Natural resources and bioeconomy studies 2/2020

Benefits of conserving agricultural genetic resources in Finland: Summary of the recent Finnish research and setting it in the international context

Doctoral Dissertation

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Faculty of Agriculture and Forestry
University of Helsinki

Academic dissertation

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Supervisors:
Professor Eija Pouta
Natural Resources Institute Finland (Luke), Helsinki, Finland

Professor Markku Ollikainen
Department of Economics and Management, University of Helsinki, Helsinki, Finland

Pre-examiners:
Professor Unai Pascual
University of Basque Country, Spain

Senior Research Fellow Kerstin Zander
Charles Darwin University, Australia

Opponent:
Professor Jutta Roosen
Technical University of Munich, Germany

Custos:
Professor Markku Ollikainen
Department of Economics and Management, University of Helsinki, Helsinki, Finland

Annika Tienhaara
Natural Resources Institute Finland (Luke)
Latokartanonkaari 9
FI-00790 Helsinki
Finland
annika.tienhaara@luke.fi

Luke

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Abstract

The diversity of agricultural genetic resources (AgGR) is the foundation of food security. A diverse gene pool enables adaptation to changing conditions and is therefore essential, for example, to responding to climate change. However, during the past decades, intensification of agriculture has led to genetic erosion. Previously common animal breeds and plant varieties are becoming rare or extinct throughout the world as they are being replaced with small ranges of more productive specialized breeds and varieties. Yet, indigenous breeds and varieties have a wide range of socio-economic, cultural, ecological and genetic values and, in fact, the importance of conserving genetic resources has been acknowledged in global agreements and national policy programs.

Nonetheless, as the resources available for conservation are limited, information on the value of AgGR is needed in order to compare the costs and benefits of conservation and to support decision making. Benefits from the conservation of AgGR can be measured from citizens' and consumers' preferences. This dissertation provides new, policy-relevant information on citizens' and consumers' willingness to pay for conservation and sustainable use of AgGR.

Three stated preference methods were used to examine the value that citizens and consumers place on AgGR. Consumers' willingness to purchase Finncattle meat and their willingness to pay for it was studied with contingent behavior and contingent valuation methods. In turn, willingness to support a conservation program for AgGR was examined with contingent valuation and choice experiment methods. In addition, heterogeneity in preferences and the effect of information use were analyzed.

The results show strong support for the conservation of AgGR. There is a high willingness to purchase Finncattle meat among Finnish consumers, and a share of respondents is willing to pay +20-26% more for Finncattle meat compared to conventional meat. Studies also revealed that over 70% of the respondents supported an AgGR conservation program despite the increased cost related to it. Average willingness to pay for the program was €50-170 depending on the method of calculation. However, there was significant heterogeneity among respondents' preferences. This is important to take into account, as ignoring the heterogeneity can lead to overestimation of benefit estimates.

This dissertation provides new information on the benefit estimates of the AgGR conservation in Finland, which has not been studied before. It also contributes to the globally scarce literature on citizens' and consumers' preferences related to AgGR. The results of this dissertation can be used in cost–benefit analysis and they can assist in designing optimal AgGR conservation policies.

Keywords: agricultural genetic resources; valuation; willingness to pay; Finnish agriculture; contin-gent valuation; contingent behavior; choice experiment

Tiivistelmä

Maatalouden geenivarojen monimuotoisuus on ruokaturvan perusta. Monipuolinen geenipooli mahdollistaa muuttuviin olosuhteisiin sopeutumisen ja on siten keskeinen esimerkiksi ilmastonmuutoksen kannalta. Viime vuosikymmeninä maatalouden tehostuminen on kuitenkin johtanut geneettiseen köyhtymiseen. Aiemmin yleiset eläinrodut ja kasvilajikkeet ovat harvinaistuneet tai kuolleet jopa sukupuuttoon eri puolilla maailmaa. Tämä johtuu siitä, että maataloustuotannossa on keskitytty vain muutamaan tuottavampaan, pitkälle jalostettuun rotuun ja lajikkeeseen. Alkuperäisillä roduilla ja lajikkeilla on kuitenkin monia sosioekonomisia, kulttuurisia, ekologisia ja geneettisiä arvoja ja geenivarojen säilyttämisen merkitys onkin tunnustettu sekä kansallisesti että maailmanlaajuisesti.

Koska säilyttämiseen käytettävissä olevat resurssit ovat rajalliset, tarvitaan tietoa maatalouden geenivarojen arvosta, joka auttaa vertaamaan geenivarojen säilyttämisen kustannuksia ja hyötyjä sekä tukemaan poliittista päätöksentekoa. Maatalouden geenivarojen säilyttämisen hyötyjä voidaan mitata kansalaisten ja kuluttajien preferenssien avulla. Tämä väitöskirja tuo esiin uutta, poliittisesti relevanttia tietoa kansalaisten ja kuluttajien halusta maksaa maatalouden geenivarojen säilyttämisestä ja kestävästä käytöstä.

Kansalaisten ja kuluttajien käsitystä maatalouden geenivarojen arvosta tutkittiin kolmella arvottamismenetelmällä. Ehdollisen käyttäytymisen ja ehdollisen arvottamisen avulla selvitettiin kuluttajien halukkuutta ostaa suomenkarjan lihaa sekä halukkuutta maksaa siitä lisähintaa tavanomaiseen lihaan verrattuna. Kansalaisten halukkuutta tukea maatalouden geenivarojen säilyttämisohjelmaa tutkittiin puolestaan ehdollisen arvottamisen ja valintakoemenetelmän avulla. Lisäksi analysoitiin kansalaisten preferenssien heterogeenisyyttä ja sitä, miten kyselyssä tarjottu informaatio vaikuttaa vastaajien valintoihin.

Tutkimustulokset osoittavat, että maatalouden geenivarojen säilyttäminen on tärkeää suomalaisille. Kuluttajat ovat halukkaita ostamaan suomenkarjan lihaa, ja osa vastaajista on valmis maksamaan lihasta 20–26 prosenttia enemmän kuin tavanomaisesta lihasta. Tutkimuksissa kävi myös ilmi, että yli 70 prosenttia vastaajista kannatti geenivarojen säilyttämisohjelmaa siihen liittyvistä kustannuksista huolimatta. Keskimääräinen maksuhalukkuus säilyttämisohjelmasta oli 50–170 euroa vuodessa kymmenen vuoden aikana, riippuen laskentamenetelmästä. Vastaajien preferensseissä oli kuitenkin merkittävää heterogeenisyyttä. Tämän huomioiminen on tarpeellista, jotta vältetään hyötyestimaattien yliarviointi.

Tämä väitöskirja tuo uutta tietoa Suomen maatalouden geenivarojen säilyttämisen hyödyistä ja hyötyjen arvosta. Lisäksi väitöskirja täydentää maailmanlaajuisestikin erittäin niukkaa kirjallisuutta kansalaisten ja kuluttajien preferensseistä maatalouden geenivaroja kohtaan. Väitöskirjan tutkimustuloksia voidaan käyttää kustannus-hyötyanalyysissä ja hyödyntää suunniteltaessa optimaalista geenivarojen säilyttämispolitiikkaa.

Avainsanat: maatalouden geenivarat; arvottaminen; maksuhalukkuus; Suomen maatalous; ehdollinen arvottaminen; ehdollinen käyttäytyminen; valintakoe

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Helsinki, 9th of December 2019
Annika Tienhaara

List of original publications

This dissertation is based on the following studies:

I. Tienhaara, A., Ahtiainen, H. & Pouta, E. 2013. Consumers as conservers – could consumers' interest in specialty product help to preserve endangered Finncattle? Agroecology and Sustainable Food Systems 37: 1017–1039.

II. Pouta, E., Tienhaara, A. & Ahtiainen, H. 2014. Citizens' preferences for policies to conserve agricultural genetic resources. Frontiers in Genetics 5 (Article 440): 1–10.

III. Tienhaara, A., Ahtiainen, H. & Pouta, E. 2015. Consumer and citizen roles and motives in the valuation of agricultural genetic resources in Finland. Ecological Economics 114: 1-10.

IV. Tienhaara, A., Ahtiainen, H., Pouta, E. & Czajkowski, M. Role of information in the valuation of unfamiliar environmental goods – the case of genetic resources in agriculture. Manuscript.

List of abbreviations

AgGR	agricultural genetic resources
AnGR	animal genetic resources
CB	contingent behavior
CDB	Convention on Biological Diversity
CE	choice experiment
CV	contingent valuation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
MLE	maximum likelihood estimation
MXL	mixed logit
PGR	plant genetic resources
RUM	random utility model
TEV	total economic value
WTA	willingness to accept
WTP	willingness to pay

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1. Introduction

1.1. The need for conservation of agricultural genetic resources

Agriculture has changed rapidly in recent decades. The intensification of agriculture, such as internationalization and increased efficiency requirements, has led to significant changes in the utilization of genetic resources. As a result, many previously common animal breeds and plant varieties have become rare, endangered, or even extinct. Of the world's farm animal breeds, 20% are endangered and the number is increasing. The situation is especially critical in Europe, where livestock industries are highly specialized and dominated by a small number of breeds. The Food and Agriculture Organization of the United Nations (FAO 2015a) reports that 31% of mammalian breeds and 35% of avian breeds are at risk of extinction in Europe. For example, out of 464 indigenous European cattle breeds, half are endangered (Duclos & Hiemstra 2010). Drucker and Rodriguez (2009) emphasize that genetic erosion is more serious for animal breeds than crop varieties, as the gene pool is much smaller and wild relatives are lacking.Write the second paragraph here.

In Finland, the Northern Finncattle and Kainuu Grey sheep are endangered, according to the FAO classification (MMM 2018). In addition, the populations of Finnhorse, native chicken, Åland sheep, native goat and Western and Eastern Finncattle are described as vulnerable. The majority of the old Finnish crop varieties and the Finnish Landrace pig are already extinct.

Population growth, increasing demand for food, climate change and urbanization set challenges for agricultural production. The endangerment of indigenous animal breeds and plant varieties is a global environmental problem, as the loss of agricultural genetic resources (AgGR) significantly reduces the options for current and future generations to adapt to these challenges. The diversity of AgGR is the foundation of food security (Drucker & Anderson 2004, Mendelsohn 2003) and preserving AgGR plays an important role in maintaining and enhancing the efficiency and the resilience of production systems around the world, as well as in the provision of environmental services (FAO 2015b). Genetic diversity is essential in responding to climate change as a diverse gene pool enables adaptation to changing conditions (FAO 2015b). Furthermore, as many traditional breeds survive in low input agriculture, AgGR play a central role in the livelihoods of the world's rural poor (Drucker, Gomez & Anderson 2001).

The importance of conserving genetic resources has been acknowledged in The Convention on Biological Diversity (CBD) (United Nations 1992), to which also Finland is committed. One of the objectives of the CBD is the sustainable use of biodiversity. In the current United Nations strategic plan for biodiversity (CBD 2011), central goals include maintaining the genetic diversity of cultivated plants and domesticated animals and developing strategies to minimize genetic erosion. The sustainable management of genetic resources, including the conservation of Europe's agricultural genetic diversity, is also emphasized in the EU Biodiversity Strategy to 2020 (European Commission 2011).

The need for enhancing the conservation of genetic resources in agriculture and for promoting the sustainable use of traditional breeds and varieties to make their conservation economically viable has been recognized. Global Plans of Action have been adopted for both plant and animal genetic resources (FAO 2012, FAO 2007) aimed at the efficient conservation and sustainable use of AgGR.

The National Genetic Resources Programme (MMM 2018), prepared by the Ministry of Agriculture and Forestry together with Natural Resources Institute Finland, guides the preservation, conserva-tion, and sustainable use of genetic resources in Finland. The aims of the program include, for example, the preservation of genetic diversity, development of business activities related to the use of genetic resources, adapting to environmental changes, and fostering cultural heritage related to genetic resources.

In Finland, the conservation of AgGR is currently mainly based on ex situ and in situ conservation. Ex situ conservation refers to the conservation of genetic resources outside their natural habitat, this includes conserving frozen genetic material, such as seeds, sperm and embryos, in gene banks. In situ conservation, i.e. on-site conservation, is carried out in Finland on public teaching and research farms, as well as on some private farms by producers who have a strong interest in the conservation of genetic resources.

Conservation of genetic resources on active farms is financially supported by agri-environmental payments. The support policy for native breeds and varieties is part of the agri-environmental pro-gram. For AnGR, the payment depends on the species and it is applied over five-year periods. How-ever, farmers have not been keen to apply for this support. Reasons for this reluctance include uncertainty about possible changes in support during the contract period, the “inflexible, complex and bureaucratic” nature of the support scheme, and payments that are considered to be too low (Lilja 2016). For example, for cattle breeds the support is not sufficient to compensate for the difference in profitability between indigenous breeds and highly specialized breeds (Turunen 2007), even though the payment has increased over the years (Lilja 2016). Insufficient payments do not only apply to Finland, but also to many other European countries (Signorello & Pappalardo 2003). With regards to the conservation of plant genetic resources, the payment is the same regardless of the variety or the area cultivated. As currently fewer than 10 farms in Finland are growing indigenous plant varieties under a maintenance contract, the payment is clearly not enough to attract farmers.

In addition to in situ and ex situ conservation methods, AgGR can also be preserved through using them sustainably in production. However, sustainable use requires that the product price obtained is higher than production costs, as the support for production cannot likely last forever. Sustainable use also requires that there are consumers who are willing to buy products and services based on these genetic resources. Since the markets alone cannot currently be expected to guarantee the preservation of genetic resources, there is a need to enhance existing conservation policy, and this requires citizens’ monetary contribution.

As there are limited resources for conservation, there is a need to prioritize which breeds or varieties should be targeted and how much should be spent on their conservation (Rege & Gibson 2003). Information on the value of AgGR is important to enable a comparison of the costs and benefits of conservation, hence supporting decision making. According to FAO (2015a), a number of studies related to AgGR have been conducted in recent years, mainly focusing on the valuation of breeds in developing countries and livestock-keepers' preferences. However, studies from developed countries and studies focusing on citizens' or consumers' preferences are sparse. This dissertation attempts to fill this gap.

1.2. A conceptual framework for the loss of agricultural genetic resources

The erosion of AgGR can be seen as replacing diverse indigenous animal and plant genetic resources (i.e. landraces) with a smaller range of specialized breeds and varieties. This replacement is a part of agricultural intensification. Generally, indigenous AgGR perform better in marginal production environments (low external inputs). With agricultural intensification, specialized AgGR become more productive as they are highly responsive to external inputs (Narloch, Drucker & Pascual 2011).

To understand the reasons behind the loss of agrobiodiversity, it is important to examine it from the economic perspective. There is a large divergence between the conservation costs that are incurred by individual farmers and the benefits of conservation that accrue at the community, national or even global levels (Pasqual et al. 2011).

Even though genetic resources themselves are public goods, animals and plants can be traded in the market. Hence, AgGR include a private production value component that is directly linked to farmers' decisions (Smale et al. 2004). To the farmer, abandoning local, indigenous breeds and incurring a loss of genetic resources can appear to be economically rational (Drucker 2003). Profits from highly specialized breeds or varieties are likely to be higher than from indigenous breeds or varieties (e.g. Sardaro et al. 2017). However, preserving AgGR also has non-market benefits (associated with the provision of insurance, adaptation, resilience and sustainability) that accrue to people other than the farmers themselves and these are not taken into account in farmers' decision-making process. As a result, the benefits from indigenous AgGR are underestimated (Pasqual et al. 2011).

Furthermore, the benefits from specialized AgGR are overestimated, because external costs (e.g. environmental impacts) are not accounted for (Narloch et al. 2011). Therefore, the economic incentives are biased toward a few, financially profitable, high-yielding, specialized breeds and varieties. In addition, there are intervention failures that further increase the profitability of specialized AgGR, such as subsidies for fertilizers and pesticides or free availability of improved seeds (Narloch et al. 2011). As there are market, intervention and global appropriation failures, the financial incentives are not equal to the real value of AgGR (Drucker & Rodriguez 2009). Hence, the level of agrobiodiversity conservation is at a suboptimal level, from a social point of view.

Following Drucker and Rodriguez (2009), Figure 1 illustrates the economics of replacing indigenous AgGR by few commercially improved, highly specialized breeds and varieties. The solid curves reflect the current situation, where the benefits of indigenous AgGR are underestimated and the benefits of specialized AgGR are overestimated. In turn, dotted curves represent the true profit functions of indigenous and specialized AgGR. As can be seen from Figure 1, with low level of agricultural intensification (I), the profit function of indigenous AgGR is above the profit function of specialized AgGR, implying indigenous AgGR to be more profitable. As the degree of intensification increases and the level of I*(0) is reached, financial incentives encourage farmers to replace indigenous AgGR with specialized breeds and varieties. However, due to the reasons discussed above, this replacement point is to the left from social optimum I*(S), as the benefits of indigenous AgGR are underestimated and the benefits of specialized AgGR are overestimated. Hence, the replacement taking place between I*(0) and I*(S) leads to greater loss of AgGR than is socially optimal. Even though it seems financially reasonable from farmers' perspective, it is not economically justified.

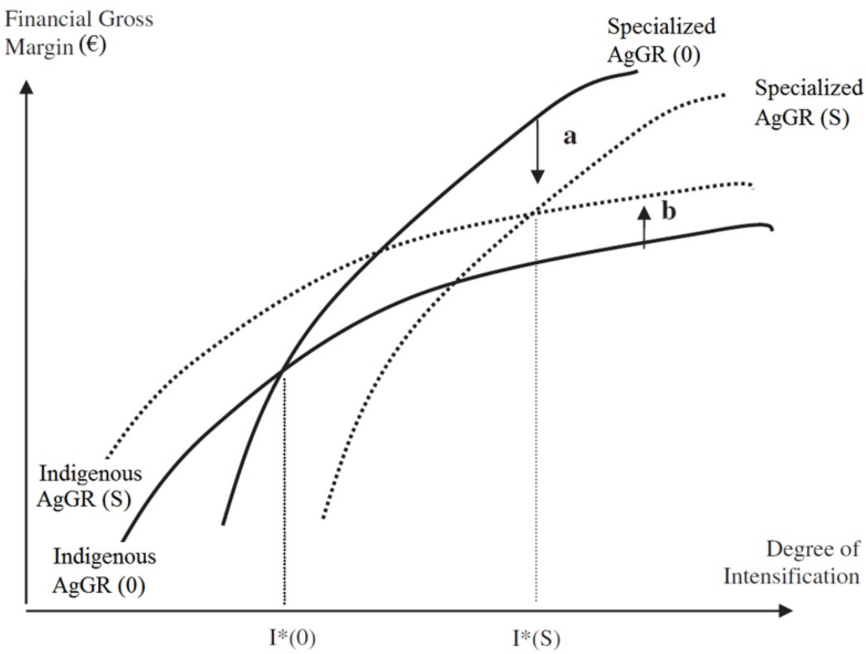

Figure 1. Economics of agrobiodiversity loss: replacement of indigenous AgGR by specialized AgGR (adapted from Drucker & Rodriguez 2009).

Narloch et al. (2011) suggest that in order to reach the socially optimal replacement point and optimal level of AgGR conservation two interventions are needed. The first is to take the negative externalities associated with specialized AgGR into account as well as remove distorting subsidies. This would correct the overestimation of benefits related to specialized breeds and shift the curve for specialized AgGR downwards (a in Figure 1). The second is to capture non-market benefits of indigenous AgGR, hence accounting for all aspects of their value and shifting the curve for indigenous AgGR upwards (b in Figure 1). Following these interventions, the curves would better reflect the social optimum. The aim of this dissertation is to examine the latter and measure non-market benefits associated with Finnish AgGR.

1.3. Need for economic valuation

Based on the conceptual framework presented in the previous chapter, it is evident that AgGR are not self-sustaining, and that policy interventions are necessary. Justifying conservation requires increasing awareness of genetic resources and recognizing the economic values associated with them. Information on the value of genetic resources plays an important role, for example from the point of view of branding indigenous breeds for the most interested market segment, developing genetic resource products and designing optimal conservation policies.

Determining the economic value of AgGR is usually based on the approach developed to examine the value of biodiversity, where the total economic value (TEV) of biodiversity consists of use values and non-use values (Randall & Stoll 1983, Pearce & Moran 1994, Bateman et al. 2002), presented in Figure 2.

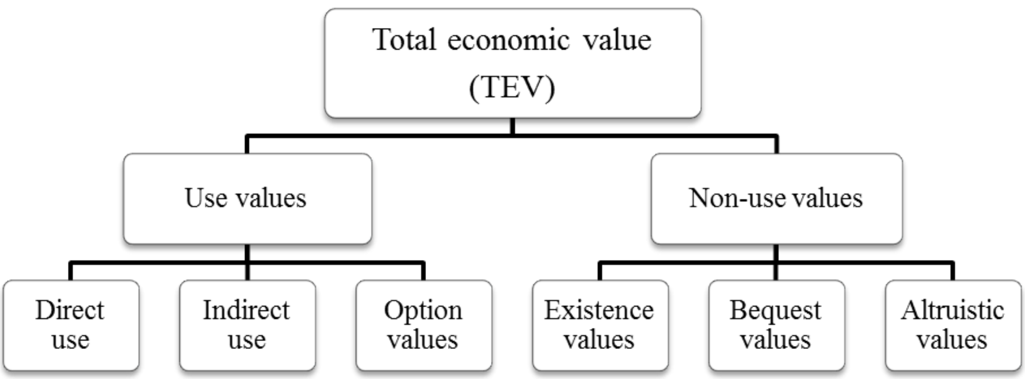

Figure 2. The components of total economic value.

Use values can be divided into direct use, indirect use and option values. Direct use values refer to values resulting from the direct use of the resource. An indigenous breed can be valued, for example, for producing milk for a particular type of cheese. In turn, indirect use values refer to functional benefits, including, for example, the contribution of AgGR to landscapes or ecosystems (Mendelsohn 2003). The option value indicates the value of possible future consumption. Uncertainty about future changes in the economy and environmental conditions can strengthen the desire to protect genetic resources as a form of insurance (Roosen, Fadlaoui & Bertaglia 2005). In the future, certain traits of the indigenous breed or variety, for example, better ability to adapt to different climatic conditions and resistance to diseases may become very desirable and valuable.

Non-use values include existence, bequest and altruistic values (Bateman et al. 2002). The existence value is related to the fact that people simply value the existence of an asset, even if they never use it. For example, many people are willing to pay for the protection of endangered species, just because they have the right to exist, regardless of whether they benefit humans. Bequest value refers to the value that a person can experience when others have the opportunity to benefit from the resource in the future. In this case, preserving AgGR for future generations is considered valuable. Altruism, in turn, refers to value individual perceives when others in the current generation can use the good.

Currently, economic decisions related to AgGR are mainly based on direct use values (Drucker 2003). AgGR conservation is a public good, as it is non-excludable, i.e. it is not possible to exclude someone, and non-rival, i.e. individual’s consumption does not reduce others’ possibilities to benefit from it. Hence, the markets do not fully capture the benefits it generates. Furthermore, as existence and option values can cover around 80 % of the TEV for indigenous breeds (Martin-Collado et al. 2014, Zander et al. 2013), it is very important to take into account all components of TEV in the decision making. In order to capture the TEV associated with AgGR, specific valuation methods, such as contingent valuation and choice experiment, are needed. These methods enable measuring individuals’ monetary valuations of benefits, i.e. their willingness to pay (WTP).

Regarding the conservation of AgGR, the question from a societal point of view is how large costs can be accepted in order to properly conserve genetic resources and how conservation targets should be set. On one hand, one should take a stand on whether all genetic resources are equally important or whether the available resources should be directed to the protection of certain breeds or varieties. On the other hand, different conservation methods produce different kinds of results. Genetic resources can be part of production in active agriculture or they can be stored in gene banks. These different conservation methods have also different benefits.

An interesting question is whether individuals perceive conservation as a social responsibility or if they would be willing to support conservation through consumption choices. In the valuation literature, citizen and consumer roles are often assumed to be distinctive (see e.g. Howley, Hynes & O´Donoghue 2010, Blamey, Common & Quiggin 1995); in the role of a “consumer” the individual acts as an agent only for herself and this could be seen as emphasizing use values, while in the "citizen role" the individual acts as an agent for society, evaluating alternatives according to some social welfare function instead of a personal utility function. Non-use values, such as altruistic, bequest or existence values, could be interpreted as being associated with this kind of citizen perspective. Alphonce, Alfnes and Sharma (2014), for example, assumed that respondents adopted either the consumer or citizen role depending on the question framing, however, in the case of AgGR conservation, these roles are likely to coexist. All in all, consumers' and citizens' appreciation reflects the value of the benefits and should affect the content and aims of an optimal AgGR conservation policy.

1.4. Objectives and outline

The preferences of consumers and citizens regarding the AgGR have not been studied in Finland before. In addition, even on a global scale the literature is scarce (Ahtiainen & Pouta 2011). This dissertation provides information on citizens' and consumers' preferences and values related to AgGR. It compiles studies that help to evaluate policy options for conservation of AgGR set policy targets and prioritize conservation methods. Studies in this dissertation provide information to decision makers and policy actors (such as the Finnish Ministry of Agriculture) in order to assess current and future AgGR conservation strategies and improve economic effectiveness of genetic resource policies. In addition, the dissertation raises awareness of the value of genetic resources and provides an opportunity to identify consumers interested in native breed products. Research results can thus be utilized by farmers and developers of genetic resource products in identifying customer segments.

The overall objective of this dissertation is to provide information on the willingness of Finnish citizens and consumers to support the conservation of AgGR and to purchase products that support the sustainable use of AgGR. This dissertation is composed of four studies.

Study I used contingent behavior and contingent valuation methods to examine consumers' willingness to buy Finncattle meat and their willingness to pay for it.

Study II applied choice experiment method to study citizens' willingness to pay for an AgGR conservation program. The study examined the value of both plant and animal genetic resources, as well as the effect of conservation methods, i.e. in situ and ex situ conservation, on them. In addition, the study identified heterogeneity in preferences of respondents by using the latent class approach.

Study III used contingent valuation to examine willingness to pay for the conservation of AgGR via buying a native breed product and paying for a conservation program. This approach enabled examining how the perceived consumer and citizen roles are revealed in different valuation contexts. The study also investigated the heterogeneity of the respondents' preferences.

Study IV analyzed the information effects on stated preferences for AgGR using data from a choice experiment. Two groups of respondents were defined by their use of additional information provided in the survey. The determinants of information acquisition as well as the effect accessing the information on individual preferences were explored.

The next section outlines random utility theory and presents the valuation methods used in this dissertation. The third section describes the applied research data and econometric models. The fourth section summarizes the main results of each study. The final section provides discussion and conclusions on the relevance of this work.

2. Valuing agricultural genetic resources – stated preference methods

The costs of providing public goods, such as an improvement in the state of the environment or conservation of genetic resources, are typically known by decision makers. If the costs of public goods provision can be compared with their benefits, decision makers can make more informed choices, leading to efficiency gains. Since genetic resources themselves are not typically directly traded in the markets, there are few genetic resource products and the existence values do not play a role in the consumption of products, the total value of AgGR is not revealed by the markets, so assigning monetary value for the conservation of genetic resources is challenging. Therefore, specific valuation methods are needed (Drucker et al. 2001) to provide value information of the economic benefits that arise from the conservation of genetic resources.

A variety of valuation techniques have been developed to value non-market goods in environmental economics. These techniques are based on either revealed preferences, i.e. observed behavior toward a market good that is related to non-market good, or stated preferences, i.e. preferences for a non-market good stated in surveys (Carson 2000).

In economics, the concepts of willingness to pay (WTP) and willingness to accept (WTA) can be used in order to examine monetary welfare measures. Assuming that the level of utility does not change, WTP can be defined as the maximum monetary payment that an individual is willing to pay to for an increase in the quantity or quality of public good (assuming that the increase is desired) (Haab & McConnell 2002). In turn, WTA is the minimum compensation that an individual is willing to accept in order to forego the increase in the quantity or quality of public good.

2.1. The random utility model (RUM)

In order to examine consumers' and citizens' preferences, a conceptual framework is needed to understand how underlying influences affect individuals' choice behavior. Random utility theory (McFadden 1974) provides a framework for modeling choices between alternatives. Individual n maximizes utility by selecting alternative j with the highest utility U_{jn} from J_n alternatives in a choice set C_n. The RUM assumes that utility consists of deterministic (v) and random components (ε):

$$U_{jn} = v(x_{jn}, z_n) + \varepsilon_{jn} \tag{1}$$

where x_{jn} is the vector of attributes describing the alternative, z_n is the vector of characteristics describing the individual n and ε_{jn} is the error term. From the perspective of the decision maker, the choice is assumed to be deterministic, but as the researcher cannot observe everything, the error term reflects the researcher's uncertainty about the choice (Holmes & Adamowicz 2003). As the error term is not observed, only probabilistic assumptions can be made about the choice behavior. The probability that an individual chooses alternative j from all of the alternatives in a choice set can be expressed as:

$$P(j|C_n) = P\left(U_{jn} > U_{in}\right) = P\left(v_j + \varepsilon_j > v_i + \varepsilon_i\right), \forall\ i \in J_n \qquad (2)$$

Rearranging equation 2 shows that choices are made based on the differences in utilities derived from different alternatives:

$$P(j|C_n) = P(v_j - v_i > \varepsilon_i - \varepsilon_j), \forall\ i \in J_n \qquad (3)$$

Utilities derived from choice models are ordinal and hence, only utility differences matter and the absolute value of utility is meaningless (Hensher, Rose & Greene 2015). Ordinal utilities can be measured, for example, by using contingent valuation or choice experiment methods.

2.2. Contingent valuation and contingent behavior

Contingent valuation (CV) is one of the frequently used stated preference methods. Carson (2011) provides a comprehensive bibliography and history for this method. The CV method uses survey questions to elicit people's preferences for goods and services by examining what they would be willing to pay for a specified change in the quality or quantity of these goods (Mitchell & Carson 1989). As non-use values can form a large share from the TEV of environmental public goods, the CV method is particularly suitable for valuation because it can reveal both use and non-use values (Bateman et al. 2002).

In CV analysis, the design of the survey is crucial in order to obtain reliable welfare estimates (Boyle 2003, Haab & McConnell 2002). A CV question has to be carefully constructed and must clearly specify the change in good that is being valued and how it will be provided, as well as the payment method. Assigning different cost levels randomly to respondents allows the tracing of the distribution of WTP for the good (Carson 2000).

There are different approaches for asking CV questions, i.e. elicitation formats, including using an open-ended question, bidding game, payment card and dichotomous choice (Haab & McConnell 2002). Studies in this dissertation employed two approaches. The first is the payment card approach in which respondents were asked to choose the amount they are willing to pay from a predetermined list of values and the second is the dichotomous choice approach in which respondents were asked to state whether they support a conservation program with an increased level of cost or preferred the status quo.

Whereas payment card approach asks respondent to state their willingness to pay directly, modeling dichotomous choice CV questions follows RUM framework. In this case, there are two alternatives, i.e. there are only two values for j in equation (2) (j=1 is the state where conservation program is implemented and j=0 is the status quo). The respondent will support the conservation program if the utility obtained from it is higher than the utility in the status quo.

The contingent behavior (CB) method can be used when it is not possible to observe respondents' behavior. In CB, respondents are asked how they would behave under a certain scenario. The CB method has been used to examine the demand for non-market goods, e.g. outdoor recreation (Englin & Cameron 1996, Rosenberger & Loomis 1999), and it is often combined with revealed preference data. Instead of focusing on hypothetical prices as in the CV method, CB focuses on hypothetical behavior. In this dissertation, CB was used to examine respondents' willingness to purchase a product, i.e. Finncattle meat, which is not currently available on the markets on a large scale. In Studies I and III, CB questions preceded CV questions to reveal potential buyers.

2.3. Choice experiment method

Another stated preference approach, the choice experiment (CE) method (e.g. Hanley, Mourato & Wright 2001), has increased in popularity over the past several years and is now dominantly used for the valuation of environmental goods. The idea behind CE is that the value of, for example, an AgGR conservation program is determined by its characteristics.

CE is a survey-based method that consists of several choice sets with two or more alternatives described by attributes and the levels that these take. Attribute levels vary between alternatives and cost is often included as one of the attributes to enable the estimation of welfare estimates. The respondents are asked to choose their preferred alternative and are assumed to consider the utility from different alternatives and to select the option with the highest utility. Typically choice sets include a status quo option or a no-choice option; hence they do not force the respondents to choose an option with increased cost.

According to RUM, respondents' choices reveal trade-offs between attributes, and, therefore, WTP for different alternatives can be estimated based on these choices. One advantage of the CE method compared to CV is that it can also produce information on the effect of an individual attribute on the value, as well as on the relationship between the values of different attributes.

In order to select the attribute levels for each choice task, different experimental design approaches can be used (Hensher et al. 2015). These contain full factorial design, which includes all possible combinations and is often not feasible due to there being a really large number of choice tasks, and fractional factorial design, which is a selected subset from the full factorial design. This subset can be selected randomly or by using efficient (optimal) design that aims to satisfy statistical efficiency criteria (Hensher et al. 2015) and generate parameter estimates with standard errors as low as possible (Rose & Bliemer 2009).

The stated preference methods face a certain amount of criticism related to hypothetical bias (e.g. Bateman et al. 2002), warm glow effect (Andreoni 1989), insensitivity to scope (Carson 1997) and protest responses (e.g. Halstead, Luloff & Stevens 1992). However, as there are cases such as AgGR, when observing respondents' behavior and WTP is not possible, the stated preference methods provide an important tool for examining TEV and incorporating non-use values into the decision making.

2.4. Empirical applications of stated preference methods in AgGR valuation

There are no previous stated preference studies related to AgGR conducted in Finland. Even globally, the number of AgGR valuation studies is limited, especially in developed countries. Ahtiainen and Pouta (2011) provide a thorough meta-analysis assessing valuation studies related to AgGR. Table 1 compiles 7 animal genetic resources and 4 plant genetic resources valuation studies that have used either CV or CE and that were conducted after the meta-analysis mentioned above. There is a range of studies that examine the values of specific traits of indigenous breeds from breeders' perspectives (FAO 2015a). Studies with a focus on consumers' or citizens' WTP are scarce, but the number has been increasing over more recent years.

In Europe, AgGR valuation has lately mainly focused on plant genetic resources. Tyack and Scasny (2018) estimated citizens' WTP for conserving crop varieties in gene banks and Rocchi et al. (2016) as well as Dinis, Simoes and Moreira (2011) examined consumers' WTP for traditional varieties. In turn, Sardaro et al. (2016) studied farmers WTA for conservation program for olive landraces. Related to animal genetic resources, Martin-Collado et al. (2014) and Zander et al. (2013) examined TEV of threatened cattle breeds in Italy and Spain.

In Asia, stated preference studies related to AgGR have been conducted in Nepal, India and Vietnam. Pallante, Drucker and Sthapit (2016) explored potential niche markets for finger millet landraces by estimating consumers' WTP using CE, whereas Krishna et al. (2013) examined farmers WTA for on-farm conservation of millet landraces.

A recent American study (Palma, Collart & Chammoun 2015), examined product differentiation and whether consumers' WTP for native and improved pecans differed. Even though the focus of the study was not directly in the conservation of AgGR, they found a positive price premium for native pecans.

Many of the stated preference studies focusing on AgGR, and especially animal genetic resources, have been conducted in African countries. Still, the focus of most of these studies has been on the valuation of different traits of indigenous breeds (e.g.

Faustin et al. 2010). However, Bett et al. (2013) estimated consumers' preferences and WTP for meat and eggs of indigenous chickens.

Mean WTP and WTA estimates for different studies are presented in Table 1. Positive price premiums range between 6% and 42% for genetic resource products. For conservation programs, WTP estimates ranged between €9 and €90/year per person.

Table 1. AgGR valuation studies using stated preference methods

Authors (publication year)	Country	Genetic resource	Species	Valuation method	Mean WTP/WTA
Dinis, Simoes & Moreira (2011)	Portugal	PGR	Apple	CV	+6%
Bett et al. (2013)	Kenya	AnGR	Chicken	CV	23.26% (meat) 41.53% (eggs)
Zander et al. (2013)	Italy	AnGR	Cattle	CE	90€/year
Krishna et al. (2013)	India	PGR	Millet	CV	5.3$/0.1 acres/year
Martin-Collado et al. (2014)	Spain	AnGR	Cattle	CE	83€/year
Palma, Collart & Chammoun (2015)	USA	PGR	Pecan	CE	0.07-0.19$/8-oz bag
Pallante, Drucker & Sthapit (2016)	Nepal	PGR	Finger millet	CE	14%
Sardaro et al. (2016)	Italy	PGR	Olive	CE	235€/ha/year
Rocchi et al. (2016)	Italy	PGR	Tomato	CV	2.38€/kilo (use value) 14.49€ (non-use value)
Tyack & Scasny (2018)	Czech Republic	PGR	Crop varieties	CV	9$/10 years

Notes: WTP willingness to pay; WTA willingness to accept; AnGR animal genetic resources; PGR plant genetic resources; CV contingent valuation; CE choice experiment

3. Applied research data and econometric models

3.1. Data

3.1.1. Survey 1

Willingness to purchase a genetic resource product, i.e. Finncattle meat, was examined as a part of a large survey designed by MTT Agrifood Research Finland and Finnish National Consumer Research Center with the aim of investigating consumers' meat-purchasing behavior. The survey data were collected in March 2010 via a probability-based internet panel. A pilot (n=50) was used to test the questionnaire and especially the bid range of the WTP question. The final data set comprised 1,623 responses, which corresponds to a 37.8% response rate.

As the survey was about meat-purchasing behavior in general, the number of questions related to indigenous breeds was very limited. Hence, additional questions, for example, on the respondents' perceptions of Finncattle could not be asked. However, as the context of the survey was meat-purchasing behavior in general, it was likely to give a realistic picture of the demand for Finncattle meat.

A CB question was used to measure the buying intention. The respondents were asked whether they would be willing to purchase Finncattle meat if it was available in stores. The options were to buy it regularly, to but it occasionally, to try it or to not buy it at all.

For those respondents who were willing to buy Finncattle meat, WTP was measured using CV. The respondents were asked whether they would by Finncattle meat even if it was more expensive, if the price was equal, or only if it was cheaper compared to the price of conventional meat, i.e. WTP was allowed to be positive, zero or negative. If the respondent was willing to buy Finncattle meat even if it was more expensive than conventional meat, a follow-up question was asked to assess how much higher, as a percentage, the price of Finncattle could be. The options in the payment card approach ranged from 10% to 100% in 10% increments. Respectively, respondents who were willing to buy Finncattle meat only if it was cheaper than conventional meat were asked to state how much lower the price should be. The response options for this negative price premium ranged between 10% and 70% in 10% increments. Percentages were used instead of monetary prices in order to avoid tying the values to any particular type of meat.

Explanatory variables for both willingness to purchase and willingness to pay included sociodemographic variables (gender, age, children in the household, income), behavioral variables (meat consumption, environmental activity, cooking behavior, political party) as well as attitudinal variables (appreciation for local food, preference for meat, environmentally friendly attitude, concern about biodiversity loss and food production issues, sensitivity to price in food purchases).

3.1.2. Survey 2

The value of AgGR was examined with a citizen survey designed by MTT Agrifood Research Finland. The survey was carried out during summer 2011 using a probability-based internet panel. After a pilot study (n=138), the survey was sent to a random sample of 6,200 respondents. The response rate for the final study was 24%, i.e. there were 1,495 fully completed responses.

The survey began with questions about respondents' level of knowledge about AgGR and their familiarity with genetic resource products. As determining respondents' attitudes, beliefs and knowledge is important in order to examine determinants of value for genetic resources, a series of questions were constructed to measure the importance of the conservation of both plant and animal genetic resources, as well as to reveal conservation motives (use versus non-use motives). In addition, the perceived conservation responsibilities of purchasers, taxpayers and farmers were investigated.

The respondents were presented with a short description of the conservation of AgGR in Finland and the current state of different conservation measures, before being given the opportunity to access additional information on both plant and animal genetic resources by clicking hyperlinks. Time spent on these additional information pages was recorded. In the survey, two different choice contexts were constructed: citizen's choice of conservation programs and consumers' choice of genetic resource product purchase.

In the citizens' choice context, the survey presented a conservation program for AgGR that was described with six attributes. These attributes included the number of native food plant varieties in gene banks, number of farms growing native food plants, number of native ornamental plant varieties mapped and in gene banks, native breeds in gene banks, native breeds kept on farms and the program cost. Attributes and their levels were defined with genetic resource researchers (see Study II for descriptions of attributes, their current state and levels). The cost attribute was specified as an increase in income tax during a 10-year period (2012-2021).

The respondents' WTP for the AgGR conservation program was elicited using both CV and CE. The CV question was a single-bounded binary choice, where respondents chose whether they supported the program or the status quo, i.e. the current situation. Cost levels varied from €5 to €300 and were evenly distributed among the sample.

In the CE, the respondents were presented with six choice sets, each containing three alternatives: status quo alternative and two program alternatives with improved levels of conservation and increased level of cost. The cost levels varied between €5 and €300, as in the CV question. The status quo alternative was identical across choice sets. The experimental design for the CE was generated using Ngene (v. 1.0.2), employing a Bayesian D-efficient design. Parameter estimates obtained from the pilot were used as priors for the final design (D-error 0.002). Altogether, the final design consisted of 180 choice sets blocked in to 30 subsets.

The consumers' choice context focused on WTP for Finncattle meat. The valuation question was only presented to those respondents who were willing to buy Finncattle meat. The approach was similar to that in Survey 1, except the positive price premiums ranged from 10% to 70% as opposed to the 100% in Survey 1.

Table 2 summarizes the data, valuation methods and econometric models used in each study.

Table 2. A summary of the data and methods

	Main focus	Number of respondents	Studies	Valuation methods	Econometric models
Survey 1	Meat consumption	1623	Study I	Contingent behavior, contingent valuation	Ordinal regression, interval regression
Survey 2	Conservation of AgGR	1495	Study II	Choice experiment method	Conditional logit, latent class model
			Study III	Contingent valuation, choice experiment method	Logit, interval regression
			Study IV	Choice experiment method	Logit, mixed logit model

3.2. Econometric models

3.2.1. Ordinal regression

Respondents' willingness to purchase Finncattle meat in Study 1 was examined with an ordinal regression model. In ordinal regression, the dependent variable is categorical and has a limited number of values that can be put into an order (Greene 2008). The model assumes that there is an unobserved continuous latent variable y^* behind the ordinal responses:

$$y^* = X\beta + \varepsilon, \varepsilon \sim [N\ 0, \sigma^2] \tag{4}$$

where β is the vector of regression coefficients, X presents measurable factors and ε unobservable factors. The relationship between the dependent variable $y(0,1,\ldots,J)$and the latent variable y^* is:

$$y = \begin{cases} 0\ if\ y^* \leq 0, \\ 1\ if\ 0 < y^* \leq \mu_1, \\ 2\ if\ \mu_1 < y^* \leq \mu_2, \\ . \\ . \\ . \\ J\ if\ \mu_{J-1} \leq y^* \end{cases} \tag{5}$$

where J is the number of categories and μ's are the threshold values between categories. In ordinal regression, the threshold parameters that are used to segment the distribution of likelihoods into different categories are estimated. The threshold parameters do not have any intrinsic interest of their own, but are merely necessary for the computations (Greene & Hensher 2010).

Different variants of ordinal regression can be estimated by using different assumptions on the distribution of the error term ε. Ordered probit model estimates the probability of a respondent belonging to certain category as follows:

$$P(y = j) = \phi(\mu_j - X\beta) - \phi(\mu_{j-1} - X\beta), \tag{6}$$

where $\phi(\cdot)$ is the cumulative probability function of a normal distribution.

3.2.2. Interval regression

Interval regression was used for analyzing respondents' WTP for Finncattle meat in Studies I and III. Interval regression (see e.g. Cameron and Huppert 1989, Long and Freese 2006, Stewart 1983) resembles ordinal regression (presented in 3.2.1), except the threshold values of the categories are known. When the number of intervals is J, the model has $J - 1$ limit values. The equation 4 still holds for latent variable y^*, but the relationship between y^* and observed y is:

$$y = j\ if\ A_{j-1} \leq y^* < A_j, j = 1, \dots, J, A_0 = -\infty, A_J = +\infty \tag{7}$$

3.2.3. Logit regression

Logit regression model was used in Study III for analyzing the determinants of willingness to support the AgGR conservation program and in Study IV to examine the use of additional information. Logit regression (see e.g. Greene 2008) is a binary choice model, where the dependent variable can only take two values, 0 and 1. The logit model estimates the probability of dependent variable being 1, which in Study III was the probability of choosing the conservation program and in Study IV the probability of reading the additional information.

$$P_n(Y_n = 1|X_n) = \frac{e^{\beta X_n}}{1+e^{\beta X_n}} = \Lambda(\beta X_n), \quad (8)$$

where $\Lambda(\cdot)$ indicates the logistic cumulative distribution function (Greene 2008). Binary choice models are typically estimated using maximum likelihood estimation (MLE). MLE maximizes the log-likelihood function for different observations by finding parameter estimates β that maximize the likelihood of the entire sample.

3.2.4. Conditional logit regression

Conditional logit (CL) model was used in Study II as a baseline model to examine choices between conservation programs. CL model was proposed by McFadden (1974) in order to model the expected utilities in terms of the attributes of the choice alternatives. Hence, the expected utility from alternative j for respondent n is:

$$V_{jn} = x_j'\beta \quad (9)$$

where x_j is the vector of attributes describing the choice alternative. As the CL model assumes similar preference structure for all respondents, it is rather restrictive.

3.2.5. Latent class model

In Study II, latent class model was estimated to examine the heterogeneity in respondents' preferences for the conservation of AgGR. A latent class model divides individuals into behavioral segments and estimates a choice model for each class. Preferences are assumed to be homogenous in each segment, but heterogeneous between segments. The probability that respondent n belongs to segment s and will select alternative i can be expressed as (Boxall & Adamowicz 2002):

$$P_{\mathrm{ni|s}} = \sum_{s=1}^{S} \left[\frac{e^{\alpha\lambda_s Z_n}}{\sum_{s=1}^{S} e^{\alpha\lambda_s Z_n}}\right] * \left[\frac{e^{\mu_s\beta_s X_i}}{\sum_{j=1}^{J} e^{\mu_s\beta_s X_j}}\right], \quad (10)$$

where Z_n is a vector of socioeconomic characteristics and psychometric constructs of individual n, λ_s is a vector of parameters, X is a vector of attributes of certain alternative, β_s and μ_s are segment-specific utility and scale parameters. The error terms are assumed to be independently distributed across individuals and segments with Type 1 extreme value distribution. To examine class membership, covariates can be included in a latent class model as active or inactive. If covariates are active, they affect the probability of class membership (Vermunt & Magdison 2005). Alternatively, the relationship between covariates and the latent variable can be examined posterior to estimating a model without covariates with an inactive covariates method.

The latent class model is first estimated assuming one class, then two classes and so on. The estimation is continued until the change in log-likelihood becomes very small. Minimizing information criteria (e.g. The Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC) and the Consistent Akaike Information Criterion (CAIC)) guide the choice of the optimal number of classes. However, interpretation of the classes and their differences by an analyst is also required in order to select the final number of classes.

3.2.6. Mixed logit model

A mixed logit (MXL) model (McFadden and Train 2000) was used in Study IV in order to examine unobserved preference and scale heterogeneity between respondents who did/did not access voluntary information. This model takes into account respondent heterogeneity by allowing coefficients to vary across the respondents according to a pre-specified distribution. MXL is a highly flexible model that can estimate any discrete choice model and it relaxes the assumption of the independence of irrelevant alternatives (IIA) related to multinomial and conditional logit models (Train 2003).

The MXL probability of choosing alternative i is the expected value of the logit probability integrated over all different values of β, weighted by the mixing distribution $f(\beta)$ (Hensher, Rose & Greene 2005):

$$P_{ni} = \int \left(\frac{e^{\beta' x_{ni}}}{\sum_{j=1}^{J} e^{\beta' x_{nj}}} \right) f(\beta) d\beta \quad (11)$$

In most MXL applications, $f(\beta)$ is specified as continuous and it can follow lognormal, uniform, triangular or any other distribution. The mixing distribution can also be discrete, with β taking a finite set of distinct values. However, in this case, MXL becomes a latent class model (Train 2003).

There is a growing interest in accounting for scale heterogeneity in addition to heterogeneity in preferences. Scale represents the variation in the random component of utility in relation to the deterministic component. Scale heterogeneity implies that the scale of the error term varies across respondents. When the mean scale is higher, the respondents' choice behavior appears less random from the analyst's perspective. In the context of unfamiliar goods, allowing for scale heterogeneity may be especially important (Christie & Gibbons, 2011). Hence, scale heterogeneity was included in the modeling in Study IV.

As the WTP is the ratio of the attribute's coefficient to the price coefficient, allowing cost parameter to vary across respondents can cause problems in the estimation of WTP (Hensher, Rose & Greene, 2015). When both attribute and price coefficients are allowed to vary, the distribution of WTP is quite complex as it is no longer just the scaled distribution of the attribute's coefficient (Train, 2003). Train and Weeks (2005) suggest that WTP measures can be estimated directly in MXL model by re-formulating the model. In this WTP space approach, the coefficients represent the WTP measures instead of preferences and the WTP distributions can be specified directly. Therefore, the problem of selecting the distribution for the price coefficient is avoided and more realistic WTP estimates can be obtained (Hole & Kolstad 2012). Study IV estimated MXL models in both preference and WTP space.

4. Summaries of studies

4.1. Study I: Consumers as conservers – Could consumers' interest in a specialty product help to preserve endangered Finncattle?

Study I examined consumers' potential demand for Finnish indigenous cattle meat using CB and CV methods. Sustainable use is an important part of AgGR conservation, and markets for specialty products can help to preserve rare native breeds.

The results suggested that there would be considerable demand for Finncattle meat, as 86% of the respondents would like to buy it. The majority of these respondents would like to buy it occasionally or to try it. Approximately one-tenth of the respondents would buy Finncattle meat on a regular basis.

The results of the ordered probit model revealed that the consumer segment with the highest probability of purchase was characterized by male gender and frequent consumption of meat. The willingness to purchase was also positively affected by an appreciation of local food and environmental friendliness, as well as by concern about the loss of biodiversity caused by agricultural production.

For the majority of the respondents (59.3%), the breed did not produce any added value, as they would only buy Finncattle meat if it had an equal price to conventional meat. However, Finncattle meat proved to have potential for specialty markets, as almost a quarter (23.5%) of the respondents would be willing to pay more for it than for conventional meat. The average WTP for Finncattle meat was relatively low (only 6.25% higher than for conventional meat) among all respondents who were willing to buy it. However, for the quarter of the respondents who were willing to buy Finncattle meat even if it costs more than conventional meat, the average WTP was 26%.

Willingness to pay a price premium was highest among those respondents who would like to purchase Finncattle meat regularly. WTP was higher among men than women and income level affected it positively. Those respondents who voted for Green Party or were members of an environmental organization had significantly higher WTP.

The demand shown in Study I is encouraging, as a higher price compared to conventional meat could be obtained for Finncattle. However, as the costs of production were not examined, it is not possible to state whether the price premiums indicated in this study would make breeding Finncattle for meat profitable. High enough price premiums could create an incentive for farmers to preserve native breeds, and the production of Finncattle meat may possibly offer a potential means to conserve Finnish animal genetic resources.

4.2. Study II: Citizens' preferences for the conservation of agricultural genetic resources

Study II estimated the benefits of AgGR conservation program in Finland using the CE method. The conservation program contained both plant genetic resources and animal genetic resources, as well as conservation on farms and in gene banks.

The results showed that citizens are interested in the conservation of native agricultural breeds and varieties. Rather than assuming that all of the respondents have the same preferences for conservation of AgGR, a latent class model was used to examine preference heterogeneity across citizen segments.

For most of the conservation program attributes, there was significant heterogeneity in preferences. Estimation of the latent class model resulted in five citizen clusters. Respondent groups were identified based on their preferences for conservation, but they also differed with respect to their use of additional information, carefulness and certainty in responses, as well as their environmental attitudes and perceptions of who is responsible for the conservation.

The first class (27% of the respondents) was named as conservationists. These respondents did not take the cost of the conservation program into account while making their choices. However, almost all other program attributes were significant and positive. This class perceived higher use and non.-use values from AgGR conservation than did respondents in other classes.

The second class (26% of the respondents) had a high tendency to choose the conservation program compared to the status quo. The emphasis of preferences was on the conservation of animal breeds. In this class, respondents perceived that the responsibility for the conservation of genetic resources belongs to citizens and consumers.

The third class (comprising 17% of the respondents), interestingly favored the option in the middle, i.e. conservation program A over program B and status quo. This group clearly had random tendencies as respondents were relatively uncertain of their preferences, used additional information less and responded less carefully than other respondents (according to their self-evaluation). Still, this group preferred an increase in several conservation attributes.

The fourth class (17% of the respondents) clearly preferred status quo over conservation program options. The bid variable was not significant and this group perceived conservation as being the farmers' responsibility.

The fifth class (13% of the respondents) was the most sensitive to the cost of the conservation program. Still, these respondents preferred conservation program over status quo, and almost all conservation attributes were significant. Respondents in this class evaluated themselves as respondents who were careful in their choices, but still felt rather uncertain about them. They were also less familiar with products from traditional breeds and varieties.

WTP estimates were presented for three classes that had a significant cost coefficient. The marginal WTPs based on the latent class model were considerably lower than the WTPs of the whole sample based on the conditional logit model. This implies that the WTPs for whole sample were influenced by the groups that were insensitive to the costs of conservation. Hence, it is very important to take the respondents' preference heterogeneity into account in welfare estimates.

This study suggested that in the case of plant genetic resources, Finnish citizens particularly valued moderate levels of in situ conservation. Regarding the conservation of animal breeds, the importance of in situ conservation of cattle breeds was emphasized. Ex situ conservation was perceived as important, especially for those breeds that are insufficiently conserved in gene banks at present.

4.3. Study III: Consumer and citizen roles and motives in the valuation of agricultural genetic resources in Finland

Study III used the CV method to examine WTP for the conservation of AgGR in two different decision contexts: policy valuation question (i.e. paying for a conservation program) and product valuation question (i.e. buying a native breed product). Instead of assuming that respondents state their preferences strictly as either citizens or consumers, the roles were allowed to coexist. The aim was to analyze consumer and citizen roles in explaining WTP in both contexts and to investigate respondent heterogeneity.

In the policy valuation question, the respondents showed support for the conservation program as 72% chose to support the program, while 28% of the respondents preferred the status quo. The support was surprisingly high, even with the highest tax levels, as over 60% of the respondents supported the program even when the cost was €300 per year.

Because the tail of the WTP distribution extended beyond the upper range of the offered bids, a non-parametric measure was used to calculate the mean WTP for the conservation program. The annual mean WTP was €195.70 per year for a 10-year period by using Turnbull lower bound estimator. For a more conservative measure, the non-respondents were assumed to hold zero WTP and the Turnbull estimate of the mean WTP was €47.90.

Use and non-use motives, as well as the perceived importance of the conservation of AgGR in relation to other environmental problems, positively affected the willingness to support the conservation program. The perceptions of both taxpayer and purchaser responsibilities in the conservation of AgGR had a positive effect on the support, but taxpayer responsibility had a stronger effect in the policy valuation context.

The CV question in the consumer context concerned WTP for a genetic resource product, Finncattle meat. Only 2.5% of the meat-eating respondents stated that they would not buy Finncattle meat if it was available in stores. Over half of the respondents would buy it if the price was equal to that of conventional meat, and over 40% were willing to pay a higher price for Finncattle meat. The mean WTP was 8.2% higher than for conventional meat for the respondents willing to buy Finncattle meat. For those who were willing to pay a higher price, the average WTP was 20.2%.

Taxpayer and purchaser responsibilities affected WTP positively, with taxpayer responsibility having a stronger effect. As opposed to the policy valuation context, use and non-use motives did not affect WTP in the purchasing decision.

The results suggest that instead of being mutually exclusive, citizen and consumer roles are likely to be overlapping despite the valuation context. Therefore, the diversity of roles and the motivations of the respondents are important aspects to consider in the valuation surveys.

4.4. Study IV: The role of information in the valuation of unfamiliar goods – the case of genetic resources in agriculture

Study IV examined the effect of information use on respondents' choices and WTP for an unfamiliar good, i.e. AgGR. Based on the use of additional information provided in the survey, the respondents were divided into two groups. Both information use and its effect on individual preferences and scale were then analyzed.

Results indicated that both attitudinal and socio-demographic variables affect the use of information. Perceived taxpayer responsibility in conservation increased the use of information, whereas the perception of farmer responsibility and familiarity with native breeds and varieties decreased it. In addition, women and older respondents were more likely to read the additional information.

Overall, the respondents showed support for the conservation of AgGR. Nevertheless, there was considerable variation in preferences and WTP between those who accessed voluntary information and those who did not. The respondents who accessed the additional information chose the status quo less frequently and their choices could be explained with several conservation attributes. Instead, the choices of the respondents who did not read the information were associated with fewer significant conservation attributes, and the attribute coefficients were lower. This suggests that reading the additional information had a positive effect on utility derived from the environmental good.

Estimated WTPs for the conservation programs with low and high levels of improvement were €63 and €67 for those respondents who did not access the information, whereas for the respondents accessing the information, WTP estimates were €120 and €170, respectively.

No significant differences in mean scale between the information groups were found after the coefficient means for the attributes (i.e. preferences) were allowed to differ between the groups. This result differed from Czajkowski, Hanley and LaRiviere (2016), who found that respondents who were given more information in the CE made less-random choices.

Even though additional information was made available, only 60% of the respondents used the opportunity to read it. Those respondents who were not familiar with the good at the outset were more interested in reading the information. This is encouraging from a policy point of view, as it suggests that the share of well-informed respondents can be increased by providing an access to additional information.

5. Discussion and conclusions

This dissertation examined the value of Finnish AgGR. The studies used different valuation methods and approaches to analyze the issue from consumers' perspectives as a purchase decision (Studies I and III) and from citizens' perspectives as conservation policy support decision (Studies II, III and IV). Hence, the dissertation adds to the scarce body of literature on citizens' and consumers' preferences for AgGR in developed countries.

In valuation studies, a clear-cut distinction between consumers and citizens is rather artificial, although it is commonly used. Study III demonstrated that respondents may hold both roles simultaneously, as they exhibited consumer and citizen considerations in the public policy context as well as in the purchasing decision context. In addition, the thesis showed how respondents' information on AgGR affects their valuation (Study IV).

The analyses show that, overall, Finns are interested in preserving AgGR. Willingness to purchase Finncattle meat is high and there is a positive price premium compared to conventional meat (Study I and Study III). A high enough price premium could suggest potential for niche markets and create incentive for farmers to raise Finncattle, further helping to conserve these breeds and their valuable genetic resources. However, examining the profitability of these products on niche markets would also require information on the production costs. In addition, it is important to bear in mind the possible increased costs of processing, marketing and distributing for such niche products. Narloch et al. (2011) point out that it is possible that niche markets would only work for AgGR that closely match consumers' preferences. Hence, a large proportion of AgGR might continue to be neglected.

In Studies I and III, the willingness to purchase Finncattle meat and willingness to pay for it were modeled separately. Alternatively, these could have been modeled simultaneously by using a Heckit model (Heckman 1979), which decomposes the choice process into two stages. However, as the data contained specific features, i.e. ordered responses for willingness to purchase and grouped data for WTP, these would have been challenging to incorporate into a two-stage model.

Stated preference methods require that respondents are properly informed about the environmental good they are valuing (Álvarez-Farizo et al. 2007), hence information provision is important in the valuation of unfamiliar goods. AgGR was assumed to be unfamiliar to some of the respondents, and Study IV showed that approximately one-third of the respondents had never heard of half of the indigenous breeds and varieties presented in the Survey 2. Study IV also revealed large differences in WTP estimates between those who read the provided information and those who did not, hence highlighting the importance of information provision in the valuation of unfamiliar goods. With regards to Finnish AgGR conservation, it is important to provide information on AgGR to citizens, especially to avoid confusion of AgGR with GMO (genetically modified organism).

Overall, measuring the use of information provided in a survey is difficult. How can we know which respondents have actually perused the information and which respondents have just skimmed through it? Furthermore, the level of information required to make an informed choice varies between individuals, and standardized information set in a survey can lead to either information underload or overload depending on the respondent (Macmillan et al. 2002).

Time is often used as a proxy for information use, but spending time on information does not necessarily guarantee that respondent will read it. Additionally, reading the information still does not guarantee that the respondent is internalizing it. Some environmental valuation studies have used quizzes after the information to measure how well respondents have understood it (e.g. Aanesen et al. 2015). Future research should continue to examine ways to properly identify the effort respondents put into reading the provided information. An interesting topic would be to use eye-tracking to examine voluntary information acquisition. However, this would require a lab environment, and would not be applicable for nationwide internet surveys.

Even though the willingness to purchase Finncattle meat was high, the studies reveal greater support for a conservation program. This could be due to the fact that the conservation program provides wider conservation measures, but it could also reflect that for some respondents, buying rare breeds' meat in order to conserve the breed might seem counterintuitive.

The policy support was strong, as 76% of the respondents in Study II and 72% of the respondents in Study III supported the conservation program with an increased level of conservation despite the cost related to it. However, as revealed by Study II, there is substantial heterogeneity in citizens' preferences. This is important to take into account, as the assumption of homogenous preferences can lead to large distortions of WTP estimates. Some of the respondents support the conservation while ignoring the cost, and failure to detect this could lead to the overestimation of conservation benefits.

Obtaining estimates on the total economic value of AgGR is necessary in order to justify expenses used for the conservation. In the studies in this dissertation, estimated WTP for a genetic resource product, i.e. Finncattle meat, ranged between +20% and +26% compared to conventional meat. In turn, WTP for conservation policy program ranged from approximately €50 to €170 per year for a 10-year period depending on the method of calculation. Compared to WTP estimates from different countries (in chapter 2.4), these estimates seem to be of the same magnitude and are therefore realistic.

Conservation policy programs in this dissertation were stated to be financed with taxes, implying equal participation by all citizens. However, another possible approach in the conservation could be to use market-based incentives. Payments for agrobiodiversity conservation services (PACS) (Narloch et al. 2011) have been suggested as means to provide incentive for farmers to conserve threatened AgGR. Although PACS are mainly discussed in the context of poor communities in developed countries, FAO (2015a) suggests that this kind of approach could also be useful in Europe to better understand the support that farmers require in order to reach population targets; especially as the current support schemes prove to be insufficient to compensate true opportunity costs of farming indigenous breeds or varieties (Signorello & Pappalardo 2003, Turunen 2007). The results from Study II could be useful in providing starting point for identifying interested beneficiaries for a PACS scheme and defining possible buyers in addition to state. Furthermore, as the results-based agri-environmental policies are a topical issue and there is discussion on how this new policy scheme could be implemented, AgGR conservation could provide an interesting opportunity to test results-based policies, as the conservation results are easily verifiable.

For good policy decision making, it is necessary to evaluate the effects (both benefits and costs) of the policy. Even though determining the value of the AgGR conservation benefits is difficult and the value estimates may not be perfect, neglecting the valuation of benefits is more problematic. Assessing the value of AgGR from the viewpoint of citizens and consumers provides important information for decision makers that should be taken into account in the policy design.

The analysis in this dissertation is based on neoclassical economics. The central assumptions include, for example, that individuals have rational and identifiable preferences and that they maximize their utility. However, these assumptions have been criticized for being unrealistic and not holding well in the real world as people often lack clearly defined preferences, especially for complex or unfamiliar goods, such as genetic resources. Furthermore, the value of AgGR to society might be something other than aggregated individual preferences alone.

Deliberative monetary valuation (DMV) has been proposed as an approach that could overcome these problems. DMV is a participatory method using deliberation, discussion and social learning in small groups in order to produce more informed choices and thus greater legitimacy (Spash 2007, Howarth and Wilson 2006). However, few empirical applications of DMV exist and most are small-scale studies. As the objective in this dissertation was to examine the values citizens and consumers place on AgGR at a national level, employing the DMV method was not feasible. Using more established valuation methods provided a good starting point for the valuation of Finnish AgGR, but in future work, a DMV approach could provide an interesting additional perspective to integrate the value of AgGR in decision making. A more participatory approach could also be used to examine what factors affect consumers' and citizens' views on the importance of AgGR conservation and how, for example, property rights, health and security can be considered in the implementation of conservation programs.

In order to support the Finnish conservation policy design, a cost–benefit analysis needs to be conducted. Cost-benefit analysis helps to maximize social net benefits and would, therefore, guide efficient conservation design. It would be especially useful to compare the costs and benefits of in situ and ex situ conservation methods, while taking into account the TEV of AgGR. Some studies have recommended ex situ conservation as less expensive and less vulnerable method. However, these studies often neglect the additional benefits of in situ conservation, such as visibility of local breeds in the landscape or the ability to use their products. This dissertation provides the estimates on the

TEV of AgGR conservation benefits in Finland, hence, next the focus should be shifted on the calculation of conservation costs.

It is important to understand, however, that a cost-benefit analysis with a utilitarian perspective is just one way, with known limitations, of understanding the economic logic of conservation. Examining the broader economic rationale and going beyond instrumental and intrinsic values by including relational values, is an emerging subject of research (see e.g. Himes & Muraca 2018, Chan, Gould & Pascual 2018) that could also offer new approaches to assess agri-environmental policy.

During the time of dissertation work, the population of Eastern Finncattle has increased and it is no longer endangered. However, at the same time, the population of previously more common Western Finncattle has dropped and the population is now smaller than the population of Eastern Finncattle. This highlights the fact that even though some progress has been made in the conservation of AgGR, there still are endangered and vulnerable breeds and varieties, and action is needed in order to enhance the conservation and to avoid genetic erosion. As the world is facing climate change, preserving genetic diversity and the ability to adapt to changing conditions becomes more important than ever.

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Natural Resources Institute Finland
Latokartanonkaari 9
FI-00790 Helsinki, Finland
tel. +358 29 532 6000