparison based on:	spatial level	variable	simul	opti10	regopti10
Cost-effectiveness	Saxony	$Eff_{all}$	0.014	0.019	<b>0.026</b>
	region 1	$Eff_{all1}$	0.014	0.025	<b>0.073</b>
	region 2	$Eff_{all2}$	0.017	<b>0.028</b>	0.027
	region 3	$Eff_{all3}$	0.0131	0.0128	<b>0.019</b>
Equality	Saxony	$EP$	0.835	0.785	0.589
	region 1	$EP1$	0.832	0.846	0.540
	region 2	$EP2$	0.941	0.945	0.863
	region 3	$EP3$	0.862	0.756	0.600
Equity	Saxony	$EPS$	0.527	0.800	0.522
	region 1	$EPS1$	0.580	0.962	0.831
	region 2	$EPS2$	0.573	0.994	0.979
	region 3	$EPS3$	0.629	0.535	0.537

Note: bold type indicates the most cost-effective scheme in each region and for Saxony; blue indicates that the optimizations are more equal/equitable than the simulation.

Considering the situation within regions, the payments are more equally distributed in the Saxon AES than in the optimizations in region 3 with the largest grassland area. In the other two regions, the statewide optimization leads to a slightly more equal  $P$  distribution than the Saxon AES, because there are only low number of measures are applied. Thus, in regions 1 and 2 higher cost-effectiveness through spatially homogeneous payments does not compromise equality (we have a synergy). The regional optimization however leads to a trade-off – a rise in inequality (lower  $EP$ ) in all three regions, due to the lower payment levels and higher variation in  $P$ .

The *PS*-distributions from the optimizations within regions 1 and 2 are more homogeneous than in the Saxon AES, but less homogeneous within region 3. This means, in regions 1 and 2 increasing the overall cost-effectiveness with the optimizations leads to a synergy - an increase in equity - as expected, because the *PS* levels vary less, due to the orientation on opportunity costs and also much lower number of measures applied in the optimizations in these regions. In region 3, the variation of *PS* is higher in the optimizations than in the Saxon AES, because in the Saxon AES almost 50% of the participating area is covered by one measure, whereas in the optimizations there is not one single dominating measure and also due to the higher variation in opportunity costs in this region.

#### 4.5.2 Comparison based on Rawls' maximin principle

To account for Rawlsian preferences, we focus on region 1, the “poorest region” with the lowest mean income (Table 4.1), and compare the payments (i.e.  $P_{min}$ ,  $P_{mean}$  and  $P_{sum}$ ) and the net benefits generated (i.e.  $PS_{min}$ ,  $PS_{mean}$  and  $PS_{sum}$ ) of the Saxon AES and the optimizations. Surprisingly in region 1 all three net benefit values, as well as  $P_{min}$  and  $P_{sum}$  are highest in the statewide optimization, only  $P_{mean}$  is highest in the Saxon AES (Table 4.4).

**Table 4.4 Regional comparison of the minimum, average and total payments ( $P_{min}$ ,  $P_{mean}$  and  $P_{sum}$ ) and producer surplus ( $PS_{min}$ ,  $PS_{mean}$  and  $PS_{sum}$ ) from the simulation and optimizations (in Euro).**

Region	1	2	3	1	2	3	1	2	3
Variable	PS1min	PS2min	PS3min	PS1mean	PS2mean	PS3mean	PS1sum	PS2sum	PS3sum
Simul	8.22	8.22	8.22	119.87	62.93	194.46	1 258 621	1 498 020	4 467 608
opti10	<b>100</b>	100	1.53	<b>123.63</b>	123.68	135.52	<b>2 202 230</b>	3 081 842	2 906 146
regopti10	0.02	62.55	0.37	31.73	127.11	23.19	565 233	3 167 524	497 265
Variable	P1min	P2min	P3min	P1mean	P2mean	P3mean	P1sum	P2sum	P3sum
Simul	79	79	79	<b>200.42</b>	122.06	266.78	2 104 425	2 905 838	6 129 313
opti10	<b>89</b>	89	89	131.61	112.77	271.45	<b>2 344 288</b>	2 810 044	5 820 881
regopti10	15	89	15	44.95	124.99	156.04	827 988	2 891 950	5 985 013
mean income (GOS+pers. costs)* / worker	<b>31,300</b>	38,293	32,231	<b>31,300</b>	38,293	32,231	<b>31,300</b>	38,293	32,231

Thus, considering Rawlsian preferences, in our case the statewide optimization is better than the Saxon AES and the regional optimization, as it leads to higher net benefits ( $PS_{min}$ ,  $PS_{mean}$  and  $PS_{sum}$ ) in the “poorest” region 1. Due to the low opportunity costs there a larger portion of the budget is allocated to this region in the statewide optimization.

Considering region 3, which is also relatively poor compared to region 2, the Saxon AES is best on the maximin criterion, because almost 50% of the participating area in the Saxon AES in this region is covered by a mowing measure with high  $P$  and  $PS$ , which has relatively low benefit-cost ratio and thus less relevance in the statewide optimization.

## 4.6 Discussion and conclusion

Here we analyze cost-effectiveness gains through regionalization of agri-environment schemes and the distributional impact of the regionalization applying the equality principle, the equity principle and Rawls' maximin principle. We carry out our analysis by modifying an existing ecological-economic modelling procedure (Wätzold et al., 2016; Sturm et al., 2018) so that we are able to investigate regional cost-effectiveness gains and their distributional impact. We apply the modelling procedure to the case study of a grassland AES in Saxony. We compare a Saxon AES to optimized schemes with (1) spatially homogeneous payments and (2) regionally differentiated payments.

Regarding the effects of regionalization on cost-effectiveness, we find that regionalization helps in increasing the level of bird, butterfly and habitat type conservation on the federal state level through aligning the measures applied and the payments to the opportunity costs of each region. In regions 1 and 2 (with less grassland area available), however, the regional payments do not enhance the protection of butterflies and habitat types. The increase in conservation for these species is realized mainly in region 3 with the largest grassland area and in general more species occurrence. Thus through regionalization a kind of specialization is possible by focusing payments and measures to the areas where, e.g. due to more species occurrence as in the case of butterflies, a higher conservation result is possible.

By including more measures in the optimizations and not restricting the measures to the ones from the Saxon AES, we could have obtained higher conservation levels for butterflies and habitat types (Wätzold et al. 2016). However, a large number of measures is associated with high transaction costs. In general, improving the cost effectiveness through implementing more-tailored regionally differentiated payments instead of simplified homogeneous payments brings a trade-off with equality but also with transaction costs, as suggested by Armsworth et al. (2012) for AES and Wätzold et al. (2010) for conservation measures in Natura 2000 sites. In this study, we show that high cost-effectiveness improvements in AES are possible without incurring much higher transaction cost, by only choosing a limited number of measures for each region and setting regional payments. Whether in reality the transaction costs in implementing such a regionalized AES with fixed payments within regions are low, having in mind its distributional



effects, is a matter of future research. Future research can also give more insights on the effects of spatial differentiation on cost-effectiveness and distributive fairness of AES in practice.

In our theoretical analysis of distributive impacts, we apply three fairness principles: equality, equity and Rawls' maximin criterion. If we choose equality as fairness principle, on the federal state level and in region 3 the Saxon AES is superior to the more cost-effective, optimized ones. If we look at fairness as equity, and choose accountability as the fairness principle, then the increase in cost-effectiveness in the optimized schemes leads in general to more equity, except in region 3 – the region with largest grassland area and relatively low opportunity costs.

The spatially homogeneous optimized payments perform best on the maximin criterion and also lead to highest equality and equity in regions 1 and 2. Therefore, in our case study we do not find strong trade-offs in cost-effectiveness and equality/equity between the Saxon AES and the optimization with spatially homogeneous payments, except in region 3, with the highest number of farms.

Compared to the statewide optimized scheme the regionalized payments lead to an overall rise in cost-effectiveness, but also to less equality and less equity. Especially prominent trade-off between cost-effectiveness and equality through regionalization is present in region 1, where with 60% less budget the regionally differentiated payments generate twice as much  $A_{tot}^{eff}$  as the Saxon AES. By contrast, in the statewide optimization, where the budget constraint is set on the federal state level, almost the same improvement in conservation is achieved in region 1 with much higher budget (11 % higher than in the Saxon AES in region 1). Thus, in region 1, the “poorest” region, spatially homogeneous payments lead to more fairness based on the equality, equity and the maximin criterion, but are much less cost-effective than the regionalized payments.

Uthes et al. (2010) also suggest that effectiveness and cost-effectiveness are sacrificed with the usual design of AES with homogeneous payments and with the additional goal of rural income creation. They propose that in line with Tinbergen (1952) the two goals should be targeted with two instruments and a way to increase the efficiency and effectiveness of an AES could be to distribute “a basic payment to all livestock-keeping farms for their contribution to the rural environment, and an additional top-up payment for environmental services to farms that actually reduce livestock density and adjust grassland management.” To account for Rawlsian preferences and keep direct payments low they could be limited to a certain amount and scaled according to the size of the farm (smallest, small, medium, large) and in combination with an income parameter (such as income (e.g. gross operating surplus+personnel costs) per worker.

This could possibly be an alternative to the proposed “reduction of payments as of €60,000 and compulsory capping for payments above €100,000 per farm” (where labour costs are taken fully into account) in the CAP (Common Agricultural Policy) post 2020 (European Commission, 2018).

In our case study, homogeneous optimized payments are actually superior to regionally differentiated payments in region 2 – with the highest opportunity costs (i.e. “richest” region), where differentiated payments do not lead to more cost-effectiveness. There, as in region 1 (the “poorest” region), we have synergies between cost-effectiveness and equality, and equity resulting from homogeneous optimized payments. The more cost-effective regionalized payments lead to substantial redistribution effects and lower substantially the producer surplus for farmers in the “poorer” regions 1 and 3, but increase the producer surplus for farmers in the “richer” region 2. This trade-off between maximizing public policies’ performance on a supra-regional (national) level and the corresponding regional performance and distributive fairness is also identified in Mouysset (2014) and highlights the importance of analyzing public policy effects on different levels – state, federal state, and regional levels.

Also important is a discussion on the socially desirable fairness principle in AES. Literature on PES offers more insights into this issue and suggests different fairness preferences of ecosystem service (ES) providers (e.g. farmers). Loft et al. (2017) find a preference for merit-system distribution, i.e. equity, among PES participants in Vietnam, whereas Gross-Camp et al. (2012) and Narloch et al. (2011) find preferences for an equal distribution in Rwanda and the Andes, respectively. In Markova-Nenova and Wätzold (2017) and Randrianarison and Waetzold (2017) potential ES buyers (donors) in Germany and in Madagascar show preferences for a maximin or equal distribution over an unknown distribution of PES in Madagascar. Based on a study on preferences for ethical milk attributes Markova-Nenova and Wätzold (2018) suggest that poor farmers’ support is important for milk buyers as taxpayers and potential ES buyers and support for all farmers is approved of only in one’s own region. A question arises how the fairness preferences would look like if ES buyers in AES had to choose between a less cost-effective, but fairer homogeneous payments scheme and a more cost-effective, but less fair regionalized scheme. This could be a topic for future research.

Unfortunately, we have only mean income data available for the three economic regions in Saxony, which makes the analysis based on the maximin principle difficult. Much more detailed research results on distribution could be possible, if farm data in Germany were available

openly as in Sweden (Nordin and Höjgård, 2018). This would in general facilitate research on agricultural topics.

Another limitation of our analysis is the focus on three strictly defined social fairness principles relevant for the distribution of payments to farmers. We acknowledge that multiple dimensions of fairness exist, and pursuing different fairness objectives can lead to different results (Law et al., 2018). If we look at existence values (Schlosberg, 2009), or responsibility to future generations and to other species as environmental justice principles (Clayton, 2000) the fairness comparison will depend more strongly on the number of species conserved through an AES and the extent to which they are conserved.

## 5 Discussion and Conclusions

Agriculture is important for human development and delivers numerous ecosystems services (Power, 2010), however agriculture is also one of the major drivers of habitat destruction and biodiversity loss and a threat to vital ecosystems, such as tropical forests, but also biodiversity rich habitats all over the world (IPBES, 2018). To counteract these negative effects, scientists and policy makers have endorsed the use of different policy instruments, such as PES and AES. The main goals of these market-based environmental policy instruments (e.g. Wunder et al., 2018) are ecological effectiveness and cost-effectiveness (understood here as the ability to achieve the best possible environmental result using the available financial resources (Wätzold and Schwerdtner, 2005)).

Since PES and AES involve payment distribution among different actors, questions of fairness and equity arise in their implementation. PES specifically have also additionally been seen as an instrument for poverty alleviation (van Noordwijk et al., 2017), since they are often implemented in developing countries and poor regions, but also AES have the goal of rural development besides environmental improvement (Prager and Freese, 2009).

While the importance of fairness aspects is widely acknowledged in the literature, the extent to which they should be considered in scheme design and the practical way of implementation remain controversial (Wells et al., 2020; Wunder et al., 2020), mainly due to the well-established Tinbergen rule (cf. Tinbergen, 1952) in economic theory, which stipulates that endeavouring two goals with one policy instrument leads to compromising the goals.

Thus a long-lasting debate exists in the literature on PES and AES about reconciling their cost-effectiveness and fairness. Since fairness issues can significantly influence the successful implementation of PES and AES in practice (He and Sikor, 2015), careful consideration of the fairness implications of such policies is crucial (Pascual et al., 2010). Especially in developing countries, where governments are often weak (Rice and Patrick, 2008), successfully implementing multiple policies for multiple goals can be difficult and in such cases considering poverty alleviation as a goal of PES together with effectiveness and cost-effectiveness can be justified. But also in the case of AES in developed countries fairness issues can become important for the cost-effectiveness of the schemes. If, for example, a spatially homogeneous payments scheme is to be substituted by a regionalized and more cost-effective scheme, this would have an effect on the distribution of payments and producer surplus. As shown in Chapter 4 of this thesis then “poorer” regions, with lower opportunity costs would receive much lower payments and producer surplus and in “richer regions” the mean payments and producer surplus

would probably not change much. In view of such a change resentment among farmers in disadvantaged regions and lower participation rate and higher transaction costs can result. To counterbalance the loss in distributive fairness, in line with Tinbergen (1952), another separate policy could be implemented, such as rural development subsidy. If the disadvantaged regions are, however, also important for the achievement of the AES conservation goals (e.g. due to high species occurrence and area covered as in the case study in Chapter 4), then the cost-effectiveness of the regionalized scheme could be compromised by lower participation rates, i.e. then the cost-effectiveness will not necessarily or not sufficiently be improved. In such a case, the validity of the Tinbergen rule will be weakened and also from an economic point of view it could be justifiable to explicitly consider distributive fairness aspects in the scheme design.

As economic literature suggests, public policies should take into account public preferences (Page and Shapiro, 2010). If fairness aspects are to be integrated into PES and AES design, then PES and AES design should take into account public fairness preferences. Using different case studies, this thesis looks into public preferences on selected fairness aspects in scheme design and contributes to an improved insight into the relationship between distribution and cost-effectiveness in PES and AES.

In the following, Section 5.1 includes a summary of the most important results of Chapters 2, 3 and 4. Section 5.2 discusses the limitations of the work and the existing research gaps. Finally, Section 5.3 presents policy recommendations and conclusions.

## 5.1 Synthesis of main results

PES as a market based instrument are alleged to offer a cost-effective way of environmental improvement, such as species conservation. Taking into consideration distributional issues already in the design of these schemes is controversial as this might undermine their cost-effectiveness. On the other hand, it can also have a positive long-term effect on the cost-effectiveness through increased legitimacy and acceptance, which prevents discontent among farmers and promotes long-term participation in PES and thus long-term ES provision (Narloch, et al., 2011).

Since PES are often implemented in developing countries, but also often funded through developed countries, and (as elaborated in Chapter 2 and section 5.1) implementing separate policies for poverty alleviation in developing countries can be difficult, the preferences of residents in developed countries, as ES buyers, for fair distribution of payments in PES should

be considered. Therefore, in this thesis distributional fairness preferences of distant donors (as potential ES buyers) were analysed in Chapter 2. The conducted CE study shows preferences of distant donors from Germany (as ES buyers) for fair distribution of payments for dry spiny forest conservation among local beneficiaries in Madagascar, in the context of PES. Significant WTP for a fair (both for maximin/pro-poor or equal) distribution and significant aversion to unknown payment distribution were stated by respondents, i.e. respondents wanted to know who receives their donations and how they are distributed. This provides evidence that schemes which account for distributional fairness explicitly are preferred by possible international donors for such schemes.

Interestingly, potential local donors (as ES buyers) for dry spiny forest conservation in Madagascar exhibit similar fairness preferences in a similar CE conducted in Madagascar by Randrianarison and Wätzold (2017). Just as the distant beneficiaries/donors surveyed in Germany, potential local donors show preference for pro-poor, followed by equal distribution and a disutility of having no information on the distribution of payments.

Preferences for fairness are also one focus of the case study in Chapter 3. Through a CE for valuing different ethical attributes of milk, preferences of a large part of the population in Germany - conventional milk consumers (as taxpayers and potential ES buyers in state-administered AES) – for fairness aspects in milk production are analysed and used as a basis for suggestions on an improved design of AES, milk labels and other policy instruments. Animal welfare is the most valued ethical attribute in the survey. Conventional milk buyers also state significant WTP for biodiversity conservation measures in milk production on grassland which is an argument in favour of AES directed at grassland biodiversity. The CE also shows significant WTP among a large part of the population for fair prices for milk farmers, especially for poorer farmers – small, below-average income farms. Since milk consumers are also taxpayers, the preferences they show for fair payment distribution should count in the design of governmental policies implemented in agriculture among milk farms, such as grassland AES. This evidence also supports the consideration of distributive fairness in designing cost-effective (grassland) AES, when their successful implementation can be at stake due to fairness issues.

Cost-effectiveness and related distributional effects in grassland AES design are in the focus of Chapter 4. Using a case study of a grassland scheme in Saxony, Germany, the cost-effectiveness gains through spatially homogeneous optimized payments and regionally differentiated payments were analysed on federal state level and on regional level alongside with the distributional effects of the optimized schemes.

The results of the analysis in Chapter 4 in general confirm a trade-off between equality and cost-effectiveness in AES and a synergy with equity. However, on a regional level these conclusions do not hold in every case. Surprisingly, in our case study, spatially homogeneous optimized payments lead to highest fairness according to the maximin principle and are also most equal and equitable in the two smaller Saxon regions. The regionally differentiated payments in general improve the cost-effectiveness of the AES but also lead to less equality compared to the Saxon AES and spatially homogeneous payments and less equity than the spatially homogeneous payments. On the regional level, different effects on the cost-effectiveness and distribution are observed. This suggests (as also pointed out in Mouysset (2014)) that the cost-effectiveness and distributional effects of AES on a supra-regional level can differ from the effects on regional level and policy design and implementation should take into account such differences.

When looking at the performance of optimized spatially homogeneous and differentiated payments on regional level the importance of fairness considerations becomes obvious. Strong redistribution effects could be, as already mentioned, a hindrance for implementing cost-effective regionalized AES and could lead to higher transaction costs (Armsworth et al., 2012). Therefore, there should be a social consensus on the extent to which fairness is/ or is not incorporated into AES, which again calls for an analysis of fairness preferences and preferences for fairness versus cost-effectiveness. As suggested by the results in the CE from Chapter 3 of this thesis, a maximin distribution is in general appreciated more than an equal distribution of financial support among farmers (small, below-average income farm support is preferred to support for all farms). However, in their own region respondents prefer equal distribution of payments. Combining this result with the comparison of spatially homogeneous and regionally differentiated payments in Chapter 4, we can infer that in our case spatially homogeneous payments correspond to the analysed fairness preferences of the public: they lead to a maximin distribution and to more equality than the differentiated payments - in all regions and on federal state level.

Since the regionalized payments can, however, increase overall cost-effectiveness to a high extent, especially by taking into account differences in opportunity costs for AES participation and differences in possible environmental benefits (e.g. due to differences in species occurrence and landscape), they provide potential for improving existing AES.

When introducing a regionalized payment scheme in regions with quite different opportunity costs, of course, the scheme will lead to less equality in payments, but to account for fairness

preferences at least the equity (i.e. the equality of the producer surplus distribution) among regions should be considered. If the measures and payments are planned in a way that at least the mean producer surplus levels per ha in the different regions are similar, then this could be a basis for justification of the scheme also on the grounds of fairness, and not only with cost-effectiveness motives. Such design could be difficult, especially due to data access restrictions and the problem of asymmetric information between the farmers and the regulating authority on farmers' costs, but even under information uncertainty, striving for a fair distribution of producer surplus among regions could be a way to reconcile the cost-effectiveness-fairness trade-off resulting from payment differentiation.

Alternatively, if the validity of the Tinbergen rule is not guaranteed, a way to reconcile cost-effectiveness and distributive fairness could be payment optimization/targeting based on three criteria: low opportunity costs together with high environmental benefits and poor land owners. As suggested by Gauvin et al. (2010) for the SLCP in China this strategy can be nearly as cost-effective as benefit-cost targeting. The validity of this last proposition, however, has to be investigated on a case to case basis, since it might not be universally valid. For example, Wu and Yu (2017) provide evidence that the CRP in the US is quite cost-effective, but not very equitable, even though large part of the payments go to lower-income counties.

## 5.2 Research gaps and outlook

This section presents the main limitations of the work and from them develops further topics of research. The specific limitations involved in the three studies in Chapter 2 to 4 are discussed in detail in each of the chapters.

Some important limitations of the specific methodology used in the surveys in Chapter 2 and 3 are, however, worth mentioning. Surveys involving questions on ethical issues often involve some degree of bias due to e.g. the warm glow effect (Andreoni, 1990; Fischer and Hanley, 2007): Respondents may receive utility from the act of charitable giving itself and not (only) from the good for which they are spending money. The theoretical nature of the conducted choice experiments also involves some hypothetical bias (Rowe, d'Arge and Brookshire, 1990): Since respondents are not required to buy or really pay after the experiment, their stated valuation of the good can exceed their real WTP. But due to the more general and theoretical nature of the research questions in this thesis implementing theoretical experiments was the only available strategy. To reduce the effects of hypothetical bias cheap talk (Cummings and Taylor, 1999) was used in the surveys, whereby respondents were asked to make all their choices under consideration of their budget constraints, just as they would do this in a real



market decision. In future research real world experiments could give more practical insights into the fairness preferences of consumers when confronted with a real choice.

In Chapter 4 some data limitations were involved in the analysis of the distributional aspects of the Saxon grassland AES, where no farm-specific income data was available, but only regional average income values could be used. It would have been good to have spatial farm data to be able to more precisely discuss fairness of AES based on the maximin principle. If farm data in Germany is made available, similarly to Sweden (Nordin and Höjgård, 2018), this would facilitate many other research efforts and make the research results more accurate. Provided there is data available, a more thorough spatial analysis of different distributional or other fairness aspects together with cost-effectiveness in AES and PES could be developed in future research.

A more general limitation of the work is the restricted number of selected distributive fairness principles for the discussion of fairness issues. Including other fairness criteria in the analysis of fairness preferences for PES and AES could be a topic for further research. McDermott, Mahanty and Schreckenber (2013) create a multidimensional framework of equity analysis in PES and suggest that apart from distribution also procedural equity and local beneficiaries' culture, traditions and understanding of fairness (the contextual dimension of equity) have to be taken into account when implementing PES. Zafra-Calvo et al. (2017) extend the framework and operationalize it for the assessment of equity in protected areas.

In addition, this thesis focuses on the preferences of potential ES buyers – the demand side in PES and AES. Fairness perceptions of ES providers (the supply side in PES and AES) are another interesting research topic and have been discussed in e.g. Loft et al. (2017), who come to the conclusion that the fairness perceptions of PES participants in Vietnam depend very much on the context – the specific situation and the rules under which the PES is implemented. They show the importance of a holistic view and consideration of the possible multidimensional equity implications of PES schemes in practice. In their case study ES providers prefer a merit-system distribution, i.e. according to the equity or accountability principle. In other case studies, of a PES in Rwanda (Gross-Camp et al., 2012) and a PES in the Andes (Narloch et al., 2011), an equal distribution has been identified as the prevalent equity perception of the local population. Differences in fairness perceptions stemming from location and context are also confirmed by Martin et al. (2019).

Thus, the diversity of cultures, historical developments and contexts in which PES are implemented calls for a case to case consideration of the multidimensional fairness implications

(cf. McDermott, Mahanty and Schreckenberg, 2013) of schemes to better reflect local preferences. This can enhance the implementation and acceptance of PES schemes both in developed and developing countries (Palmer and Di Falco, 2012). Fairness perceptions of ES providers (e.g. farmers) in developed countries are not well studied and could be an interesting topic for further consideration. The preferences of ES buyers for fairness aspects versus cost-effectiveness in PES and AES (or other policy instruments) could also be considered for future research.

However, since preferences can be dynamic, an interesting question, which is not well researched, arises, namely: if and how different policy and payment design variations possibly affect or change the fairness preferences of ES buyers and ES providers. As suggested by Rode et al. (2015) introducing economic incentives for conservation, such as PES, where social norms are strong can have a detrimental impact on the intrinsic motivation of the local population for conservation. After all: *“Markets and other economic institutions do more than allocate goods and services; they also influence the evolution of values, tastes, and personalities (...). One risks banality, not controversy, in suggesting that these allocation rules therefore influence the process of human development, affecting personality, habits, tastes, identities, and values.”* (Bowles, 1998, pp. 75–76).

Martin et al. (2019) provide evidence for different fairness preferences of ES providers from three countries for monetary vs. non-monetary payments in the case of a possible PES for community forest conservation. In their study, the preferred principles for distribution of non-monetary forest benefits are egalitarian and pro-poor, whereas for monetary benefits accountability related principles (loss compensation and reward for contribution) are preferred. Thus, commodification of environmental resources through PES can change the fairness norms in a society and therefore it is necessary to look at the fairness implications of PES and AES from a broad perspective and to analyse possible effects prior to implementation.

In general, research on fairness in PES and AES is mainly focused on the fairness evaluation of specific case study PES implemented in practice and on the development of theoretical frameworks for fairness analysis (see Calvet-Mir et al (2015) for an overview of related studies).

The distributive implications and possibly other fairness aspects of different policy design variations of PES and AES, such as different payment designs (e.g. fixed payments vs. auctions, payment by result or action-related payments, targeted vs. non-targeted payments), are not that well researched. Exceptions include Narloch et al. (2011), who analyse the effect of selected

targeting approaches on the distributive fairness of a PES in the Andes, and Gauvin et al. (2010), who indicate that in the case of the SLCP in China the most cost-effective strategy is benefit-cost targeting, but targeting parcels for jointly maximizing the environmental and poverty alleviation benefits is only slightly less cost-effective. Another interesting question for further research with respect to payment designs are preferences of ES buyers and ES providers for the different payment designs.

In the literature the comparison of different payment designs in PES and AES is mainly based on the criterion of cost-effectiveness. The evidence on cost-effectiveness of different payment designs is mixed. In general, fixed action-related payments are considered less cost-effective than results-based payments or auctions (e.g. Klimek et al., 2008), or targeted payments (Wünscher et al., 2008). However, in the case of multiple environmental objectives (Uthes et al., 2010a), or potentially higher transaction costs (Klimek et al., 2008), fixed payments could be more cost-effective.

Thus, the role of transaction costs in the analysis of cost-effectiveness and distributive aspects in PES and AES is also a promising topic for future research, especially on the transaction costs of regionally differentiated payments. An overview of different transaction costs related to the CRP is provided by Lehmann (2005), Mettepenningen and Van Huylenbroeck (2009) identify factors influencing private transaction costs related to AES participation in Europe and Mettepenningen, Beckmann and Eggers (2011) discuss factors that determine public transaction costs in European AES. However, research on transaction costs in AES and PES especially in relation to different payment designs is rare and focuses more on a comparison of homogeneous payments with individual contract design, e.g. Hanley et al. (1998) and Moxey, White and Ozanne (1999). The regionalization of payments and measures in Chapter 4 brings significant cost-effectiveness improvements and seems quite simple to implement – only differentiating the payments and measures by region, it could be associated with low transaction costs. Whether this proposition is true, also keeping in mind the considerable redistribution effects, can be a topic for future research in the field.

Future research can also consider the implications of climate change for fairness aspects in PES and AES design. For instance, the fairness implications of a PES or AES can change, if climate change considerations are incorporated in PES and AES design (as suggested by Schöttker and Wätzold (2020)) by targeting strategies so that participation is only possible on specific climatically suitable or prioritized areas or is rewarded higher on these areas.

### 5.3 Policy recommendations and conclusions

Many specific policy recommendations are included in Chapter 2 to 4. Some more general conclusions and policy recommendations can be derived based on a joint consideration of the results of the different case studies in this thesis and are included below.

Successfully implementing separate policies for separate policy goals, as suggested by Tinbergen (1952) and propagated in economic literature, can be difficult, especially in developing countries, where governments are often weak (Rice and Patrick, 2008). But also in AES in developed countries fairness aspects could influence the acceptance and participation of farmers and can become important for the cost-effectiveness of the schemes. Therefore, considering poverty alleviation as a goal of PES together with effectiveness and cost-effectiveness and taking into account the fairness implications of AES in their design can be justified.

This thesis provides evidence that potential ES buyers in PES and AES have preferences for distributive fairness in the design of PES and AES. This is an argument in favour of a more thorough analysis of the distributive aspects and other fairness implications of such schemes, at best on a case to case basis. It also calls for more research on the public preferences for fairness versus cost-effectiveness of different public policies. A way to incorporate fairness preferences (not only distributional, but also e.g. environmental or intergenerational fairness) and find a justifiable compromise between different goals in public policy setting could be social multi-criteria evaluation, as suggested by Munda (2017). Thereby, the guiding principles of policy evaluation should be: interdisciplinary framework, considering social values and preferences, thorough investigation of distributive aspects and transparency of the evaluation process (Munda, 2017).

Since PES and AES are implemented in different cultural and developmental contexts, their multidimensional fairness implications have to be considered on a case to case basis to address local specificity and to design tailor-made schemes which reflect the preferences of ES buyers and ES providers and at the same time strive for cost-effectiveness.

In the studies conducted for this thesis citizens show preferences for animal welfare, small below-average income farms, and biodiversity conservation related to dairy farming and further developing AES in these directions seems appropriate, as well as investigating the related trade-offs with cost-effectiveness and potential ways to minimize them. It seems that a general farm support is only approved of in the citizen's own region, which implies that EU policies

providing direct financial support to (dairy) farms are inconsistent with public preferences and more emphasis should be put on agri-environmental policies.

To account for Rawlsian preferences (which based on the results of this thesis are important for potential ES buyers) and limit the direct payments for farmers in the EU, the payments in each Member State could be capped and scaled according to the size of the farm (smallest, small, medium, large) and in combination with an income parameter per worker (such as e.g. gross operating surplus+personnel costs/ per worker). This could be a better option than the proposed “reduction of payments as of €60,000 and compulsory capping for payments above €100,000 per farm” (where labour costs are taken fully into account) and “complementary redistributive income support for sustainability” in the European Commission (2018) suggestions for CAP post 2020. In combination with regional payment differentiation in AES this could also help to induce a more cost-effective and sustainable shift in the EU’s agricultural income support, much of which in Central and Western Europe is currently going to farms with low nature value and with high GHG emissions, as Scown, Brady and Nicholas (2020) suggest.

The thesis also shows that cost-effectiveness and distributional effects of AES on a supra-regional level can differ from the effects on regional level. Therefore, policy design and implementation of (spatially differentiated) AES and PES should take into account such differences and should be based on a thorough analysis of the joint cost-effectiveness and fairness implications.

As raising animal-welfare standards requires substantial investments in farm infrastructure, state support for small, below average income farms in this direction seems justifiable. A promising and more market-oriented measure for promoting animal-welfare in dairy farming and in general are labels and the successful implementation of a trustworthy state animal-welfare label should be stimulated. Labels by their nature can cover different objectives, such as animal-welfare, environmental protection and fairness to farmers, and can be an effective way of attainment for multiple goals. But as our results and other studies on ethical preferences (e.g. Pelsmacker et al, 2006; Ubilava et al, 2010) suggest labels for ethical attributes are more likely to reach socially aware and higher income individuals, and the importance of governmental policies like AES remains high.

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## A. Appendix to Chapter 3

### Overview of basic choice modelling approach

To investigate the trade-offs in milk preferences we use the stated-preference method choice experiments, which is based on Lancaster's (1966) characteristics theory of value and on random utility theory (McFadden and Train, 2000). According to the former, consumers' preferences relate to the different characteristics of a good and not directly to the good as a whole. According to the random utility theory, the utility  $U_{nsi}$  an individual  $n$  gets from an alternative  $i$  in a choice situation  $s$  involves an observable component  $V_{nsi}$  and a stochastic element  $\varepsilon_{nsi}$ , which is not observable to the researcher.

$$U_{nsi} = V_{nsi} + \varepsilon_{nsi} \quad (\text{A. 1})$$

The observable part of utility depends on the characteristics  $x_{nsi}$  of the alternative and/or of the respondent and the corresponding marginal utilities or weights  $\beta_n$  that respondents assign to them.

$$V_{nsi} = \beta_0 + \beta'_n x_{nsi} \quad (\text{A. 2})$$

where  $\beta_0$  represents an alternative-specific constant.

The general form of choice models is represented by Eqs. (A. 3) and (A. 4), where the probability of choosing an alternative  $i$  equals the probability that this alternative's utility is higher than the utility of any of the other  $(J-1)$  alternatives in a choice set (Hensher et al., 2015).

$$P_{nsi} = \text{Prob}(U_{nsi} \geq U_{nsj}, \forall i \neq j) = \text{Prob}(V_{nsi} + \varepsilon_{nsi} \geq V_{nsj} + \varepsilon_{nsj}, \forall i \neq j), j = 1, \dots, J \quad (\text{A. 3})$$

$$P_{nsi} = \frac{\exp(V_{nsi})}{\sum_{j=1}^J \exp(V_{nsj})} \quad (\text{A. 4})$$

Different choice models can be employed depending on the assumptions made on the distribution of the stochastic component  $\varepsilon_{nsi}$ . In a mixed logit model (MLM) the marginal utility parameter estimates are assumed to vary over all respondents with a predefined distribution (cf. Train, 2009), whereas in a latent class model (LCM) the parameter estimates are assumed to vary between classes of respondents (Boxall and Adamowicz, 2002).

The panel specification for LCM is shown in Eqs. (A. 5) and (A. 6) (based on Hensher et al., 2015), where  $c$  is the index for the estimated latent classes and  $y$  is the index of the observed choices.  $P_{nsi|c}$  is the probability of individual  $n$  choosing alternative  $i$  in choice situation  $s$  conditional on membership to class  $c$ .

$$P_{nsi|c} = \frac{\exp(V_{nsi|c})}{\sum_{j=1}^J \exp(V_{nsj|c})} \quad (\text{A. 5})$$

The probability of membership to class  $c$  ( $P_{nc}$ ) is estimated based on the observed utility component  $V_{nc} = \delta_c h_n$  from the class assignment model, where  $h_n$  are predefined respondents' characteristics which determine class membership.

$$P_{nc} = \frac{\exp(V_{nc})}{\sum_{c=1}^C \exp(V_{nc})}, \text{ where } V_{nc} = \delta_c h_n \quad (\text{A. 6})$$

## B. Appendix to Chapter 3

**Table B. 1 Percent of cows kept in tie- and free-stalls and provided with pasture access in Germany, in total and according to farm size (data from 2009 provided by the Federal Statistical Office Germany 2010).**

	Tie-stall	Free-stall	Access to pasture	% of cows
<b>According to farm size:</b>				
smallest farms (1-19 cows)	89.9%	8.4%	44.5%	6.0%
small farms (20-49 cows)	69.4%	30.1%	41.2%	24.9%
medium-sized farms (50-199 cows)	8.5%	91.2	50.6%	48.8%
large farms ( $\geq 200$ cows)	2.9%	95.6	16.6%	20.4%
<b>All farms</b>	<b>27.3%</b>	<b>72.0%</b>	<b>41.8%</b>	<b>100%</b>

*Note: In tie-stall systems cows are tethered and cannot move freely whereas in free-stalls they can move around the stall.*

**Table B. 2 Sample statistics.**

Quota sampling <sup>a</sup> based on:	Sample in %	(count)
<b>Gender</b>		
Male	42.5	(442)
Female	57.5	(598)
<b>Age (years)</b>		
18-29	15.1	(157)
30-39	14.7	(153)
40-49	18.1	(188)
50-59	18.8	(195)
$\geq 60$	33.4	(347)
<b>Highest level of education completed</b>		
No secondary general school-leaving certificate	0.4	(4)
Secondary general school-leaving certificate without apprenticeship qualification	5.7	(59)
Secondary general school-leaving certificate with apprenticeship qualification	33.0	(343)
Intermediate school-leaving certificate	31.4	(327)
University/ polytechnic entrance qualification	14.5	(151)
Higher education (university/ polytechnic)	15.0	(156)
<b>Settlement size (population numbers)</b>		
1-4.999	14.3	(149)
5.000-19.999	26.2	(272)
20.000-99.999	27.7	(288)
$\geq 100.000$	31.8	(331)
<b>Sample size (count)</b>	<b>1040</b>	

**Table B. 3 Information on attributes and levels used in the text of the survey.**

Information pertaining to the characteristics and production processes involved in the different milk alternatives, which you will see in the next survey section.	
<ul style="list-style-type: none"> <li>Animal welfare/ Housing system of dairy cows</li> </ul>	<p>This characteristic of the milk alternatives shows how appropriate the housing system is for the species. In Germany about one fourth of the milk cows are kept in tie-stalls, 42% of all dairy cows have access to pasture.</p> <ul style="list-style-type: none"> <li>Tie-stall, i.e. the dairy cows cannot walk around, but just stay up or lie</li> <li>Tie-stall with summer pasture, i.e. the dairy cows cannot walk around in the stall, but they are kept on pasture during summer</li> <li>Free-stall, i.e. the dairy cows can walk around in the stall, but not outside</li> <li>Free-stall with summer pasture, i.e. the dairy cows can move around all year round in the stall and in summer also on the pasture field</li> </ul>
<ul style="list-style-type: none"> <li>Biodiversity conservation – Effect of the milk production on the protection of endangered species, especially birds, which breed on pastures and meadows, but also on butterflies and other insects.</li> </ul>	<p>Irrespective of the housing system used (e.g. if pasture access is provided or not) milk farmers can aid biodiversity conservation by e.g. longer intervals between cuts and by mowing outside the breeding times of meadow birds, and by reduced use of fertilizer and concentrated feed. Thus, milk production can have the following effect on endangered species:</p> <ul style="list-style-type: none"> <li>Good for biodiversity conservation– many endangered species get protected</li> </ul> <p>e.g. through reduced use of mineral fertilizer and a differentiated meadow and pasture management that is oriented at protecting many different endangered species – such as ensuring no cut during the reproductive period of meadow birds.</p> <ul style="list-style-type: none"> <li>No special biodiversity conservation – loss of biodiversity is not mitigated</li> </ul> <p>e.g. in the case of intensive grassland management without fertilizer use restrictions and with high input of concentrated feed, such as grain, maize and soy</p>
<ul style="list-style-type: none"> <li>Support for milk farms – fair prices to producers</li> </ul>	<p>To ensure that milk farmers get sufficient income, a specific part of the end price of milk (e.g. 10 Cent per litre) can go to a special fund for the support of either all milk farms or of only small milk farms with below-average income.</p> <ul style="list-style-type: none"> <li>Support for all milk farms</li> <li>Support for small milk farms with below-average income</li> <li>No support</li> </ul>
<ul style="list-style-type: none"> <li>Origin of the milk – through regional/local production transport distances are shortened and regional enterprises are supported</li> </ul>	<ul style="list-style-type: none"> <li>From your region (within a radius of max. 40 km)</li> <li>From Germany</li> </ul>
<ul style="list-style-type: none"> <li>Price per litre – 0.60 €; 0.78 €; 0.96 €; 1.14 €; 1.32€</li> </ul>	

**Table B. 4 Overview of variables used in the presented choice models.**

<b>Variable</b>	<b>Meaning</b>	<b>Coding</b>
<b>Attributes</b>		
Free-stall+pasture	Free-stall+summer pasture	1, if yes, -1, if tie-stall, 0, otherwise
Free-stall	Free-stall	1, if yes, -1, if tie-stall, 0, otherwise
Tie-stall+pasture	Tie-stall+summer pasture	1, if yes, -1, if tie-stall, 0, otherwise
Biodiversity conservation	Biodiversity conservation	1, if yes -1, if no
Support small farms	Support for small farms with below-average income	1, if yes, 0, if support for all farms, -1, if no support
Support all farms	Support for all farms	1, if yes, 0, if support for small farms, -1, if no support
Regional milk	Regional milk	1, if yes -1, if no
Price	Price in € per litre	0.60, 0.78, 0.96, 1.14, 1.32
<b>Alternative-specific constants (ASC)</b>		
A-ASC	ASC for the A-Alternative	1, for A-alternative 0, otherwise
SQ-ASC	ASC for the lowest fixed-price alternative	1, for fixed alternative 0, otherwise
NO-ASC	ASC for the ‘no-buy’ alternative	1, for ‘no-buy’ alternative 0, otherwise
<b>Covariates</b>		
Gender	Female Male	1, if female 0, if male
BuyerOrg	Frequent organic milk buyers	1, if yes 0, if no
SQPlow ‘cheapest-milk buyers’	Buyers with lowest currently paid price (0.60 € – 0.69 € per litre)	1, if yes 0, if no
SQP70	Buyers with currently paid price between 0.70 € – 0.79 € per litre	1, if yes 0, if no
SQPhigh	Buyers with high currently paid price ( $\geq 1.00$ € per litre)	1, if yes 0, if no
Friendfarm	Buyers having a farmer as friend or family member	1, if yes 0, if no
DonAnimal	Buyers having donated to animal protection in the last two years	1, if yes 0, if no

**Table B. 5 Results of panel mixed logit model.**

Attribute		Marginal utility	Standard error	95% Confidence interval	
Random parameters in utility functions					
Free-stall+pasture		1.15***	0.08	1.00	1.31
Free-stall		-0.11**	0.06	-0.23	0.00
Tie-stall+pasture		0.35***	0.07	0.22	0.48
Tie-stall <sup>a</sup>		-1.39			
Biodiversity conservation		0.43***	0.04	0.35	0.51
No special biodiversity conservation <sup>a</sup>		-0.43			
Support small farms		0.31***	0.08	0.16	0.47
Support all farms		-0.10	0.06	-0.22	0.03
No support <sup>a</sup>		-0.21			
Regional milk		0.13**	0.05	0.02	0.23
From Germany <sup>a</sup>		-0.13			
Tie-stall+pasture*Support small farms		0.40***	0.15	0.10	0.70
Tie-stall*Support small farms		0.40***	0.15	0.10	0.71
Regional milk*Support small farms		-0.12	0.13	-0.38	0.14
Nonrandom parameters in utility functions					
Regional milk*Support all farms		0.62***	0.15	0.33	0.91
Price		-4.77***	0.18	-5.13	-4.42
A-ASC		-0.33***	0.06	-0.44	-0.21
SQ-ASC		-1.21***	0.11	-1.41	-1.00
NO-ASC		-6.39***	0.20	-6.79	-6.00
Standard deviation of random parameters					
NsFree-stall+pasture		1.59***	0.08	1.43	1.75
NsFree-stall		0.52***	0.11	0.30	0.75
NsTie-stall+pasture		0.89***	0.08	0.74	1.05
NsBiodiversity conservation		0.88***	0.04	0.80	0.97
NsSupport small farms		1.09***	0.06	0.97	1.21
NsSupport all farms		0.39***	0.07	0.26	0.53
NsRegional milk		0.51***	0.05	0.42	0.61
NsTie-stall+pasture*Support small farms		1.22***	0.22	0.78	1.65
NsTie-stall*Support small farms		1.02***	0.22	0.58	1.45
NsRegional milk*Support small farms		0.83***	0.17	0.50	1.17
Goodness of fit					
Number of respondents	1,040				
Number of observations	8,320				
Log-likelihood	-7,521.17				
McFadden Pseudo-R <sup>2</sup>	34.79%				
BIC	15,267.99				
CAIC	15,292.99				
AIC (normalized)	1.81				

Note: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%.

<sup>a</sup>The utility parameters of the effects-coded base levels are calculated as the negative sum of the estimates for the other levels (Cooper et al., 2012).

## Appendix

**Table B. 6 a. Results from latent class model with class membership function.**

Class	Class 1 - ‘organic, regional, animal and farmer fairness milk buyers’			Class 2 - ‘highest animal welfare, biodiversity and regional milk buyers’			Class 3 - ‘lower income, price sensitive milk buyers with preferences for animal and farmer fairness’			Class 4 - ‘lower income, cheapest-milk buyers with no WTP for ethical attributes’			Class 5 - ‘animal and farmer fairness milk buyers’		
Attribute	Marg. utility	95% Confidence interval		Marg. utility	95% Confidence interval		Marg. utility	95% Confidence interval		Marg. utility	95% Confidence interval		Marg. utility	95% Confidence interval	
Utility parameters															
Free-stall+pasture	1.35***	1.19	1.51	1.74***	1.50	1.98	0.69**	0.16	1.23	-0.51	-176.36	175.33	0.68***	0.46	0.90
Free-stall	-0.30***	-0.45	-0.16	0.17	-0.08	0.42	-0.05	-0.42	0.31	3.53	-178.55	185.61	-0.10	-0.27	0.07
Tie-stall+pasture	0.39***	0.21	0.56	0.16	-0.13	0.44	0.11	-0.18	0.41	-1.77	-119.83	116.29	0.29***	0.12	0.46
Tie-stall <sup>a</sup>	-1.44			-2.07			-0.75			-1.25			-0.87		
Biodiversity conservation	0.55***	0.44	0.67	0.63***	0.49	0.76	0.14	-0.06	0.34	-1.37	-61.58	58.84	0.41***	0.32	0.50
No special biodiversity conservation <sup>a</sup>	-0.55			-0.63			-0.14			1.37			-0.41		
Support small farms	0.46***	0.29	0.62	0.22	-0.06	0.49	-0.28	-0.88	0.31	2.80	-5042	5048	0.33***	0.10	0.56
Support all farms	0.00	-0.17	0.17	-0.02	-0.30	0.26	0.31	-0.13	0.75	0.09	-5459	5459	-0.19**	-0.38	0.00
No support <sup>a</sup>	-0.46			-0.20			-0.03			-2.89			-0.14		
Regional milk	0.24***	0.09	0.38	0.22*	-0.01	0.46	0.12	-0.15	0.38	3.35	-7971	7977	0.04	-0.11	0.20
From Germany <sup>a</sup>	-0.24			-0.22			-0.12			-3.35			-0.04		
Price	-0.79***	-1.25	-0.33	-3.87***	-4.67	-3.07	-11.53***	-13.46	-9.60	-12.97	-1391	1365	-6.68***	-7.27	-6.09
Tie-stall+pasture *Support small farms	0.42**	0.07	0.78	0.82***	0.25	1.39	1.10**	0.08	2.13	8.62	-442.16	459.41	0.03	-0.40	0.47
Tie-stall*Support small farms	0.28	-0.10	0.65	-0.06	-1.19	1.06	1.01*	-0.11	2.12	-4.47	***** **	52993	0.56**	0.10	1.01
Regional milk*Support small farms	0.20	-0.12	0.53	-0.40	-1.01	0.20	0.14	-0.60	0.88	-7.64	***** **	15788	0.00	-0.37	0.37
Regional milk*Support all farms	0.17	-0.24	0.58	0.60	-0.14	1.33	-0.13	-1.01	0.74	4.36	***** **	16317	0.63**	0.07	1.18
SQ-ASC	-2.94***	-4.03	-1.85	-2.94***	-5.05	-0.82	-1.44***	-2.03	-0.85	11.46	-15949	15972	-3.05***	-3.37	-2.73
NO-ASC	-3.93***	-4.51	-3.36	-3.17***	-3.90	-2.44	-13.03***	-14.59	-11.47	-7.76	-2310	2294	-9.86***	-10.61	-9.12
A-ASC	-0.27***	-0.43	-0.11	-0.26	-0.59	0.08	-0.12	-0.53	0.28	-3.82	-272.92	265.28	-0.19**	-0.37	-0.01

Note: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%. Fixed parameter is constrained to equal the value.

<sup>a</sup>The utility parameters of the effects-coded base levels are calculated as the negative sum of the estimates for the other levels (Cooper et al., 2012).

**Table B. 6 a. Results from latent class model with class membership function (continued).**

Class	Class 1 - 'organic, regional, animal and farmer fairness milk buyers'			Class 2 - 'highest animal welfare, biodiversity and regional milk buyers'			Class 3 - 'lower income, price sensitive milk buyers with preferences for animal and farmer fairness'			Class 4 - 'lower income, cheapest-milk buyers with no WTP for ethical attributes'			Class 5 - 'animal and farmer fairness milk buyers'	
Class membership function parameters	Coefficient	95% Confidence interval		Coefficient	95% Confidence interval		Coefficient	95% Confidence interval		Coefficient	95% Confidence interval		Coefficient	95% Confidence interval
Constant	-0.69***	-1.17	-0.20	-1.58***	-2.16	-1.01	-2.16***	-3.13	-1.19	3.32***	-4.86	-1.78	0.00	(Fixed Parameter)
Gender	0.89***	0.47	1.32	0.73***	0.23	1.23	-0.15	-0.71	0.40	-0.33	-0.83	0.17	0.00	(Fixed Parameter)
BuyerOrg	0.93**	0.13	1.72	0.61	-0.40	1.61	0.46	-7.13	8.04	-5.68	-4008	3997	0.00	(Fixed Parameter)
SQPlow	-0.60**	-1.17	-0.02	0.08	-0.61	0.77	2.30***	1.30	3.29	3.97***	2.41	5.54	0.00	(Fixed Parameter)
SQP70	-0.056*	-1.13	0.02	-0.10	-0.77	0.57	0.95*	-0.12	2.01	1.70**	0.04	3.35	0.00	(Fixed Parameter)
SQPhigh	1.79***	1.16	2.42	1.17***	0.41	1.93	-0.44	-8.12	7.24	1.77*	-0.10	3.64	0.00	(Fixed Parameter)
Friendfarm	-0.41	-0.94	0.12	0.27	-0.28	0.82	-0.69*	-1.44	0.07	-0.72**	-1.39	-0.06	0.00	(Fixed Parameter)
DonAnimal	0.91***	0.23	1.60	0.84**	0.08	1.59	-0.33	-1.60	0.94	-2.22**	-4.32	-0.11	0.00	(Fixed Parameter)

Note: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%. Fixed parameter is constrained to equal the value.

<sup>a</sup>The utility parameters of the effects-coded base levels are calculated as the negative sum of the estimates for the other levels (Cooper et al., 2012).

**Table B. 6 b. Results for goodness of fit from latent class model with class membership function.**

Indicator	Value
Number of respondents	1,040
Number of observations	8,320
Log-likelihood	-5,999.60
McFadden Pseudo-R <sup>2</sup>	47.98%
BIC	12,965.02
CAIC	13,072.02
AIC(normalized)	1.47

**Table B. 7 Different characteristics and LCM class membership of milk buyers in the sample.**

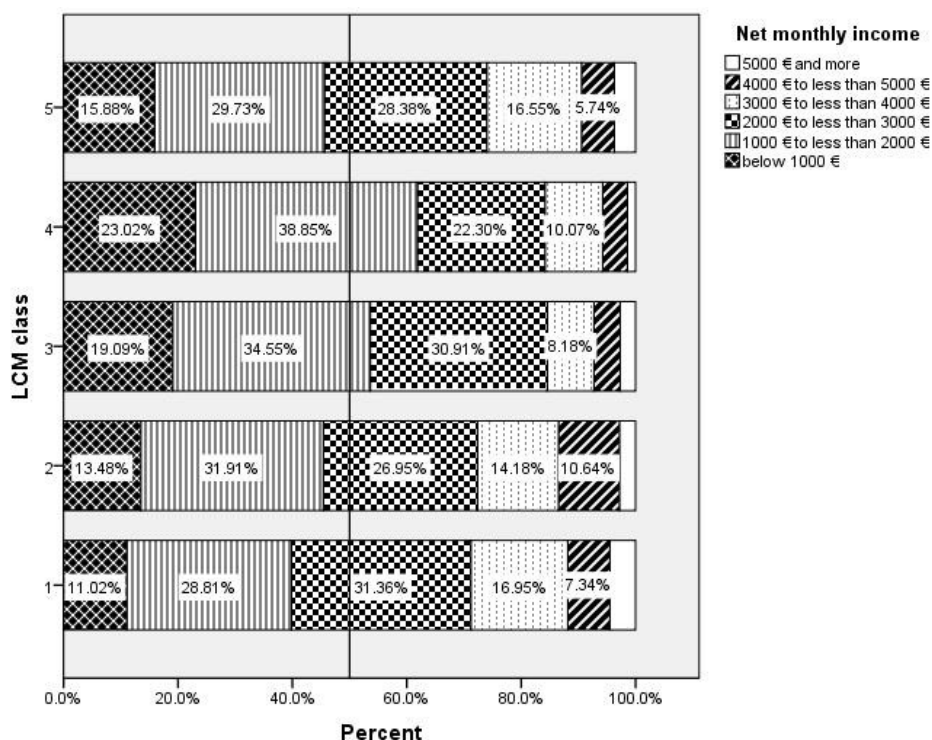
LCM class		Category						Count in class and as % of respondents
		Female	Frequent organic milk buyers	Frequent pasture milk buyers	Donors for animal protection	Donors for environmental protection	Having farmer as family or friend	
<b>1</b>	Count	245	71	78	62	49	62	354
	% within class	69.2%	20.1%	22.0%	17.5%	13.8%	17.5%	34.0%
	% within category	41.0%	71.0%	49.1%	54.4%	56.3%	31.2%	
<b>2</b>	Count	95	15	22	25	16	40	141
	% within class	67.4%	10.6%	15.6%	17.7%	11.3%	28.4%	13.6%
	% within category	15.9%	15.0%	13.8%	21.9%	18.4%	20.1%	
<b>3</b>	Count	53	2	10	5	5	14	110
	% within class	48.2%	1.8%	9.1%	4.5%	4.5%	12.7%	10.6%
	% within category	8.9%	2.0%	6.3%	4.4%	5.7%	7.0%	
<b>4</b>	Count	61	0	12	1	2	18	139
	% within class	43.9%	0.0%	8.6%	0.7%	1.4%	12.9%	13.4%
	% within category	10.2%	0.0%	7.5%	0.9%	2.3%	9.0%	
<b>5</b>	Count	144	12	37	21	15	65	296
	% within class	48.6%	4.1%	12.5%	7.1%	5.1%	22.0%	28.5%
	% within category	24.1%	12.0%	23.3%	18.4%	17.2%	32.7%	
<b>Total</b>	Count	598	100	159	114	87	199	1040
Count in category as % of respondents		57.5%	9.6%	15.3%	11.0%	8.4%	19.1%	



**Table B. 8 Ranking comparison of the LCM classes based on tests for statistical significance of differences.**

Category/ LCM class characteristics	Lowest to Highest				
WTP values	Class 4	Class 3	Class 5	Class 2	Class 1
Mean monthly net household income <sup>a</sup>	Class 3 and 4		Class 1, 2 and 5		
Mean education level	Class 4	Class 1, 2, 3 and 5			
Mean milk consumption	Class 1, 2, 3 and 5				Class 4
Mean meat consumption per week	Class 1	Class 2	Class 3, 4 and 5		
Attitude to agriculture in general	Class 4	Class 3	Class 2 and 5		Class 1
Importance of ethical issues in buying decisions (fair production, regional production, climate protection, environmental and nature protection, animal welfare)	Class 4	Class 3	Class 5	Class 2	Class 1
Importance of price in buying decisions	Class 1 and 2		Class 5	Class 3	Class 4
Importance of cows' welfare (freedom to move and pasture access)	Class 4	Class 3	Class 5	Class 1 and 2	
Importance of farmers' fairness (support/ fair prices to farmers)	Class 4	Class 3	Class 2 and 5		Class 1

Note: <sup>a</sup>Paired-classes income comparisons show that the mean income in class 1 is higher than in class 3 and 4, but not higher than that of class 2, and only on the 10% significance level higher than the mean income of class 5. There is no statistical difference in income between classes 2 and 5. Mean income is, however, lower in class 3 and class 4.

**Figure B. 1 Net monthly income vs. LCM class.**

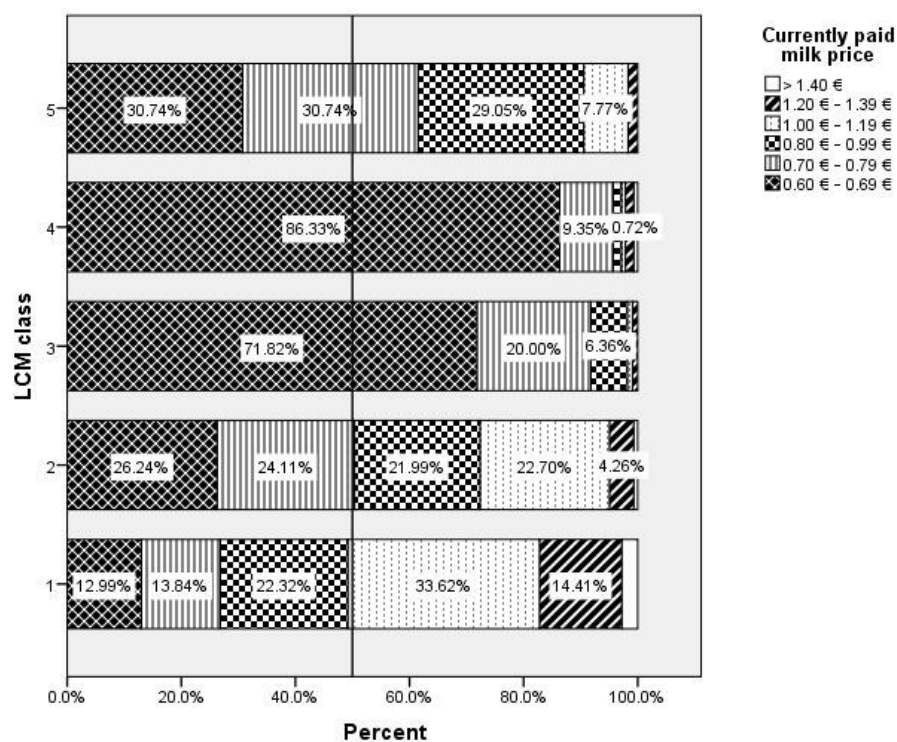


Figure B. 2 Currently paid milk price vs. LCM class.

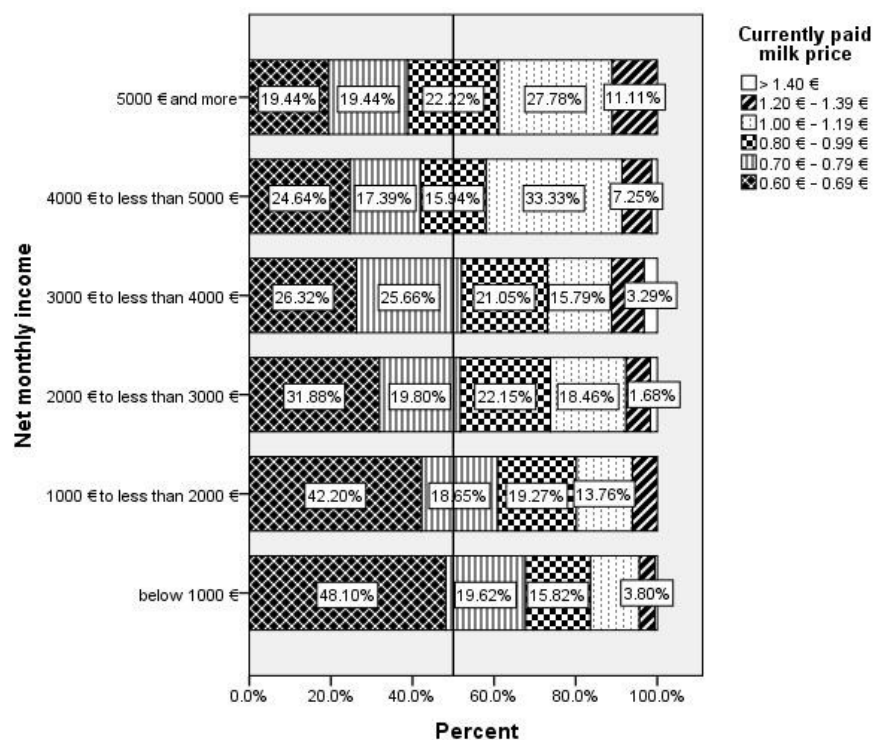


Figure B. 3 Currently paid milk price vs. net monthly income.

## C. Appendix to Chapter 4

### Tables:

**Table C. 1 Measures according to Directive “Agricultural environmental measures and forestation” (Directive AuW/2007), part A, section G , “Extensive grassland use, nature conforming grassland management and conservation” (modified from Wätzold et al. 2016).**

Name of measure and main requirements <sup>1</sup>	Payment per ha in € <sup>1</sup>	Size of area for this measure in 2013 in ha <sup>2</sup>	Overall expenses for this measure in 2013 in € <sup>2</sup>
G1a (extensive grassland management pasture) <sup>3</sup> use of pasture or of pasture with early mowing, minimum (maximum) stocking rate of 0.3 (1.4) grazing livestock unit per ha (GLU/ha), maximum input of liquid manure not to exceed 1.4 LU/ha per annum, N fertilizer restriction according to EC 834/2007	108	23,734	2,563,272
G1b (extensive grassland management meadow) extensive meadow, use of pasture allowed after 15 August (maximum stocking rate 1.4 GLU/ha), maximum input of liquid manure not to exceed 1.4 LU/ha per annum, N fertilizer restriction according to EC 834/2007	108	6,265	676,620
G2 (conservation-enhancing meadow use; no fertiliser before mowing, 15 June) first mowing not allowed before 15 June (grazing only allowed after 1 August), no application of N fertilizer before first mowing	312	3,092	964,704
G3a (conservation-enhancing meadow use; general ban on fertiliser, 15 June) first mowing not allowed before 15 June (grazing only allowed after 1 August), complete ban on application of N fertilizer	373	11,417	4,258,541
G3b (conservation-enhancing meadow use; general ban on fertiliser, 15 July) first mowing not allowed before 15 July (grazing only allowed after 1 September), complete ban on application of N fertilizer	394	3,105	1,223,370
G5 (conservation-enhancing meadow use; ban on fertilizer, temporary halt of utilization) <sup>4</sup> minimum two mowings per year, completion of first mowing not after 10 June, second mowing not before 15 September, complete ban on application of N fertilizer	392	805	315,560
G6 (conservation-enhancing grazing, late beginning) minimum period of grazing each year with minimum stocking rate 0.3 GLU/ha, beginning of grazing not before 1 June, complete ban on application of N fertilizer	190	4,701	893,190
G9 (establishment of fallow land/strips on grassland) mowing and clearing of cut grass between 15 August and 15 November at least every two years, measure is only supported if (agriculturally used) grassland is adjacent, minimum size of 0.1 ha, maximum size of 2 ha, complete ban on application of N fertilizer	536	368	197,248

**Note:** Overall budget spent on the above measures: 11,092,505 €

<sup>1</sup> Information and data from Saxon State Ministry of the Environment and Agriculture (2015)

<sup>2</sup> Data from Saxon State Ministry of the Environment and Agriculture (2014b, p.50)

<sup>3</sup> Since this measure prescribes either pasture or pasture with mowing, in the simulation it is divided into two land use measures.

<sup>4</sup> Since this measure prescribes two flexible time limits in the simulation it is divided into two land use measures with different mowing times.

**Table C. 2 Ecological effectiveness of the Saxon grassland AES – results of the simulation, the optimization and the regional optimization**

<b>Species or Habitat types</b>	<b>Simulation <math>A_j^{eff}</math> in ha</b>	<b>Statewide optimization <math>A_j^{eff}</math> in ha</b>	<b>Regional optimization <math>A_j^{eff}</math> in ha</b>
<b>Birds</b>			
Black Grouse	12 139.77	13 847.09	18 208.59
Corncrake	4 618.03	20 117.37	18 709.76
Crested Lark	0.00	0.00	0.00
Curlew	7 014.24	3 417.95	7 067.10
Garganey	434.62	0.00	168.59
Hoopoe	762.49	17.79	1 398.82
Lapwing	11 618.22	20 401.44	23 449.90
Meadow Pipit	46 921.47	51 412.36	64 607.56
Partridge	16 715.04	24 138.54	28 057.03
Redshank	11 378.51	18 698.35	21 545.56
Skylark	8 615.30	16 816.79	19 395.99
Snipe	3 031.74	596.37	2 201.72
Whinchat	31 481.10	36 877.50	44 659.95
<b>Butterflies</b>			
Amanda's Blue	0.00	0.00	0.00
Chestnut Heath	21.96	13.23	102.57
Dingy Skipper	0.00	0.00	0.00
Dusky Large Blue	0.00	25.39	7.04
Five-spot Burnet	7.30	0.00	33.35
Glanville Fritillary	0.00	0.00	0.00
Large Wall Brown	0.00	0.00	0.00
Marsh Fritillary	0.65	0.00	0.65
Mazarine Blue	0.00	0.00	0.00
Purple-edged Copper	2.36	0.00	88.71
Scarce Large Blue	0.00	0.00	0.00
Silver-spotted Skipper	0.00	0.00	0.00
Small Blue	0.00	0.00	0.00
Woodland Ringlet	13.31	0.00	88.06
<b>Habitat types</b>			
Alluvial meadows	612.50	867.55	428.29
Lowland hay meadows	1 840.14	822.41	0.00
Molinia meadows	0.00	0.00	0.00
Mountain hay meadows	836.35	3 157.33	3 362.31
Nardus grassland	0.00	0.00	0.00
Semi-natural dry grassland	0.00	0.00	0.00
Wet meadows	515.63	218.75	1 759.38
<b>Total achieved effective area <math>A_{tot}^{eff}</math> *</b>	<b>158 580.71</b>	<b>211 446.21</b>	<b>255 340.91</b>
<b>% of all targeted species covered</b>	<b>62%</b>	<b>50%</b>	<b>62%</b>
<b>Subtotal <math>A_{birds}^{eff}</math></b>	<b>154 730.52</b>	<b>206 341.55</b>	<b>249 470.56</b>
<b>% of targeted species covered</b>	<b>92%</b>	<b>85%</b>	<b>92%</b>
<b>Subtotal <math>A_{butterflies}^{eff}</math></b>	<b>45.58</b>	<b>38.62</b>	<b>320.37</b>
<b>% of targeted species covered</b>	<b>36%</b>	<b>14%</b>	<b>43%</b>
<b>Subtotal <math>A_{habitats}^{eff}</math></b>	<b>3 804.61</b>	<b>5 066.04</b>	<b>5 549.98</b>
<b>% of targeted species covered</b>	<b>57%</b>	<b>57%</b>	<b>43%</b>
<b>Total participating area in ha</b>	<b>57 281.25</b>	<b>64 175.00</b>	<b>79 912.50</b>

*Note:* \* equals the sum of column values

**Table C. 3 Results from the simulation, the statewide optimization and the regional optimization of the Saxon AES (10, 7 and 10 measures resp.)**

Measure code*/ Measure ID	Run	Participating area per measure and region			Total part. area per measure in ha	$A_{tot}^{eff}$ per measure and region			$A_{tot}^{eff}$ per measure	Mean payment $P_{mean}$			Mean producer surplus $PS_{mean}$		
		region 1	region 2	region 3		region 1	region 2	region 3		region 1	region 2	region 3	region 1	region 2	region 3
Mowing 23/6/01, LU 0/ 96	simul	812.50	1 043.75	1 225.00	3 081.25	3 832.16	5 168.89	7 275.90	16 276.96	312	312	312	250.04	250.07	256.97
	opti10	-	-	437.50	437.50	-	-	2 556.18	2 556.18	-	-	535	-	-	262.13
	regopti10	-	-	3 556.25	3 556.25	-	-	21 363.45	21 363.45	-	-	304	-	-	27.09
<b>Mowing 19/16/00, LU 2/ 3410</b>	simul	293.75	12.50	75.00	381.25	883.66	39.17	245.91	1 168.74	392	392	392	192.76	192.76	192.76
	regopti10	-	293.75	237.50	531.25	-	892.23	778.91	1 671.15	-	631	372	-	275.99	59.02
Mowing 21/14/00, LU 2/ 3413	simul	262.50	6.25	131.25	400.00	1 016.21	25.96	553.95	1 596.12	392	392	392	191.83	192.22	190.98
	opti10	818.75	-	3 793.75	4 612.50	3 308.47	-	15 196.11	18 504.59	631	-	631	321.71	-	338.26
	regopti10	-	-	687.50	687.50	-	-	2 735.04	2 735.04	-	-	351	-	-	10.33
<b>Mowing 19/6/60, LU 2/ 3439</b>	simul	2 031.25	2 993.75	1 231.25	6 256.25	2 682.17	4 136.33	1 637.61	8 456.10	108	108	108	51.19	51.63	51.40
	regopti10	-	-	1 806.25	1 806.25	-	-	2 379.58	2 379.58	-	-	401	-	-	40.47
Mowing 23/6/60, LU 2/ 3503	simul	-	6.25	11 193.75	11 200.00	-	30.11	51 977.79	52 007.90	-	373	373	-	299.59	302.63
	opti10	-	-	4 281.25	4 281.25	-	-	20 025.59	20 025.59	-	-	374	-	-	5.09
	regopti10	-	18.75	2 675.00	2 693.75	-	93.85	12 185.47	12 279.32	-	465	405	-	68.16	50.91
<b>Mowing 27/6/60, LU 2/ 3550</b>	simul	2 118.75	31.25	931.25	3 081.25	13 475.48	186.24	6 058.41	19 720.13	394	394	394	290.53	285.76	288.56
	regopti10	756.25	506.25	2 406.25	3 668.75	5 071.95	3 175.68	17 426.56	25 674.19	432	747	449	39.66	315.98	74.04
Rotational grazing 19/6/62, LU 101/ 3610	simul	1 900.00	2 093.75	3 500.00	7 493.75	2 779.26	2 844.47	4 656.19	10 279.92	108	108	108	38.67	45.03	37.95
	opti10	2 425.00	4 818.75	4 293.75	11 537.50	3 442.06	6 636.02	5 742.71	15 820.79	157	157	157	112.64	123.78	111.58
	regopti10	1 768.75	3 875.00	2 381.25	8 025.00	2 620.77	5 408.92	3 182.31	11 212.00	49	157	49	11.19	128.37	9.37
Rotational grazing 21/6/62, LU 101/ 3642	simul	625.00	2 668.75	1 393.75	4 687.50	1 081.32	4 972.74	3 149.31	9 203.37	190	190	190	137.51	137.18	138.38
	opti10	193.75	-	1 081.25	1 275.00	390.88	-	2 850.97	3 241.85	163	-	163	127.28	-	129.91
	regopti10	-	943.75	7 768.75	8 712.50	-	1 707.77	20 332.10	22 039.87	-	163	52	-	105.21	7.81
Mowing & pasture comb. 19/6/62, LU 101/ 3739	simul	2 093.75	11 056.25	3 037.50	16 187.50	2 977.07	15 652.11	3 979.75	22 608.93	108	108	108	13.48	12.58	12.88
	opti10	925.00	1 800.00	468.75	3 193.75	1 353.82	2 419.56	617.54	4 390.92	236	236	236	164.97	164.97	164.97
	regopti10	2 381.25	-	11 556.25	13 937.50	3 362.63	-	15 456.42	18 819.05	89	-	94	13.86	-	8.22
Mowing strips 19/6/6 1, LU 2/ 3922	simul	362.50	3 893.75	256.25	4 512.50	1 253.58	15 048.51	960.45	17 262.53	79	79	79	113.93	120.34	112.84
	opti10	13 450.00	18 300.00	7 087.50	38 837.50	49 343.61	69 866.59	27 696.09	146 906.29	89	89	89	110.66	119.59	111.39
	regopti10	13 512.50	17 500.00	5 281.25	36 293.75	49 590.21	66 970.23	20 606.82	137 167.27	15	89	15	37.13	120.12	39.12
<b>Totals per region</b>	<b>simul</b>	<b>10 500.00</b>	<b>23 806.25</b>	<b>22 975.00</b>	<b>57 281.25</b>	<b>29 980.91</b>	<b>48 104.52</b>	<b>80 495.28</b>	<b>158 580.71</b>	<b>200.42</b>	<b>122.06</b>	<b>266.78</b>	<b>119.87</b>	<b>62.93</b>	<b>194.46</b>
	<b>opti10</b>	<b>17 812.50</b>	<b>24 918.75</b>	<b>21 443.75</b>	<b>64 175.00</b>	<b>57 838.86</b>	<b>78 922.16</b>	<b>74 685.19</b>	<b>211 446.21</b>	<b>131.61</b>	<b>112.77</b>	<b>271.45</b>	<b>123.63</b>	<b>123.68</b>	<b>135.52</b>
	<b>regopti10</b>	<b>18 418.75</b>	<b>23 137.50</b>	<b>38 356.25</b>	<b>79 912.50</b>	<b>60 645.57</b>	<b>78 248.69</b>	<b>116 446.65</b>	<b>255 340.91</b>	<b>44.95</b>	<b>124.99</b>	<b>156.04</b>	<b>31.73</b>	<b>127.11</b>	<b>23.19</b>

Table C. 3 continued

Measure code*/ Measure ID	Run	Budget per measure and region			Total budget per measure	PS per measure and region			Total PS per measure
		region 1	region 2	region 3		region 1	region 2	region 3	
Mowing 23/6/01, LU 0/ 96	simul	253 500.00	325 650.00	382 200.00	961 350.00	203 159.59	261 015.21	314 791.32	778 966.11
	opti10	-	-	234 062.50	234 062.50	-	-	114 682.88	114 682.88
	regopti10	-	-	1 081 100.00	1 081 100.00	-	-	96 334.16	96 334.16
<b>Mowing 19/16/00, LU 2/ 3410</b>	simul	115 150.00	4 900.00	29 400.00	149 450.00	56 621.78	2 409.44	14 456.63	73 487.84
	regopti10	-	185 356.25	88 350.00	273 706.25	0.00	81 073.24	14 016.86	95 090.10
Mowing 21/14/00, LU 2/ 3413	simul	102 900.00	2 450.00	51 450.00	156 800.00	50 356.34	1 201.38	25 066.63	76 624.34
	opti10	516 631.25	-	2 393 856.25	2 910 487.50	263 403.29	-	1 283 280.09	1 546 683.38
	regopti10	-	-	241 312.50	241 312.50	-	-	7 104.18	7 104.18
<b>Mowing 19/6/60, LU 2/ 3439</b>	simul	219 375.00	323 325.00	132 975.00	675 675.00	103 981.54	154 558.61	63 288.97	321 829.12
	regopti10	-	-	724 306.25	724 306.25	-	-	73 094.81	73 094.81
Mowing 23/6/60, LU 2/ 3503	simul	-	2 331.25	4 175 268.75	4 177 600.00	-	1 872.41	3 387 538.15	3 389 410.56
	opti10	-	-	1 601 187.50	1 601 187.50	-	-	21 803.01	21 803.01
	regopti10	-	8 718.75	1 083 375.00	1 092 093.75	-	1 278.01	136 186.94	137 464.95
<b>Mowing 27/6/60, LU 2/ 3550</b>	simul	834 787.50	12 312.50	366 912.50	1 214 012.50	615 565.59	8 930.09	268 720.01	893 215.69
	regopti10	326 700.00	378 168.75	1 080 406.25	1 785 275.00	29 993.50	159 964.64	178 166.52	368 124.66
Rotational grazing 19/6/62, LU 101/ 3610	simul	205 200.00	226 125.00	378 000.00	809 325.00	73 468.33	94 272.02	132 835.66	300 576.01
	opti10	380 725.00	756 543.75	674 118.75	1 811 387.50	273 153.36	596 477.44	479 108.94	1 348 739.74
	regopti10	86 668.75	608 375.00	116 681.25	811 725.00	19 785.74	497 452.70	22 318.38	539 556.82
Rotational grazing 21/6/62, LU 101/ 3642	simul	118 750.00	507 062.50	264 812.50	890 625.00	85 946.69	366 101.92	192 868.73	644 917.34
	opti10	31 581.25	-	176 243.75	207 825.00	24 659.92	-	140 468.39	165 128.31
	regopti10	-	153 831.25	403 975.00	557 806.25	-	99 295.31	60 689.44	159 984.75
Mowing & pasture comb. 19/6/62, LU 101/ 3739	simul	226 125.00	1 194 075.00	328 050.00	1 748 250.00	28 220.72	139 086.42	39 127.08	206 434.22
	opti10	218 300.00	424 800.00	110 625.00	753 725.00	152 595.40	296 942.40	77 328.75	526 866.55
	regopti10	211 931.25	-	1 086 287.50	1 298 218.75	33 008.66	-	94 953.55	127 962.21
Mowing strips 19/6/6 1, LU 2/ 3922	simul	28 637.50	307 606.25	20 243.75	356 487.50	41 300.47	468 572.49	28 914.98	538 787.94
	opti10	1 197 050.00	1 628 700.00	630 787.50	3 456 537.50	1 488 418.39	2 188 422.57	789 474.17	4 466 315.14
	regopti10	202 687.50	1 557 500.00	79 218.75	1 839 406.25	501 682.38	2 102 037.99	206 589.18	2 810 309.55
<b>Totals per region</b>	<b>simul</b>	<b>2 104 425.00</b>	<b>2 905 837.50</b>	<b>6 129 312.50</b>	<b>11 139 575.00</b>	<b>1 258 621.06</b>	<b>1 498 019.99</b>	<b>4 467 608.14</b>	<b>7 224 249.19</b>
	<b>opti10</b>	<b>2 344 287.50</b>	<b>2 810 043.75</b>	<b>5 820 881.25</b>	<b>10 975 212.50</b>	<b>2 202 230.36</b>	<b>3 081 842.42</b>	<b>2 906 146.22</b>	<b>8 190 219.00</b>
	<b>regopti10</b>	<b>827 987.50</b>	<b>2 891 950.00</b>	<b>5 985 012.50</b>	<b>9 704 950.00</b>	<b>584 470.26</b>	<b>2 941 101.89</b>	<b>889 454.03</b>	<b>4 415 026.19</b>

Note: \*The first number in the code is the quarter month (QM) of the first cut/beginning of grazing, the second (third) number indicates the interval between the first (second) cut and second (third) cut in QM. The fourth number indicates that N-fertilizer is not allowed: 0 (only after the first cut: 1), while LU indicates the maximum grazing livestock unit permitted. For example, "mowing 19/6/60 LU 2" means that the first cut is not allowed before the 19QM, a second cut is allowed six weeks later, a third cut or grazing is allowed six weeks after the second cut, and the use of N fertilizer is not allowed, the maximum grazing livestock units shall not exceed 2 LU (corresponds to measure G1b in Table C. 1).

**Table C. 4 Comparison over Saxony and for each region of the cost-effectiveness measures (Efftype in Eq. 6)**

spatial level	variable	simul	opti10	regopti10
Saxony	<i>EffBirds</i>	0.014	0.019	<b>0.026</b>
region 1	<i>EffBirds1</i>	0.014	0.024	<b>0.073</b>
region 2	<i>EffBirds2</i>	0.016	<b>0.028</b>	0.027
region 3	<i>EffBirds3</i>	0.013	<b>0.012</b>	<b>0.019</b>
Saxony	<i>EffButterflies</i>	0.0000041	<b>0.0000035</b>	<b>0.0000330</b>
region 1	<i>EffButterflies1</i>	0.0000003	<b>0.0000000</b>	<b>0.0000008</b>
region 2	<i>EffButterflies2</i>	<b>0.0000053</b>	<b>0.0000047</b>	<b>0.0000000</b>
region 3	<i>EffButterflies3</i>	0.0000048	<b>0.0000044</b>	<b>0.0000534</b>
Saxony	<i>EffHabitats</i>	0.00034	0.00046	<b>0.00057</b>
region 1	<i>EffHabitats1</i>	<b>0.00058</b>	<b>0.00055</b>	<b>0.00000</b>
region 2	<i>EffHabitats2</i>	<b>0.00028</b>	<b>0.00000</b>	<b>0.00008</b>
region 3	<i>EffHabitats3</i>	0.00029	0.00065	<b>0.00089</b>

Note: red indicates that optimizations are less cost-effective than the simulation;

bold type indicates the most cost-effective scheme on each indicator in each region and

bold green indicates the most cost-effective scheme on each indicator on federal state level for Saxony.

Figures:

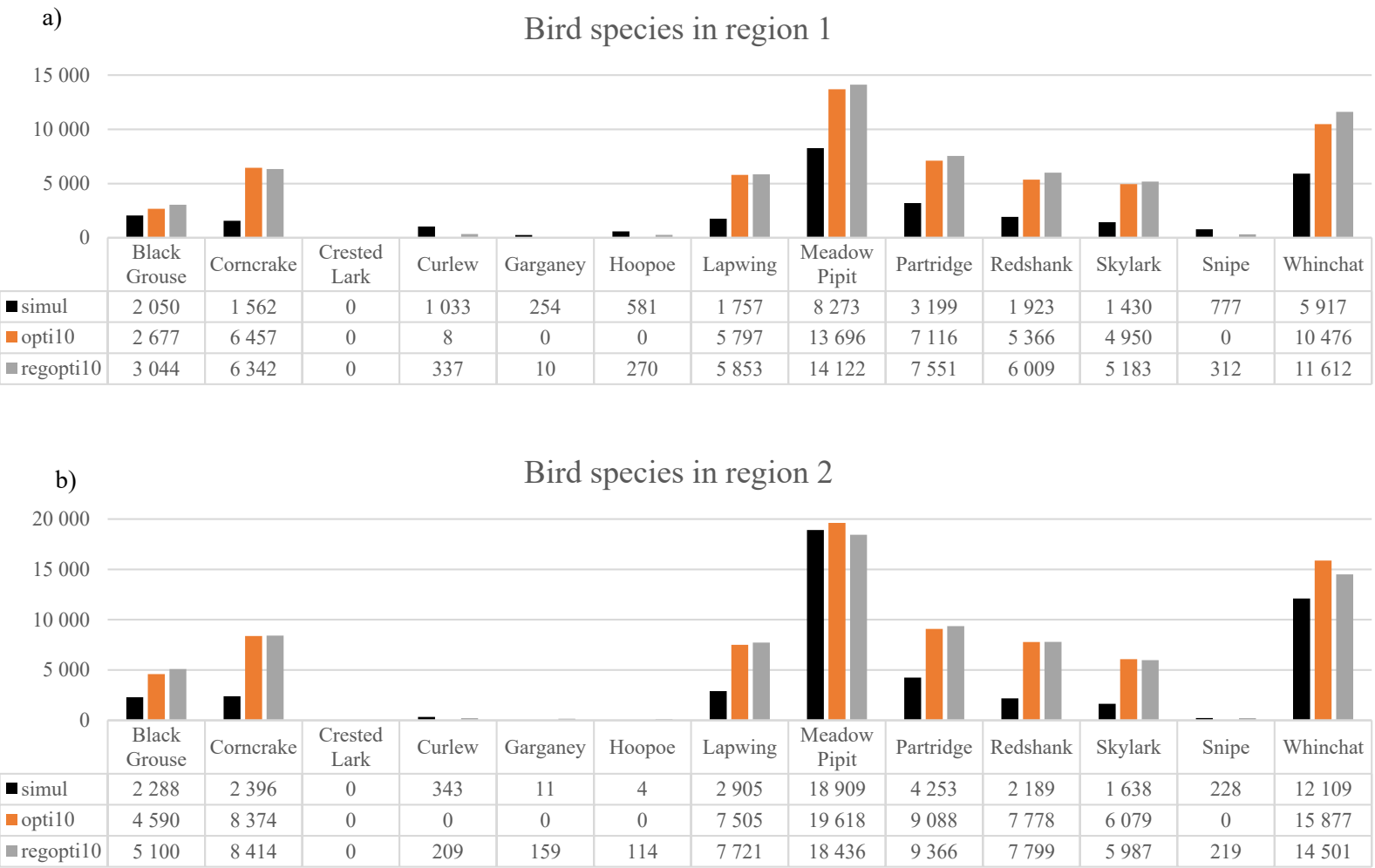


Figure C. 1 Regional comparison of the ecological effectiveness of the Saxon AES (simul), the statewide optimization (opti10) and regional optimization (regopti10) for birds in region 1 (a), region 2 (b) and region 3 (c). The y-axis indicates the effective habitat area  $A_j^{eff}$  in ha achieved for each species.



c)

## Bird species in region 3

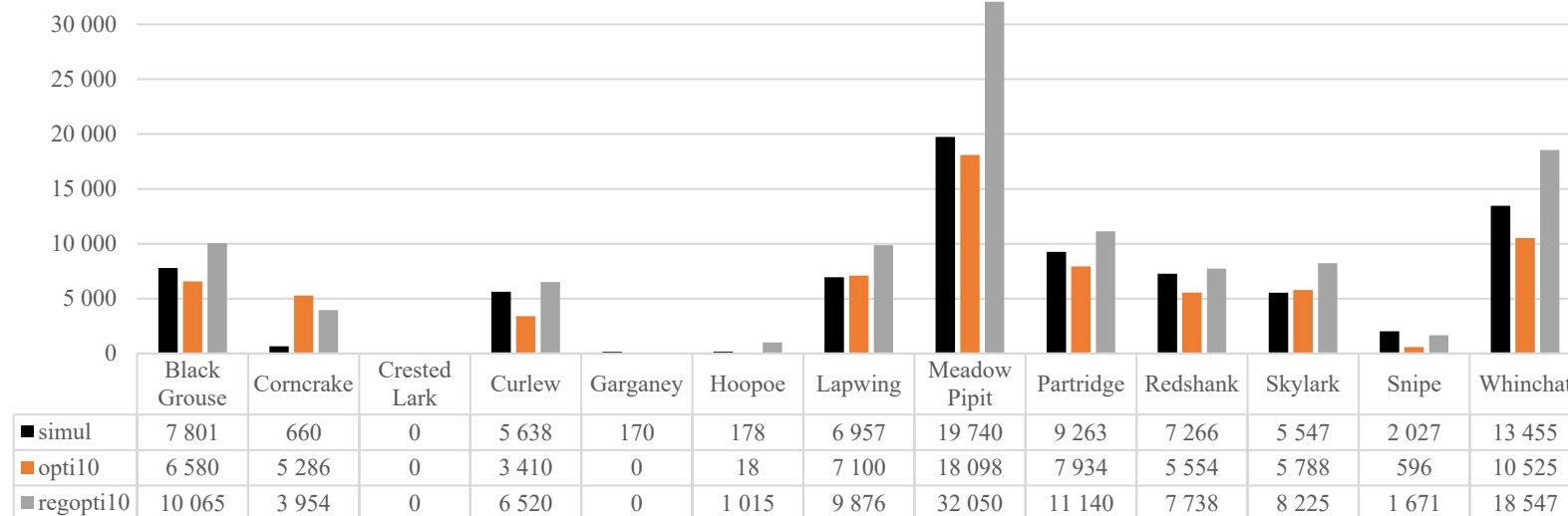
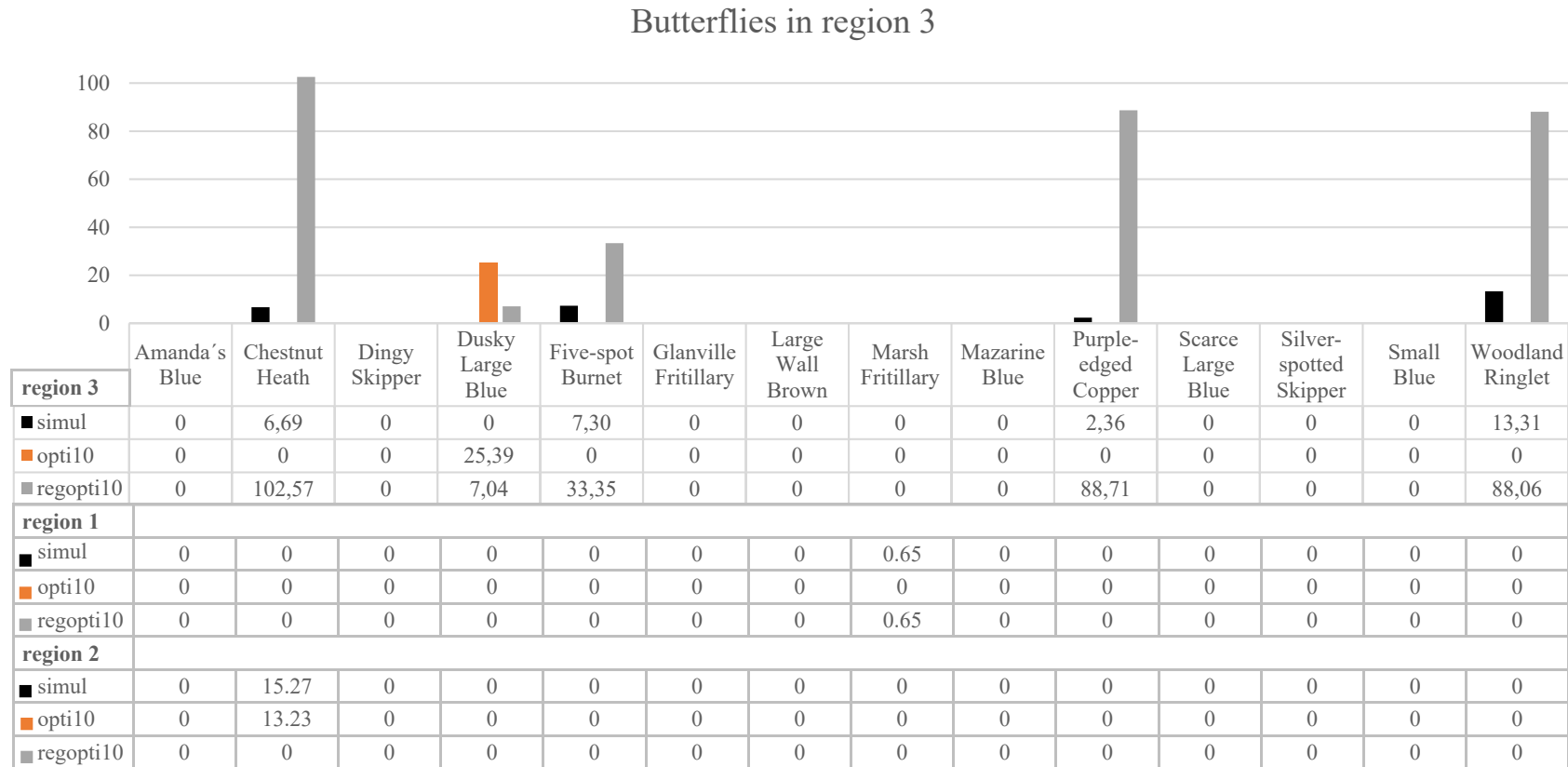


Figure C. 1 (continued)

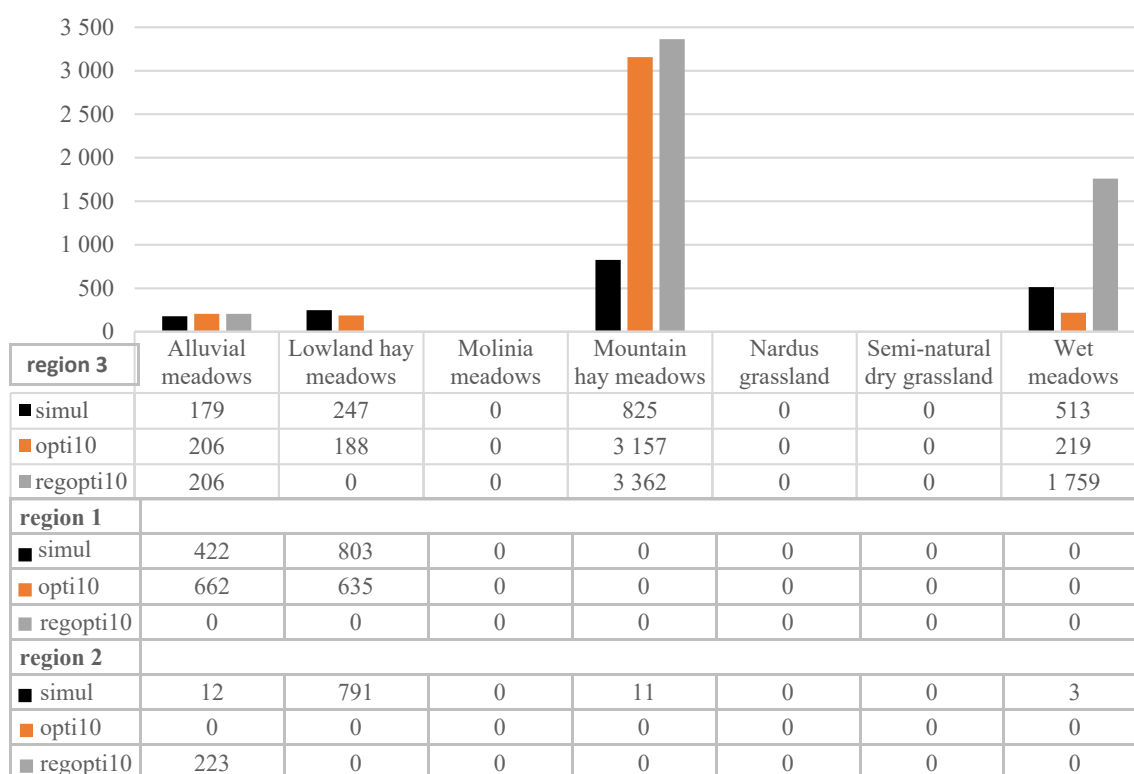
Regional comparison of the ecological effectiveness of the Saxon AES (simul), the statewide optimization (opti10) and regional optimization (regopti10)

for birds in region 3 (c). The y-axis indicates the effective habitat area  $A_j^{eff}$  in ha achieved for each species



**Figure C. 2 Regional comparison of the ecological effectiveness of the Saxon AES (simul), the statewide optimization (opti10) and regional optimization (regopti10) for butterflies in region 1, 2 and 3. The y-axis indicates the effective habitat area  $A_j^{eff}$  in ha achieved for each species.**

## Habitat types in region 3



**Figure C. 3 Regional comparison of the ecological effectiveness of the simulation (simul), the statewide optimization (opti10) and regional optimization (regopti10) for habitat types in region 1, 2 and 3. The y-axis indicates the effective habitat area  $A_j^{eff}$  in ha achieved for each species.**

## D. Appendix to Chapter 4

For our analysis we consider farms with a relatively high percentage of grassland area which are likely to participate in a grassland AES (e.g. cattle and dairy farms). In Saxony these are the following types of farms with a relatively high percentage of grassland area which are likely to participate in a grassland AES according to TF8 grouping of the FADN (Farm Accountancy Data Network) with the respective EU-code (European Commission, 2019):

- 450. Specialist dairying
- 460. Specialist cattle - rearing and fattening
- 470. Cattle - dairying, rearing and fattening combined
- 482. Sheep and cattle combined
- 483. Specialist goats
- 484. Various grazing livestock
- 731. Mixed livestock, mainly dairying
- 831. Field crops combined with dairying
- 832. Dairying combined with field crops