**The economic value of Farm Animal Genetic Resources (FAnGR)**

**By Warwick Wainwright**

**Supervisory panel**

Prof. Dominic Moran (SRUC, Land Economy, Environment & Society)

Prof. Geoff Simm (SRUC, Vice Principal Research)

Dr. Antonio Ioris (UoE, Human Geography)

**Advisor**

Dr. Marisa Wilson (UoE, Human Geography)

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**Executive Summary**

The diversity of Farm Animal Genetic Resources (FAnGR) is a crucial component of resilient agricultural systems. Increasingly intensified production has resulted in a global tendency towards ‘exotic’ (non-native) breeds that generally offer improved yields but displace local breeds, resulting in lower (between breed) diversity. Many indigenous breeds are resilient in specific agro climatic conditions and reflect strong regional identities whilst producing distinctive products embedded in cultural tradition.

Economic analysis of FAnGR is generally underpinned by two main distinctions; (i) understanding demand or value associated with FAnGR and (ii) the costs of supplying genetic resources (i.e. economic efficiency / current and future levels of supply). We focus mainly on the supply side of FAnGR management and explore the most effective economic and policy measures for ensuring efficient supply of genetic resources. Further exploration of these mechanisms (Choice Experiments, Competitive Tender, Weitzman approach and Social Network Analysis) has been lacking in the literature and is urgently needed to ensure conservation spend is maximised to deliver greatest supply of genetic resources relative to the costs.

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# 1.0 Introduction

Globally, the livestock sector accounts for 40% of agricultural Gross Domestic Product (GDP) and employs 1.3 billion people (Steinfeld *et al.*, 2007). Global production of meat is projected to more than double from 229 million tonnes in 1999/01 to 465 million tonnes in 2050 whilst milk production is expected to grow from 580 to 1,043 million tonnes (Steinfeld *et al.*, 2007). Increasing demand for livestock products is particularly strong in developing countries where growing populations, rising incomes and changing consumer preferences have resulted in increased demand. The environmental impact per unit of livestock must be cut by half (Nellemann, 2009) which means increasing efficiencies per animal, where future livestock breeding programmes will play a key role.

Genetic diversity forms a crucial element in resilient and sustainable agricultural systems (MEA, 2005; UNEP, 2010). Breed diversity is the result of many years of natural and human-directed selection, genetic admixture, mutational events and genetic drift, as production environments have changed (Hoffmann, 2010). Many breeds underpin our cultural traditions, reflect strong regional identities and produce distinctive products such as hides, cheeses and flavoursome meats (Gandini and Villa, 2003). These breeds also serve a range of other purposes (e.g. transport, draught power) in developing countries (Drucker et al., 2001).

Agrobiodiversity (the diversity of plant varieties and animal breeds) often receives less attention than its more “natural” counterpart (naturally occurring species richness) and has been declining. In response to these challenges, the United Nations Food and Agricultural Organisation (FAO) commissioned the world’s first global report entitled *“State of the Worlds Farm Animal Genetic Resources”* (FAO, 2007). Acknowledgement for the need to enhance monitoring, classification and characterisation of local breeds led to the FAO’s *“Global Plan of Action for Animal Genetic Resources”* (FAO, 2007). Strategic Priority Area Four within this report entitled ‘Policy, *Institutions and Capacity Building’* highlights a number of economic considerations which must be addressed to safeguard genetic diversity.

Our work follows on from this action plan and aims to address economic and policy level considerations concerning the design of conservation programmes. Management of FAnGR is inherently a question of supply and demand. The supply side perspective concerns declining levels of supply, which are mainly attributed to economic factors (i.e. reduced profitability of traditional breeds, marketability of animals, carcass conformity requirements and consumer tastes). Supply is inherently related to demand but the measurement or expression of the latter is complicated by the public good nature of genetic resources (non-rival, non- excludable) meaning that they are typically under-supplied by the market. Further, the costs of conservation are largely private and local, whereas the benefits of conserved diversity are more diffuse and not completely captured by those incurring the conservation costs.

To determine the optimal (or economically efficient) supply it is important to understand the societal demand and willingness to pay that may approximately compensate the supply cost. The demand side comprises different elements of value often termed the Total Economic Value (TEV) derived from genetic resources. It is important to distinguish elements of TEV and to work out which element can be transacted by existing markets and which need non market approaches for their identification.

# 2.0 Aims and Objectives

A range of conservation mechanisms (both *in situ* and *ex situ*) and economic instruments (Weitzman Approach and Competitive Tender) exist to support FAnGR conservation. The most effective ‘mix’ of these methodological approaches will influence the success of a conservation scheme and by extension value for money. We plan to identify optimal instruments and mechanisms for supplying FAnGR in case study countries.

## 2.1 Aims of Research

The primary aim of this PhD is to provide “*an economic assessment of FAnGR conservation”*. A number of secondary aims contribute to this overarching goal:

* Analysis of optimum definition for defining rare breeds
* Identification of key factors which currently govern supply of FAnGR
* Assessment of market and non-market based values associated with FAnGR
* Appraisal of economic instruments which have potential to increase FAnGR conservation efficiency
* Evaluation of policy mechanisms influencing supply of genetic resources

## 2.2 Key Research Questions

Key research questions underpinning the PhD can be categorised as supply and demand side factors and are outlined below.

2.2.1: Supply questions

How is supply measured and what are the current levels of supply?

What are the societal costs of increasing / decreasing genetic resources? (I.e. it is thought more diversity is generally preferred and we are damaged by loss - is this the case?)

What measures (regulatory, economic and policy) help to conserve FAnGR?

Which measures work best (i.e. most effective)?

What do economic measures (i.e. Payments for Ecosystem Services) cost – what might a notional supply curve look like?

Where should we implement key measures for optimal diversity conservation? (i.e. geographical coverage, institutions maintaining supply, breeds supported)

Who should maintain supply and implement supply measures (i.e. which farms / farmers) and what would a successful social network look like?

2.2.2: Demand questions

Who values FAnGR and what is the scale of demand?

How do we measure this demand and what does existing value tell us?

What Willingness to Pay (WTP) information might we need?

How do private individuals or government transact for this demand (market and non-market methods)

How might increased understanding of demand/WTP for FAnGR go in terms of incentivising the right supply? What mix of the market and government do we need?

# 3.0 Literature Review

## 3.1 What are Farm Animal Genetic Resources (FAnGR)?

3.1.1 The history of agrobiodiveristy:

Agricultural biodiversity is the product of thousands of years of human-induced genetic modification which has targeted adaption to a range of climatic and ecological conditions (FAO, 2007). Most of the approximately 40 animal species relied upon worldwide today were domesticated around 10,000 to 12,000 years ago (Simm, 1998). Many of these species originated in areas of the world now occupied by developing countries (Figure 1) and were subsequently transported globally following colonisation, human migration and trade (Hiemstra et al., 2006). Today, domestic animals supply around 30% of total human food requirements; whilst only 15 animal species worldwide account for 90% of livestock production globally (Villanueva et al., 2004). In developing countries, ~70% of the world’s rural poor rely on livestock for their livelihoods (Hiemstra et al., 2006).

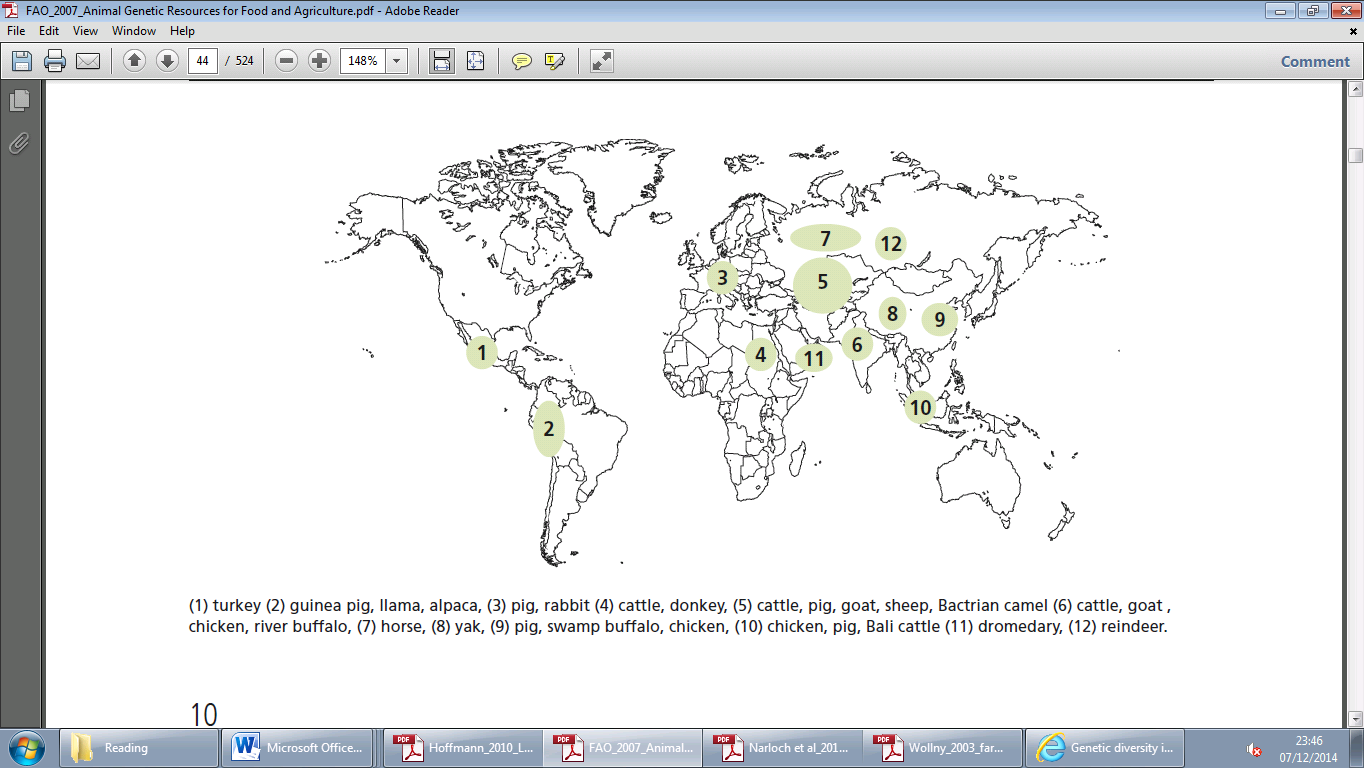


Figure : Major centres of livestock domestication (FAO, 2007)

3.1.2 Factors defining a breed

A breed of livestock is essentially a recognised group of interbreeding animals of a given species. Animals belonging to the same breed are usually of fairly uniform appearance which distinguishes them from other breeds (Villanueva et al., 2004). In other cases, animals belong to the same breed by virtue of their geographical location which can result in a wide range of appearances. Breeds have been created through geographical or human induced reproductive isolation (i.e. mating between separate groups of animals within the same species). This has resulted in animals of interbreeding type (breeds) which possess similar genetic characteristics.

Breeds exhibit a greater number of similar genes compared to animals of different interbreeding groups. This is because interbreeding animals share common genes or alleles through mating’s between closely related animals. This results in common traits which occur in breeds (e.g. hoof size) which can be selected for through specific mating’s between animals. Today, breeds have been developed through reproductive management (selective mating’s) which usually target specific genetic traits which may be adaptive (e.g. heat stress tolerance) or productive (e.g. milk yield).

3.2.3 Characterisation of diversity

Biological diversity is characterised at different scales and by different measures of diversity. Taxonomic diversity; species diversity; ecosystem diversity; morphological diversity and genetic diversity are important measures of overall biological diversity (Magurran, 2013). These can further be measured at different scales (i.e. alpha, beta or gamma diversity) (Yoccoz et al., 2001). Breed diversity mainly encompasses measures of genetic, morphological and physiological diversity. Genetically, breed diversity falls under two main umbrellas, within and between breed diversity. Both are important indicators of the viability of (i) a population of interbreeding animals; (ii) a particular trait or feature of interest within a species of animals. Morphological diversity refers to the structure and phenotypic characteristics of animals. Physiological diversity encompasses the growth, reproduction and respirational features of animals which allow them to inhabit different environments (Hill et al., 2004).

## 3.2 Genetic diversity and genetic improvement

3.2.1 Genetic principles influencing breeds

DNA (Deoxyribonucleic acid) is a central information reservoir and is made up of strands which are connected by bases. Genes are made up of particular sequences of bases at particular locations in DNA molecules (Vajta and Gjerris, 2006). The process of inheritance is built into genes which occur in sequences often linked to a string of beads on the chromosomes, which are present in the nuclei of all cells (Vajta and Gjerris, 2006). In all cells accept the gametes (sex cells) the chromosomes occur in pairs. Each sperm and each egg of an animal only carries a single set of chromosomes. When sperm fertilises an egg, the resulting embryo carries a combination of chromosomes both from the mother and farther. Only genes transferred through chromosomes in the gametes result in characteristics which will be inherited by offspring and can change populations. The location or the site of a gene (or allele) along the chromosome is called a loci. The genetic distance between breeds can be estimated from the difference in the frequencies of different alleles at a number of marker loci (Simm, 1998).

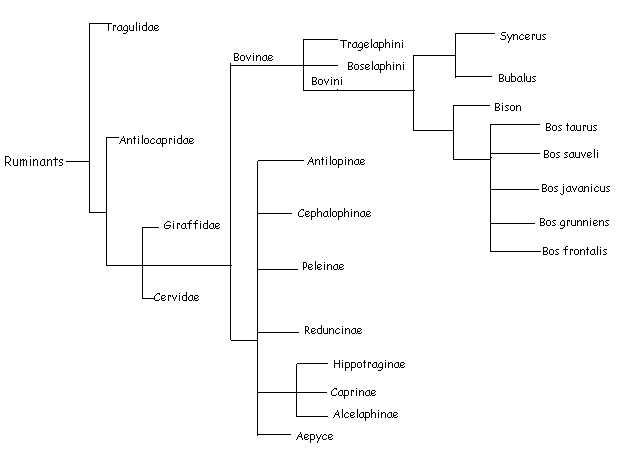


Figure : Example of a phylogenetic tree for *Bos taurus* cattle (Hayes, 2007)

Breeds which are genetically closely related share the same alleles at similar frequencies whereas those having the same alleles at different frequencies are further apart (Blott et al., 1998). Alleles which are different altogether add to this variation. Distances between breeds can be summarised using a phylogenetic tree (an example of which is given in Figure 2 for *Bos taurus* cattle) or by multidimensional scaling.

Cell division is a key process underpinning the diversity of animals. Whether cell division is occurring during growth or in the production of sperm of eggs, the copying of DNA is usually correct (i.e. identical to the original strand). However, mistakes do occur and the sequences of bases in the new copy of the DNA strand are slightly different from the original. If these gene mutations occur in the gametes they lead to changes in the genetic code of offspring (Simm, 1998). Much of the variation among farm animals exploited by human selection is a result of mutations (occurring during cell division) which have transpired over many generations (Andersson, 2001).

The genotype (i.e. the combination of genes or alleles which an animal inherits) of an animal is based upon the contribution of chromosomes and genes across generations and results in the similarity we see between relatives (inheritance). Animals which carry two copies of the same allele are said to be homozygous for that particular allele; while animals carrying different copies of a gene are said to be heterozygous (Andersson, 2001). If there is much variation, most animals will be heterozygous for particular traits (Blott et al., 1998). In small populations of animals changes may occur by chance alone and these changes in gene frequency are called genetic drift (Simm, 1998).

By predicting the outcomes of matings between different parents animal breeders attempt to maximise genetic gains within farm animals and carefully select males and females for genetic improvement (Gamborg and Sandøe, 2005). Most traits of economic importance in farm animals are controlled by genes at many different loci, making things more complicated, and have many ranges of performance. Alleles which were paired in parents pass to the next generation singly. This process of unpairing and mixing of genes is called segregation and results in the genetic variability passed onto future generations (Taylor, 1995).

3.2.2 Why genetic diversity is important

Genetic variation is fundamental to genetic improvement and the four main sources of variation are outlined in Table 1. The genotype of animal is a factor of both genetic and environmental factors and offers important variations in farm animals. Genetic improvement depends wholly on genetic variation. Maintaining this variation both within and between breeds is vital to ensure there are enough genes present in animals at different locus to influence genetic improvement (Notter, 1999).

Table : The four main processes resulting in genetic variation in species (Simm, 1998)

|  |  |
| --- | --- |
| **Process of variation** | **Description** |
| *Differences in allele frequencies* | Differences in gene frequencies are a major source of variation between groups of animals because there is an element of chance as to which parent’s alleles the offspring receives. As such, some alleles carried by parents might never appear in the offspring, while others might appear often. |
| *Segregation of alleles* | Segregation occurs due to the separation and chance sampling of paternally and maternally derived genes during meiosis (the cell division which occurs during the production of gametes as sperm or eggs only carry a single copy of each allele at any locus). Subsequently, which gene will be passed down is a chance effect. |
| *Recombination* | Recombination works with segregation and is the crossing over of segments of maternally and paternally derived members of a pair of chromosomes during meiosis. This helps to mix the genes present in a breed and to create new combinations of genes which contributes to genetic variation. |
| *Mutation* | The variability in genes present at any locus have arisen due to mutations over time. New gene mutations are a particularly important source of variation in populations which have been under intensive selection for a long time and are largely responsible for populations continuing to change even after intense selection |

3.2.3 Genetic improvement and selection

Selection for genetic improvement relies on three main methods; within breed selection, between breed selection and crossbreeding. Selection within breeds relies on comparing animal performance within the same breed. This method of selection relies primarily on genetic diversity within breeds to enhance desirable traits (Bruford et al., 2004). Genetic diversity within a breed ensures enough genetic variation can be sought from mating unrelated animals to continued expansion of the gene pool (Markert et al., 2010; Strasburg et al., 2011; Hoffman et al., 2014). The effective population size (Ne) of a breed is important to ensure sustainable genetic resources are maintained. Ne is a calculation tool which quantifies how a particular population will be affected by genetic drift or inbreeding. Effective size takes into account both the current census size of a population, but also historical records. The effective population size is the size of an ‘ideal population’ (whereby ‘ideal’ refers to a hypothetical population in the Hardy Weinberg equilibrium with a constant population size, equal sex ratio and no immigration, emigration, mutation or selection) that would experience the effects of drift or inbreeding to the same degree as the population of study (Nomura et al., 2001).

The chance that two copies of a gene will be sampled as the next generation is produced is impacted by the breeding structure of the population (Braude and Low, 2010). In a population of size N there will be 2N genes. The correct interpretation of N is when the chance of drawing two copies of the same gene is (1/2N) 2 (Taylor, 1995). If two genes are drawn from a population at a specific locality, we may be more likely to get two copies of the same gene (i.e. local adaption of animals). Low effective population sizes can result in inbreeding or genetic drift in small or isolated populations. Anything that increases the variance among individuals in reproductive success (of an ‘ideal’ population) will reduce Ne. In many industrial breeds Ne<50 is common (Table 2) (Taberlet et al., 2008).

Table : Examples of effective population sizes in some cattle breeds. Adapted from (Taberlet et al., 2008)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Cattle Breed** | **Country** | **Period** | **Census population size** | **Effective population size** | **Reference** |
| Holstein | Germany | 1999 | ~2.2 million | 52 | (Koenig and Simianer, 2006) |
| Holstein | USA | *1999* | ~8.5 million | *39* | (Weigel, 2001) |
| Jersey | Denmark | *1993-2003* | ~640 k | *53* | (Sørensen et al., 2005) |
| Danish red | Denmark | *2001-2003* | ~560 k | *47* | (Sørensen et al., 2005) |
| Japanese black | Japan | *1993-1997* | ~530 k | *17* | (Nomura et al., 2001) |
| Montbeliarde | France | *1988-1999* | ~700 k | *125* | (Boichard et al., 1996) |
| Normande | France | *1988-1991* | ~800 k | *47* | (Boichard et al., 1996) |
| Tarentaise | France | *1988-1991* | ~14 k | *27* | (Boichard et al., 1996) |

Selection between breeds relies on a diverse set of genotypes across a range of breeds. In general, the difference between breeds reflects their geographical origin (i.e. common ancestry) rather than primary use (e.g. dairy) as outlined in Figure 3. Breeds from mainland Britain tend to have less genetic variation (i.e. less heterozygosity) than continental breeds such as Limousin or Charolais; most likely related to the smaller Ne in British breeds (Blott et al., 1998).

Genotypes do not always rank the same in different environments and therefore the superiority of a particular genotype in one production environment may be differently suited to another (Gillespie et al., 1988; Kolmodin et al., 2002; Via and Lande, 1985). These factors have been further explored by analysis of productive Vs adaptive traits and have been well studied by a number of authors (Anderson, 2003; Cicia et al., 2003; Hodges, 1990; Hoffmann, 2010).

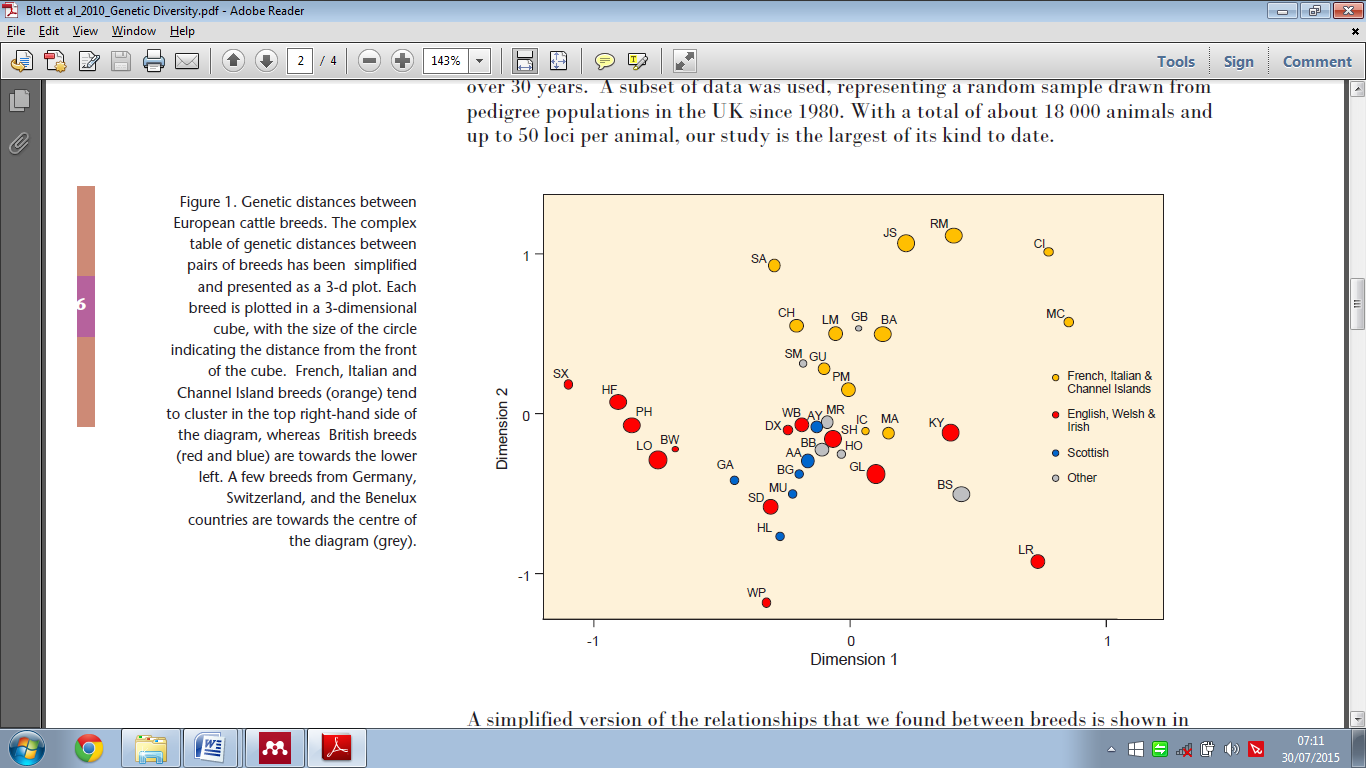


Figure : Genetic distances between European cattle breeds. Each breed is plotted with a three dimensional cube, with the size of the circle indicating the distance from the front of the cube. The letters indicate abbreviations of the breeds (i.e. AA = Aberdeen Angus). Breeds with lower diversity represent smaller circles. Their genetic distinctiveness is related to distances from other circles in the graph (Blott et al., 1998)

## 3.3 Zootechnical regulations: What defines a rare breed

3.3.1 What defines a breed

The definition of a breed has important connotations when considering conservation of genetic resources. Key questions surrounding this issue concern:

* the degree of genetic distinctness of a group of animals;
* geographical / regional consolidation of animals and;
* cultural / aesthetic values associated with a breeding group

Köhler-Rollefson (1997) states that a domestic animal population can be regarded as a breed if the animals fulfil the criteria of being subjected to a common utilisation pattern; share a common habitat or distribution area; represent a largely closed gene pool and are regarded as distinct by their breeders. The FAO (1999) note that a breed should be either;

* a specific group of domestic livestock with definable and identifiable external characteristics which enable it to be separated by visual appearance from other similarly defined groups within the same species or;
* a group for which geographical and / or cultural separation from phenotypically similar groups has led to acceptance of its separate identity

3.3.2 Defining risk status of a breed

Breeds may be ‘at risk’ because they are scarce, have low genetic variability, are geographically isolated (e.g.Herdwick sheep) or because of adaption to a particular environment (DEFRA, 2006). The FAO (1998) generally define a livestock breed as not being at risk if there are over 1000 breeding females and 20 breeding males (Narloch et al., 2011). In the UK, the Rare Breeds Survival Trust (RBST) acceptance procedure for a breed to feature on the RBST ‘watchlist’ requires continuous existence of the breed for 75 years and at least two of the following criteria:

* have accepted herdbook registrations for six generations;
* less than 20% genetic contribution from other breeds;
* parent breeds used in the formation of the breed are no longer available

Additionally, there must be fewer than the following number of breeding females in pigs (500); goats (500); cattle (750); horses (1,000) and sheep (1,500) . Importantly, the DEFRA FAnGR Committee Breeds at Risk (BAR) list and the RBST ‘watch list’ remain unaligned in definition. The FAnGR committee have aligned their definition of BAR more in-line with the FAO’s classification, whilst the RBST’s ‘watch list’ remains less aligned. This mis-match between risk classification reduces the opportunity for collaboration and concerted action in the direction of breed conservation. This acceptance criterion largely also ignores Nesize and geographical concentration of breeds. The numerical categories associated with risk status are generally defined independently of the generation intervals of livestock species concerned (Simon, 1999). Ruane and Oldenbroek (1999) determine the degree of endangerment as the most important criterion for breed conservation since this is most likely to reduce agro-biodiversity. Most criteria for defining the risk status of livestock breeds focus on population data and largely ignore key genetic variables which reduce the effectiveness of classification.

3.3.3 Assessment of breed endangerment

There are four primary indicators which can identify breeds at risk (see Figure 4):

* numerical scarcity (which accounts for inter-species variation in generation intervals, reproductive rate and mating ratio within animals);
* geographical concentration (Weighted Mean Centre (WMC) of the breed. A threshold of 75% of the population of a breed within a 25km radius of the WMC is proposed by Alderson (2010));
* Ne >50 is regarded as a safe population (Kristensen et al., 2015);
* genetic erosion (levels of introgression (which should be set at a threshold of 12.5%), inbreeding (at a threshold of 1% per generation) and genetic drift).

Figure : Critical components underlying breed risk factor

3.3.4 How does definition of breed endangerment influence conservation?

Classification of breed endangerment has potential implications for prioritising which breeds should be conserved. Table 3 describes an analysis undertaken by Simon (1999) describing the percentage of 1,029 European livestock breeds in each risk category with live conservation programmes. The overall R2  value of 0.12 (a correlation between class of endangerment and percentage of conservation programmes) is not significant meaning risk status does not significantly influence conservation. This warrants more exploration given most ‘breeds at risk’ lists largely focus on numerical populations of breeds.

Table : The percentage of breeds with live animal conservation programmes by class of risk category (Simon, 1999)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Class of endangerment** | | | | | **R2** |
| **1) Not. Endang** | **2) Pot. Endang** | **3) Min. Endang** | **4) Endang.** | **5) Crit. Endang** |
| **Cattle** | 39% | 60% | 42% | 67% | 50% | 0.6\* |
|
| **Sheep** | 30% | 48% | 67% | 29% | 19% | -0.44 |
|
| **Goats** | 30% | 13% | 14% | 25% | 0% | -0.62 |
|
| **Pigs** | 13% | 35% | 60% | 33% | 38% | 0.62 |
|
| **Horses** | 42% | 26% | 42% | 40% | 38% | -0.32 |
|
| **Total** | 32% | 45% | 49% | 43% | 33% | 0.12 |
|

\*\*P <0.05

## 3.4 Why conserve FAnGR?

Cicia et al., (2003) demonstrated the benefit to cost ratio for FAnGR conservation is 1.67; wholly justifying conservation policies. FAnGR delivers a number of ecosystem services at local, national and global scales (Notter, 1999) and these benefits are summarised in Figure 5 according to use process, ecosystem service provision and benefit values ascertained (De Groot et al., 2002; Haines-Young and Potschin, 2010). These ecosystem service benefits are associated with both use and non-use values (Gollin and Evenson, 2003) and are highlighted in Table 4.

Table 4: Use and non-use values associated with FAnGR

|  |  |
| --- | --- |
| **Type of value** | **Description** |
| Direct use | Food; fibre; tourism; landscape management; breeding programmes and; habitat creation |
| Indirect use | Risk aversion; climate change adaption |
|  |  |
| Option values | Future breeding programmes |
| Bequest values | Value from the knowledge that others might benefit from breed diversity in the future |
| Intrinsic values | Phenotypic characteristics (diversity) can be viewed |
| Existence values | Value from knowing rare breeds exist |
| Cultural values | Conservation of cultural heritage |

Food Production

Tourism

(e.g. farm parks)

Preservation of regional identities in farming

Rural employment

Distinctive local products (e.g. PDO / PGI)

Habitat mosaic

Landscape maintenance

Cultural heritage

Aesthetic purposes

Materials (e.g. wool)

**Provisioning**

Food

Moderation of extreme events

**Regulating**

**Supporting**

Maintenance of genetic diversity

Nutrient cycling

**Cultural**

Habitat creation

Conservation grazing

Animal Breeding

**Benefit values**

**Ecosystem Services**

**Usage Process**

Adaptable and resistant breeds for future breeding programmes

Animal welfare

Reduced avalanche risk

Fire hazard control

Figure 5: Ecosystem services associated with conservation of FAnGR. Thickness of the arrows indicates the strength of linkages between each process

3.4.1 Direct use values

Genetic resources have a considerable economic value (Notter, 1999). The United Nations Comtrade figures indicate global trade in bovine semen was worth US$ 400 million in 2012 whilst the rate of market growth was 21 percent over this period. Exports of purebred horses, cattle and pigs, all of which may include large shares of breeding animals from hybrid breeding programmes, have increased nearly 500 percent between 2000 and 2012 (Hoffmann et al., 2014).

Livestock outputs serve as a source of food (milk, meat and eggs), shelter and protection (hides and pelts), energy (transport and draught power), fuel and fertiliser (manure), savings (cash value and insurance) and cultural values (community prestige and tradition). Gandini et al., (2010) interviewed 371 farmers of 15 local cattle breeds in 8 European countries to determine farmer’s motives and values in keeping local cattle. Farmers ranked the functional traits of breeds most highly, followed by tradition and the availability of external support. In West Africa Tano et al., (2003) demonstrated the most important traits of breed conservation were found to be disease resistance, fitness for traction and reproductive performance.

Beyond marketable outputs, traditional breeds possess a number of adaptive traits which are used heavily in landscape management. In Austria, the risk of avalanches in the high Alps is reduced by grazing steep slopes above the tree line with traditional breeds. In France, local breeds are used for the protection of Mediterranean forests against fire risk (Ligda and Zjalic, 2011). Traditional breeds also possess adaptive characteristics of economic importance such as resistance to trypantolerance in African ruminants and helminth resistance in certain sheep breeds across tropical and temperate regions (Thornton et al., 2007; Thornton, 2010).

3.4.2 Indirect use values

FAnGR diversity also contributes to a range of non-use values mainly associated with risk aversion and climate change adaption. Multi species and multi breed herds is one strategy some traditional livestock farmers use to buffer against climatic and economic adversities (FAO, 2015). Analysis undertaken by Hoffman et al., (2014) of the FAO’s DAD-IS database showed a wide range of resilience and plasticity across breeds, indicating that genetic diversity of the world’s livestock provides a range of options that are likely to be valuable in climate change adaption. Among 834 national breed populations with information available on habitats, 45 per cent are reported to be adapted to high mountains and climatic extremes (Hoffmann et al., 2014). Furthermore, mathematical models by Springbett et al., (2003) and evidence from Mitchell et al., (2002) indicate that high species / genetic diversity within populations reduces the occurrence of disease epidemics and their outcomes.

3.4.3 Future option values

FAnGR are increasingly recognised for their importance in future breeding programmes. Jackson et al., (2007) conveys this as sustainagility in farming systems (Figure 6). Conservation occurring at the gene level delivered across multiple institutional scales maximises adaption effects within agriculture (Jackson et al., 2007).

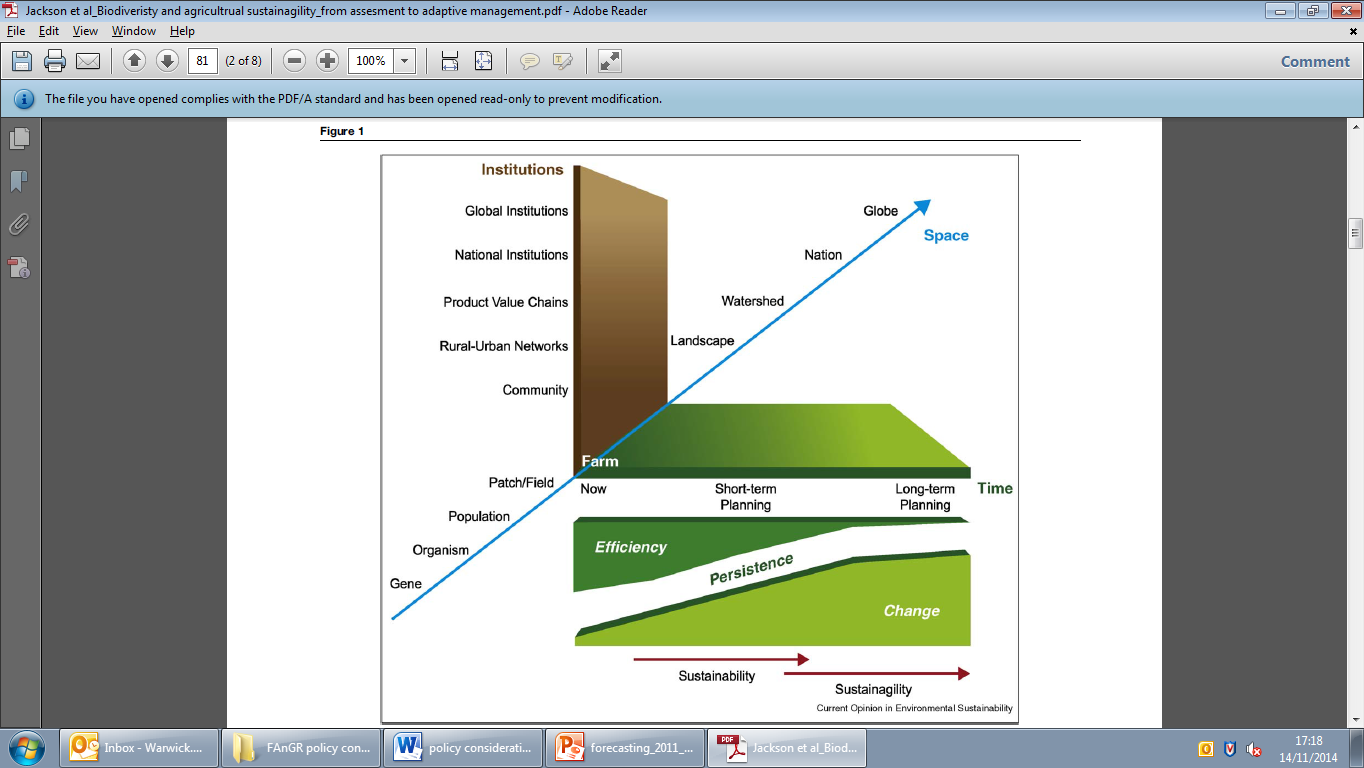


Figure : The core components of sustainagility within agricultural landscapes (Jackson et al., 2007)

A major argument for conservation of agrobiodiveristy is that breeds are central reservoirs of genetic variation which allow breeders to respond to new market signals or changing environmental conditions (Mathias and Mundy, 2010 ; Pouta, 2011). It would be difficult and costly to reinstate this genetic variation (Stoneham et al., 2010). There may also be new traits that have not been part of breeding objectives in the past but will be in the future (Hayes et al., 2013). Reducing methane emission intensity is likely to become a core part of the breeding goals associated with cattle and sheep (Aguilar et al., 2010; Bloemhof et al., 2008; Haile-Mariam et al., 2008; Hayes et al., 2003). Such changes require adaptive FAnGR (Macdonald et al., 2008).

3.4.4 Bequest, existence and cultural values

Other arguments for conserving rare breeds mainly stem from aesthetic purposes, which denote that livestock breeds are a part of our cultural heritage and are worthy of preservation (Gandini and Villa, 2003). Morgan-Davies et al., (2014) found that hill beef farmers in Scotland significantly differed in their views regarding breed hardiness, suitability and reasons for choice of breed. CE studies on threatened cattle breeds in Spain (Martin-Collado et al., 2014) and Italy (Zander et al., 2013) revealed cultural, existence and future option values of breeds make up more than 80 percent of their TEV (Zander et al., 2013). Several studies also mention the potential contribution of livestock breeds to tourism and recreation activities. For instance, the Bernheimer sheep in Germany North Rhine nature reserve is noted as a popular tourist attraction (Rook et al., 2004). In the UK, the RBST has approved farm parks (DEFRA, 2012) as both tourist attractions and conservation centres for rare breeds (e.g. The Cotswold Farm Park).

3.4.5 Intrinsic values and fangr

The Interlaken Declaration on Animal Genetic Resources (2007) recognises the *“intrinsic value of biological diversity and the environmental, genetic, social, economic, medicinal, scientific, educational, cultural and spiritual importance of breeds of livestock, and our ethical responsibility to ensure genetic resources are available to future human generations”* (Hoffmann, 2009). The CBD are also “conscious of the intrinsic value of biological diversity” (Roosen et al., 2003).

Intrinsic values are generally defined as the ‘end value’ or the value something has in itself (Ghilarov, 2000). These are normally values unrelated to human use (i.e. the right of an animal to exist). They are not usually measurable (Drucker et al., 2001) and, whilst being relevant to conservation decisions, do not help to define actions in the context where choices have to be made (i.e. limited conservation funds). Economic valuation on the other hand can be seen as an anthropocentric approach to asset management (i.e. the economic value of a resource to people) (Pearce and Moran, 1994).

Given intrinsic values are not measurable they are largely ignored through economic approaches which has led critics of economic valuation to argue that conservation is a moral issue and should be determined by the rights of other species (Laurila-Pant et al., 2015). Inflicting economic conditions on the conservation of biodiversity is often regarded as contravened. However, Pearce and Moran (1994) argue:

* The economic view can also be regarded as a moral view given it takes a utilitarian approach to conservation
* Given funds are limited, a utilitarian approach is likely to be superior from the viewpoint of saving biological diversity in real world contexts
* Due to resource constraints and expanding human populations, it is inevitable that further loss of biodiversity will occur, so establishing priorities for conservation is essential
* Given ‘economic’ causes are important, a practical agenda for conservation should include economic factors
* Most people are utilitarian and so it is the only approach which fully explains why biodiversity is being lost (at current rates) and hence corrective tools (policy) which may alleviate pressures

Within and between breed diversity is again slightly different to ‘natural’ biodiversity (i.e. naturally occurring populations with in and out migration of species not under selection). The concept of a breed is inherently a social construct which does itself highlight the overarching instrumental and cultural values associated with breed diversity (Roosen et al., 2003).

Neoclassical economic theory denotes the determination of prices, outputs and income distribution in markets through supply and demand (Daly and Farley, 2011). Rational choice theory (i.e. market choices taken in response to available information) is a central pillar of the neoclassical approach and is a framework for modelling social and economic behaviour in markets. Understanding decision making by individual actors in the market can infer individual preferences and values for a specific resource (i.e. breed diversity).

We argue these values are imperative to the decision making framework through which FAnGR conservation priorities should be established (as opposed to overarching moral arguments to conserve all FAnGR). Markets have dictated the evaluation of breeds and breeding programmes in response to changing market demands (i.e. consumer tastes, production environment and growing populations). Therefore, conservation, we argue, should be justified based wholly on such economic arguments.

## 3.5 Global stocks of FAnGR

3.5.1 Global breed diversity and distribution

Of the approximately 8,200 breeds reported to FAO, more than 2 500 are at risk of extinction or already extinct. During the first six years of this century 62 breeds became extinct (FAO, 2007). The FAO’s Global Databank for Animal Genetic Resources identified around 20 % of reported breeds are classified as ‘at risk’ (FAO, 2007). The proportion of mammalian breeds classified as at risk is 16% compared to 30% for avian breeds. Globally, the number of breeds that have become extinct is 9% (690 breeds); whilst the number with unknown data is 36% (2732 breeds) (Figure 6). The picture of breed diversity is somewhat confounded by the disparities of global reporting between regions. Areas such as Europe and North America have almost complete coverage of existing breeds, whilst many developing countries lack comprehensive data (Hoffmann, 2011). Improved monitoring, reporting and typology of breed status has been identified as a priority by the FAO (Cardellino and Boyazoglu, 2009).

Figure 6: Total number of breeds (mammalian and avian) according to FAO risk status. FAO (2007)

The global distribution of breed diversity is fairly heterogeneous (Figure 7). Asia represents a continent of high agro-biodiversity. Europe, the USA, Brazil and India also contain high levels of agro-biodiversity. Agrobiodiveristy conservation is particularly important in developing countries, where ~70% of livestock breeds are found (Drucker et al., 2001).

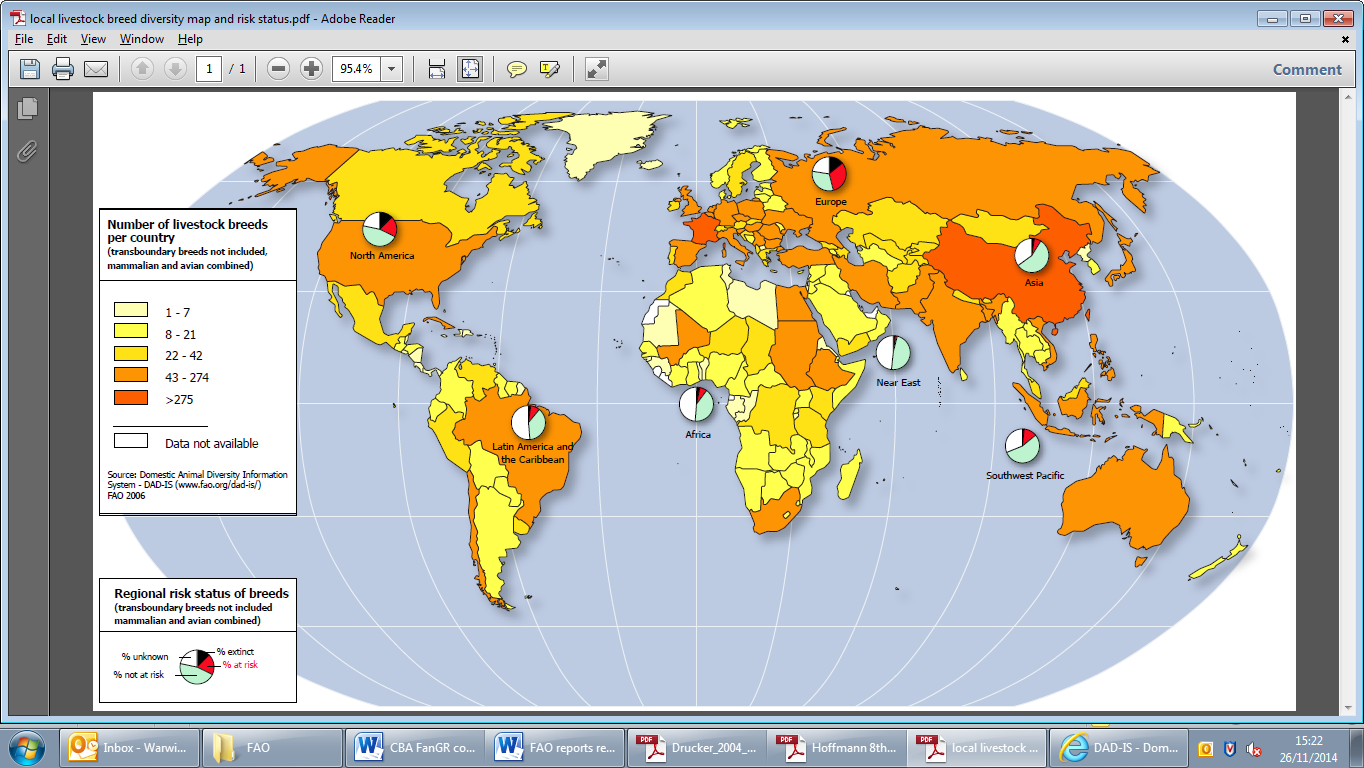


Figure 7: Distribution of the worlds FAnGR and regional risk status of breeds. FAO (2007)

## 3.6 Threats to genetic diversity in farm animals

3.6.1 Intensification

The livestock intensification process has been driven by increasing consumer demand for a range of livestock products coupled with relentless pressure from supply chains to reduce production costs (Ajmone-Marsan, 2010). This process has been facilitated by technological advances in genetics, (Groeneveld et al., 2010a; Hoffmann, 2011). A lack of structured breeding programmes in developing countries has resulted in the unsuitable introduction of some exotic livestock breeds (Hiemstra et al., 2006). Traditionally, the selection of animals in tropical breeds has been an adaptive one, but in recent times market forces have stimulated a rapidly changing demand for higher production that could not be met rapidly enough by genetic improvement of local breeds (Thornton et al., 2007). Widespread cross-breeding of local livestock, mostly with improved breeds from temperate regions has occurred often with poor results (Wollny, 2003). Poor results are often linked to a failure of breeds to cope with climatic extremes (i.e. heat stress tolerance of Holsteins in Southern USA), nutritional challenges or parasitic/disease threats posed in arid production environments (Anderson, 2004).

3.6.2 Economic pressures

Economic and market drivers tend to pose the greatest risks to FAnGR due to competition from exotic or cross breeds, limited availability of breeding stock and access to markets (Anderson, 2004). Traditional producers increasingly face problems concerning quality control and product specifications directed from market suppliers (Tempelman and Cardellino, 2007). A lack of formal supply chains attributed to traditional products further constrains the growth of these niche markets (Zander and Drucker, 2008). Pastoralists and many traditional farmers in developing countries are often located in relatively isolated areas lacking in adequate infrastructure to connect producers to markets. These producers often sell sporadically and in small quantities which does not favour formal supply chains (DEFRA, 2013).

3.6.3 Technological advancement

Intense artificial selection in livestock by the use of a few selected animals with superior genetic profiles makes the genetic contribution of animals highly skewed (Kristensen et al., 2015). Widespread use of AI in dairy systems now means one bull can sire thousands of progeny (Leroy et al., 2013). The rapid evolution of new molecular genetic tools (e.g. microsatellite markers, genome wide Single Nucleotide Polymorphisms (SNP) markers and whole genome sequencing) mean the sequences of DNA present within breeds can be analysed, at increasingly lower costs, to ensure rapid acceleration within improvement programmes (Groeneveld et al., 2010b; Hayes et al., 2013). Such methods are likely to ensure increasingly specific selection of certain traits, reducing overall diversity within breeds (Kristensen et al., 2015).

3.6.4 Geographical consolidation

The foot and mouth disease (*Aphthae epizooticae)* outbreak in the UK demonstrated the importance of maintaining a robust and geographically diverse population of breeds which can respond to environmental shocks. This outbreak decimated populations of the Herdwick sheep breed in the UK (Carson et al., 2009). Carson et al., (2009) analysed the geographical distribution of 16 heritage sheep breeds in the UK. They found 13 of the 16 breeds analysed can be defined as geographically isolated with up to 95% of their population clustered within a 65 km radius of the breeds mean centre. Their data indicates the importance of accounting for geographical concentration within breed assessments.

## 3.7 Conservation and supply of FAnGR

Conservation strategies concerning FAnGR are centred around two main options; *in-situ* and *ex-situ* conservation. Table 5 highlights the main conservation techniques available and relevance to potential objectives of a conservation scheme. Selecting the optimal scheme depends on the objective of conservation (Pattison et al., 2007).

Table : Conservation techniques and the linkages to various scheme objectives (adapted from Gandini and Oldenbroek, (2007)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Technique** | | |
| **Objective** | **Cryoconservation** | ***Ex-situ - in vivo*** | ***In-situ*** |
| Insurance against changes in production conditions | ++ | + | ++ |
| Safeguard against diseases | ++ | - | + |
| Opportunities for genomic research | ++ | ++ | ++ |
| Allowing continued breed adaption | - | + | ++ |
| Increasing knowledge of phenotypic traits of breed | + | ++ | +++ |
| Minimizing exposure to genetic drift | ++ | - | + |
| Opportunities for development in rural areas | - | + | +++ |
| maintenance of agrodiveristy | - | - | ++ |
| conservation of breed heritage | - | + | ++ |

Note: +++ indicates high level linkages / ++ moderate relevance to objective /+ low relevance to objective / - not relevant.

3.7.1 *In-situ* conservation

*In-situ* conservation of FAnGR usually requires maintenance of rare breeds on farms and is generally the preferred option (FAO, 2007). The approach has several advantages:

1. The breeds can be seen and enjoyed
2. Breeds in conservation schemes can continue to be characterised (e.g. trait analysis)
3. The breeds continually evolve to changing environmental and climatic conditions

*In-situ* conservation has the added advantage that multiple objectives can be targeted within a scheme (i.e. conservation grazing coupled with breed conservation) as is practised in the UK (DEFRA, 2006). This reduces the subsidy burden and creates a ‘market’ for rare or locally adapted ‘at risk’ breeds. *In situ* also preserves traditional knowledge and cultural dynamics associated with breeds (Gibson and Pullin, 2005). However, breeds can become geographically isolated which puts them at risk from disease outbreaks (Carson et al., 2009) and may be exposed to undesirable genetic changes through inbreeding, genetic drift or cross breeding if not managed appropriately (Hiemstra et al., 2006).

* + 1. *Ex-situ* conservation

*Ex-situ* conservation programmes usually require the creation of farm parks or collections of genetic material (frozen semen, embryos or DNA) which are stored in Cryobanks. Farm parks allow the breed to evolve over time, but suffer from many of the same disadvantages as noted for *in-situ* conservation. Cryobanking stores are advantageous as they offer protection from disease epidemics (FAO, 2012); however, a major disadvantage is that the genetic material is unable to adapt and evolve over time (DEFRA, 2006). The costs associated with cryobanks also remain poorly understood (FAO, 2015). Semen from most livestock species can be frozen but with varying results (FAO, 2012).

Labroue et al., (2001) calculated total costs for creating pig semen storage within four European countries at around €30,000 / breed. The Centre for Genetic Resources calculated that costs of collecting and freezing semen from different species vary from less than 1 euro per dose in cattle to more than 20 euro per dose (sheep and poultry) (FAO, 2006). Costs of embryo collection are much higher than for semen collection and freezing.

3.7.3 *Optimal conservation design*

A combination of *in-situ* and *ex-situ* is likely to be the most effective conservation option (FAO, 2015). It is generally accepted that *in-vitro* conservation schemes are regarded as an additional safety net when the population size of endangered breeds is very low. For *in-situ* and *ex-situ* programmes to reach their full potential, enough animals should be included to capture rare alleles within the population, ensuring the collections cover the range of phenotypes present in the breed. Deciding on the number of animals sampled in *ex-situ* requires tradeoffs between costs of collections and protection afforded (FAO, 2012)

## 3.8 Institutional mechanisms underpinning supply of FAnGR

Four priority areas were listed in the FAO (2007) SoW report which stressed *‘policies, institutions and capacity building’* as essential tools for FAnGR conservation. These features are underpinned by the laws and regulations which govern animal breeding and livestock farming.

3.8.1 Regulatory framework

Zootechnical legislation facilitates trade in pedigree breeding animals, semen, ova and embryos (DEFRA, 2006). The legislation defines what factors determine the endangerment or risk level of breeds; what constitutes a ‘native’ or ‘exotic’ breed and what constitutes a breed per se. This is important for breed societies interested in maintaining accurate herd or flock books which contain appropriate genetic material (Hiemstra et al., 2006). It also influences what constitutes a pedigree animal and by extension appropriate matings between animals. Biosecurity considerations influence the movement of breeding stock (e.g. bulls) from one herd to another (Tempelman and Cardellino, 2007). This has been a prominent problem in community managed Yak conservation projects in Tibet.

3.8.2 The UK Regulatory framework

The National Focal Point for FAnGR identified potential disease outbreaks as a principle threat to FAnGR in the UK which may severely threaten highly consolidated populations of breeds, as occurred in the UK’s FMD outbreak (Villanueva et al., 2004). DEFRA has now introduced exotic disease control legislation which means certain categories of animals may be considered for sparing from culling, provided that disease control is not compromised.

3.8.3 EU Policy mechanisms

Policy responses to conservation are often two-fold; firstly conservation of agrobiodiveristy which meets wider landscape management goals and; secondly, financial support given to farmers for rearing ‘local breeds in danger of abandonment’ (Ligda and Zjalic, 2011). The EU provides support for the conservation of FAnGR through three main policy mechanisms:

1. European Regional Focal Point (ERFP)
   1. The ERFP represents EU wide efforts to conserve FAnGR and holds important data current status and trends in breed populations, which is reported to the FAO. The ERFP also implement policies and regulations aimed at reducing drivers associated with FAnGR decline.
2. The EU Biodiversity Strategy to 2020
   1. Action 10 states “*The Commission … will encourage the uptake of agri-environmental measures to support genetic diversity in agriculture and explore the scope for developing a strategy for the conservation of genetic diversity”.*
3. The Common Agricultural Policy (CAP)
   1. Under EU Rural RDP, subsides can be paid for the conservation of genetic resources. (I.e. Pillar II CAP support). In England the HLS Scheme supports conservation grazing involving NBAR and there are currently ~1,180 agreements in place.

3.8.4 FAnGR subsides in the EU

Incentive payment schemes are implemented under the EU Council Regulation (EC) no.1698/2005 and Commission Regulation (EC) no. 817/2004 (European Union, 2004) for farmers rearing local breeds in danger of abandonment. Support levels are often calculated following guidance set out in the RDP regulations and primarily considers income foregone associated with raising traditional breeds. Kompan et al., (2014) undertook a European wide survey to assess different subsides and support measures from 28 EU member states who wished to participate, out of 35 contacted. Key findings of the project were:

* 34 out of 35 countries have a legal arrangement regarding FAnGR
* 18 out of 35 countries have specialised NGO’s for FAnGR conservation
* 26 out of 35 countries have a National Programme (NP) for FAnGR conservation
* 21 out of 35 countries adopt NP formally in national legislation
* 25 out of 35 countries include, fully or partially, the priorities of the GPA

Table 6 summarises EU support measures administered in 21 different EU countries from 28 EU member states responding to the Subsibreed survey. A total of 356 breeds are supported across 21 countries. Of these, 256 breeds are reported to be increasing population size, 64 breeds are reported to be stable and 48 breeds are declining in population. This would seem to indicate, in the majority of cases, that subsides are a relatively effective mitigation measure at increasing populations of rare breeds. In the majority of cases subsides do not differ between levels of endangerment associated with breeds.

Table : Summary of EU support measures from 21 different European countries out of 28 EU member states responding to the Subsibreed survey. Data from (Kompan et al., 2014)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **No. livestock species supported** | **No. breeds supported** | **Payment differs by sex** | **Payment differs by endangerment status** | **No. breeds increasing** | **No. breeds stable** | **No. breeds decreasing** | **Total subsides 2010 (€)** | **Notes** |
| Albania\* | 4 | 6 | Yes | No | 2 | 1 | 3 | 285,950 | \*No information available on cattle breeds |
| Austria | 5 | 31 | Yes | Yes\* | 24 | 0 | 7 | 4,513,978 | \* Has a specific breeding programme in place for highly endangered breeds |
| Bulgaria | 6 | 25 | No | No | 15 | 2 | 8 | - |  |
| Croatia | 7 | 25 | No | No | 13 | 12 | 0 | 4,715,272 |  |
| Cyprus | 2 | 2 | No | No | 1 | 1 | 0 | 450,000 |  |
| Czech Republic | 5 | 11\* | Yes | No | 7 | 0 | 3 | 382,000 | \*Also supports Rabbits, honey bee and aquaculture fish. |
| Estonia | 2 | 4 | No | No | 4 | 0 | 0 | 562,264 |  |
| Finland | 5 | 9 | Yes\* | No | 4 | 4 | 1 | 2,920,000 | \* Only varies in cattle |
| France | 6 | 79 | No | No | 79 | 0 | 0 | - |  |
| Greece | 6 | 22 | No | No | n/a | n/a | n/a | - |  |
| Hungary | 7 | 22\* | Yes\*\* | No | 17 | 1 | 4 | - | \*Also supports Chickens, Guinea fowl, Duck, Goose, Turkey. \*\*Supports female animals only |
| Iceland | 1 | 1 | No | No | 1 | 0 | 0 | 33,000 |  |
| Latvia | 5 | 6 | No | No | 0 | 3 | 3 | 221,700 |  |
| Lithuania | 4\* | 10 | No | No | 8 | 1 | 1 | 629,799 | \*Also supports Geese |
| Montenegro | 2 | 5 | No | No | 3 | 0 | 2 | 12,362 |  |
| Poland | 4 | 27 | Yes\* | No | 24 | 0 | 3 | 6,405,562 | \*Only females supported (amount of subsidy given in PLN) |
| Portugal | 5\* | 37 | Yes | Yes | 16 | 13 | 8 | 7,094,272 | \*Also supports poultry |
| Serbia | 7\* | 16 | No | No | 16 | 0 | 0 | 185,954 | \*Also supports poultry |
| Slovakia | 4\* | 10 | No | No | 8 | 1 | 1 | - | \*Also supports Chicken and Goose |
| Slovenia | 5\* | 10 | Yes | No | 5 | 4 | 1 | - | \*Also supports Chickens, Bees and Dog |
| Turkey | 4\* | 19 | No | No | 9 | 9 | 3 | 178,384\*\* | \*Also supports Bees \*\* Does not include Horses or Pigs |
| Ukraine | 5 | 12 | Yes | No | 0 | 12 | 0 | n/a |  |
| **Total** | **72** | **356** | **-** | **-** | **256** | **64** | **48** | **17,315,026** |  |

* + 1. Non-Governmental Organisations (NGO’s) and FAnGR conservation

NGO’s deliver substantial levels of support for FAnGR conservation through breeding activities, training of farmers, promotion of local products and public awareness. They serve as an important communication tool between breed societies, associations, industry, government and livestock keepers (Gamborg and Sandøe, 2005). In the UKconservation support is provided through the RBST, where a breed has not gone extinct in the UK since the 1970’s(Simm et al., 2004). Further support is sourced from The National Trust and Natural England (ADAS, 2007).

* + 1. Private sector support and certification

In the UK, several supermarkets have now started selling traditional breed meats. For instance, Waitrose established its Aberdeen Angus beef scheme and were the first supermarket to recognise the quality of this meat back in the 1970’s (Jenkins, 2014, P.C). They have now expanded their range and sell a number of other breed specific cuts (Jenkins, 2014, P.C). Marks and Spencer (M&S) have also established a similar scheme and sell a number of breed specific meats, including Angus and Hereford (ADAS, 2007). Morrison’s pay a premium of 30p/kg for Shorthorn beef and 10p/kg for traditional breed beef cuts. Latest figures from the British Cattle Movement Service (BCMS) have shown an 18% rise in registrations of Beef Shorthorn calves(Morrisons, 2015). The Beef Shorthorn range is now Britain’s fastest growing native breed range and accounts for between 30% and 50% of Morrisons traditional breed range (Morrisons, 2015).

Figure : Geographical identification of PDO and PGI products derived from local breeds across 17 EU member states (Zjalic et al., 2012)

EU certification schemes for traditional products such as PDO and PGI can add considerably to breed protection. The significant contribution of local breeds to PDO / PGI products in 17 European countries was highlighted in a review paper by Zjalic et al., (2012). They identified a total of 249 geographical indication products, 42 of which were attributed to Northern European countries whilst the remainder were derived from Mediterranean countries (Figure 7). Finally, diversifying farm businesses to exploit agro-tourism presents another market based opportunity to deliver conservation goals. A range of farm parks within the UK have already done this successfully (e.g. Cotswold Farm Park).

## Economics of FAnGR conservation

3.9.1 market mechanisms and measuring use and non-use values

Economic incentives intertwined with national level policy are required to ensure the long term supply of agrobiodiversity. As demonstrated in Figure 8[[1]](#footnote-1), policy interventions to reach the optimal level of agrobiodiveristy conservation would include; (a) accounting for negative externalities and removal of subsides which would shift the curve for improved FAnGR downwards to (S) and; (b) where significant non-market and public values of FAnGR exist, further mechanisms need to be put in place to permit the capture of the total economic values associated with local FAnGR to move the curve from (O) to (S) (Narloch et al., 2011).

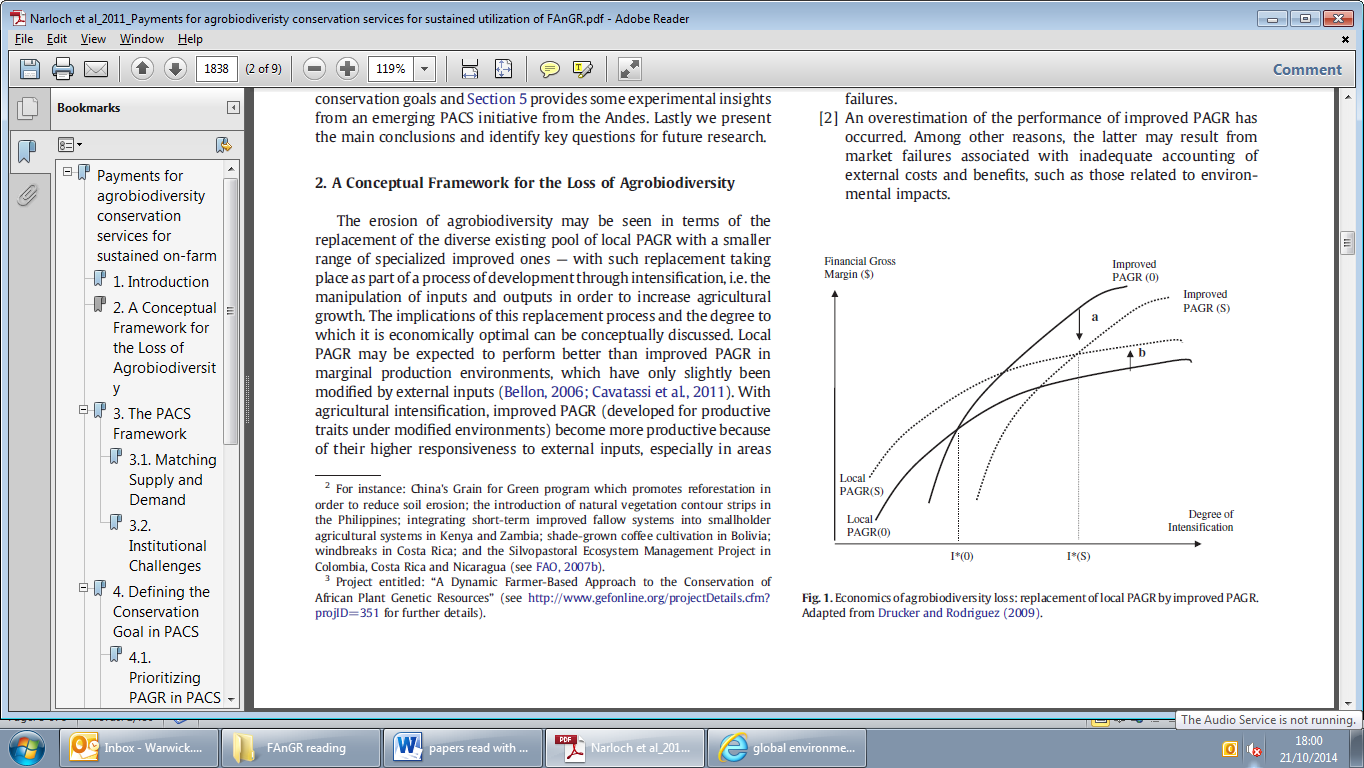


Figure : Economics of agrobiodiveristy loss and measures to correct for market failure (Narloch et al., 2011)

Key components underpinning the efficient allocation of funds within PACS schemes are comprised of two key themes; valuation and supply of genetic resources (Gandini and Villa, 2003; Gollin and Evenson, 2003; Pouta, 2011; Sukhdev et al., 2010; Zander, 2006; Zander et al., 2013). Supply mechanisms of increasing interest are conservation contracts, Weitzman approach and Safe Minimum Standards (Cicia et al., 2003; Drucker, 2004; Drucker et al., 2001; FAO, 1999; Kumar, 2010). These mechanisms form the bedrock of this PhD and will be outlined in subsequent sections. The theoretical foundations of such mechanisms can be attributed to either Revealed Preference (RP) or Stated Preference (SP) methods. Table 7 provides a summary of these methods.

Table : Summary of valuation techniques to elicit Total Economic Value (TEV) for biological resources

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Valuation Method** | **Element of TEV Captured** | **Ecosystem Services Valued** | **Benefits of approach** | | **Limitations of approach** |
| ***Revealed Preference methods:*** | | | | | |
| Market Prices | Direct and indirect use | Those that contribute to marketed  products (e.g. timber, fish, genetic  information) | Market data  readily available  and robust. | Limited to those  ecosystem services for which a market exists. | |
| Hedonic Pricing (HP) | Direct and Indirect use | Ecosystem services that contribute to air  quality, visual amenity, landscape, quality (i.e. attributes that can be appreciated by  potential buyers) | Based on market  data, so relatively  robust figures | Very data intensive and mainly limited to  services related to property | |
| Production Function | Indirect use | Environmental services that serve as inputs to market products (e.g. effects of water quality on fishery production) | Market data  readily available  and robust | Data-intensive and data on changes in services and the impact on production often missing | |
| ***Stated Preference Methods:*** | | | | | |
| CV (Contingent Valuation) | Use and non- use values | All ecosystem services | Able to capture  use and non-use  values | | Bias in responses,  resource-intensive  method, hypothetical  nature of the market |
| CE (Choice Experiments) | Use and non- use values | All ecosystem services | Able to capture  use and non-use  values | | Similar to contingent  valuation above |
| ***Cost based approaches:*** | | | | | |
| Opportunity cost | Direct and indirect use values | Depends on the existence of markets relevant to the ecosystem service in question (e.g. opportunity cost of traditional over intensive breeds) | Uses robust market data | | Can potentially over estimate values, and does not take into account passive, non-use values |
| Replacement cost method | Direct and indirect use values | Measures the cost of replacing a resource if it becomes depleted (e.g. new breeding programmes) | The approach is widely used because it is often easy to find estimates  of such costs | | Can potentially over estimate values, and does not take into account passive, non use values |

Adapted from (EFTEC, 2006)

3.9.2 CE and CV

The use of CE and CV are popular tools for valuing the benefits derived from FAnGR. Analysis by Ahtiainen and Pouta (2011) demonstrated 45.8% of studies (from a sample of 22) have used CE to value FAnGR; whilst 12.5% have used CV to elicit value. The CV method is based on a hypothetical market in which WTP is elicited through questionnaires, and/or interviews (Garrod & Willis, 1999). Respondents are generally asked if they would accept a referendum style policy change which usually has a monetary attribute (i.e. tax) associated. Presently, this method has been applied in over 1600 studies relating to environmental policy issues (Gregory, 1999). The description of the environmental asset to be valued (this being the hypothetical scenario in which the environmental good is described in market based terms) is a critical component to the reliability of this approach (Arrow et al., 1993; Bingham et al., 1995).

CE’s have been growing in popularity and are becoming an increasingly popular approach to value environmental goods and services. They have been applied to a number of FAnGR issues. Ruto et al., (2008) used a CE to demonstrate buyer groups trade off different attributes of cattle whilst Scarpa et al., (2003) note that useful policy implications for FAnGR conservation can be drawn from CE studies. The CE methodology involves the generation and analysis of choice data through the construction of a hypothetical market using a questionnaire or survey (Hoyos, 2010). This method is theoretically grounded in Lancaster's theory of value (Lancaster, 1966) and based on Random Utility Theory (RUT) (Luce, 2005; McFadden, 1973). The basis of this approach is simple, the utility maximisation of individuals within the budget constraint, and individual preferences revealed through the choices made within the experiment.

In a CE the resource is defined in terms of its attributes and the levels these attributes would take. Profiles of the resource, in terms of its attributes and attribute levels, are constructed using experimental design theory which combines the level of attributes into different scenarios to be presented to respondents. Two or three alternative profiles (or policy options) are then assembled in choice sets (usually with a monetary value associated with each alternate policy option) and presented to respondents, who are asked to state their preference. Maximum WTP or Willingness to Accept (WTA) can then be derived from this data (Bateman et al., 2003). Similar to CV, CE can estimate non-use values but also enables estimation of the implicit value of a goods attributes (Hoyos, 2010). CE can also solve for some of the biases that are present in CV (Birol et al., 2006).

3.9.3 Hedonic Pricing (HP)

Hedonic Pricing accounts for 16.7% of studies sampled by Ahtiainen and Pouta (2011). This approach is based on the reality that goods are comprised of a range of attributes or characteristics. This approach (in FAnGR valuation) is based on the assumption that the value of an animal is a function of the phenotypic and genotypic characteristics embedded in the animal (Roosen et al., 2005). The approach is consistent with Lancaster's (1966) consumer theory which dictates that consumers derive utility not from goods themselves but rather the attributes or characteristics which make up the good. Thus, the TEV of an animal or breed can be decomposed into the value of individual traits (Gandini et al., 2007). Jabbar and Diedhiou (2003) used the HP method to analyse cattle market prices and found that buyers have preferences for specific breeds for specific purposes.

The data needed for HP analysis are prices on animal market transactions (e.g. auctions) which serve as dependant variables. In addition, data on genetic traits are used as explanatory variables together with variables measuring characteristics of production environments. The marginal value describes the variation in price in response to the variation in a given animal attribute, keeping everything else constant (Roosen et al., 2005). The major advantage of HP is the use of actual market data which informs decision making.

3.9.4 Competitive tender (conservation auctions)

Understanding both the on and off-farm benefits of agrobiodiveristy conservation and how best to supply it are essential tools for effective policy design. The total cost of a PACS schemes are comprised of opportunity cost payments to the farmer; implementation costs and transaction costs. Least cost conservation of FAnGR should focus on breeds that deliver substantial public and private benefits to the farmer (benefit maximisation). Small holder farmers or breed enthusiasts with considerably lower opportunity costs might offer good potential (Pattison et al., 2007).

In competitive tenders, landowners submit a bid, or tender, for a conservation contract. These mechanisms can be used to identify least cost conservation service providers (farmers or communities) with payments being made both by cash or in-kind at the community level (Narloch et al., 2013). The major advantages attributed to the competitive tender approach over fixed price approaches is their influence on farmers to detail actual opportunity costs since it is technically a bidding game for the tender (Pascual and Perrings, 2007). Livestock managers can also tender a project based upon their own specifications which means institutions can select the most appropriate tender based upon a number of criteria (Pattison et al., 2007).

To demonstrate the effectiveness of auctions, Stoneham et al., (2003) provided a small scale pilot case study of an auctioning mechanism for biodiversity conservation contracts in Australia known as BushTender. The selection of farmers who won the contract was based on ranking the relative cost-effectiveness of each proposal against landscape level ecological goals. It was estimated that the BushTender mechanism has provided 75% more biodiversity conservation compared to a fixed price payment scheme (Stoneham et al., 2003).

3.9.5 Safe Minimum Standards (SMS)

Standalone schemes such as PACS can be developed in line with the SMS approach outlined by Drucker (2004). The concept of the SMS approach is to maintain the flow of resources within a “critical zone” where it is feasible to rebuild the stock in the future (Bishop, 1978; Ready and Bishop, 1991). The costs of implementing a SMS are a product of the opportunity cost differential of maintaining the indigenous breed rather than an exotic or crossbreed. Drucker (2004) uses empirical cost estimates obtained from three case studies in Mexico and Italy and confirms they deliver a benefit-cost ratio of >2.9.

Signorello and Pappalardo (2003) estimate that SMS costs for all 310 breeds in the EU RDP is approximately € 42 million per annum (including a 5% conservation programme cost). This figure contrasts with the EU’s CAP spending of around €4.2 billion per annum on rural development and agri-environment schemes (Drucker, 2004). Thus, the SMS approach appears well suited to FAnGR but does rely on accurate valuation of the components required to determine SMS costs (Ready and Bishop, 1991).

3.9.6 Weitzman Approach

Despite increasing interest in FAnGR conservation, little guidance has been provided to direct the selection of breeds for conservation (Fadlaoui et al., 2005). Weitzman (1993) has recognised that biodiversity conservation is inherently a question of economics and provides a useful framework for decision making and analysis (d’Arnoldi et al., 1998). The Weitzman conservation approach (Noah’s Ark Problem) combines measures of diversity, current risk status, and conservation costs (Weitzman, 1998; Zander et al., 2009). Reist‐Marti et al., (2003) evaluated the Weitzman approach for breed diversity in African cattle. Their results suggested the optimum conservation strategy is to give priority to those breeds with the highest marginal diversity, rather than those most endangered.

Zander et al., (2009) applied the Weitzman approach to assess how different types of Borana cattle might be prioritized for conservation. They found that the highest conservation priority should be given to the Ethiopian Borana (EB) type in Ethiopia. They conclude the minimum cost of conserving 1,100 animals of the EB type with the participation of Ethiopian communities is calculated at €7,700 / year. Weitzman’s approach provides a useful decision making framework which can deliver targeted policy interventions to ensure FAnGR stocks for future use (Ajmone-Marsan, 2010; Cañón et al., 2001; Caroline d’Arnoldi et al., 1998).

# 4.0 Research priorities

This literature review has identified a number of research gaps which require attention. Those relevant to this PhD are outlined below:

1. Characterisation and classification of genetic resources
2. Evaluation of the effectiveness of policy and subsidy schemes to support FAnGR
3. Estimation of cost estimates associated with cryobaking genetic material
4. **Determination of farmer preferences for FAnGR conservation programmes**
5. **Identification of optimal economic mechanisms to supply FAnGR**
6. **Exploration of a decision support tool to prioritise genetic stocks (breeds) for conservation**
7. **Review of social networks underpinning relationships between FAnGR stakeholders**
8. **Determination of livestock attributes which equate to value in rare breeds**

This PhD project plans to address those objectives (4-7) highlighted in **bold** and are discussed further in Section 5.0.

# 5.0 Methodology

**4) Identify optimal supply networks for genetic resources**

* *Fieldwork location:* United Kingdom
* *Project duration:* March 2017 to September 2018
* *Methodology:* Social Network Analysis / Hedonic Pricing
* *Relevance:* Results will identify (i) how farm animal genotypes influence sellers breed preferences (demand) and (ii) optimal supply networks for the provision of FAnGR. Results will be presented in the context of wider FAnGR conservation goals.

**3) Determine least cost conservation suppliers**

* *Fieldwork location:* Peru or Brazil
* *Project duration:* May 2016 to February 2017
* *Methodology:* Competitive Tender
* *Relevance:* Results will use data from (1) and (2) to inform parameters for the tender mechanism. The tender will aid in identifying least cost suppliers and optimal conservation contracts

**2) Develop a decision support tool for breed conservation**

* *Fieldwork location:* Peru or Brazil
* *Project duration:* May 2016 to February 2017
* *Methodology:* Weitzman approach
* *Relevance:* Results will determine most “suitable” breeds for conservation based upon economic, environmental, cultural and genetic criteria. These results will be used when prioritising least cost conservation providers (3)

1. **Determine farmer preferences for conservation contracts**

* *Fieldwork location*: Romania
* *Project duration*: June 2015 – January 2016
* *Methodology:* Choice experiment / questionnaire
* *Relevance:* Results will determine farmer WTA conservation subsides in traditional, low input farming system and preferences for conservation contracts. These systems are likely to be least cost conservation sites and will inform our supplier analysis of conservation providers (3)

Figure : Proposed project framework identified for the PhD

During this PhD project we propose four key themes which require further work, based upon research priorities identified in Section 3.0 (detailed in Section 4.0). These themes are outlined in Figure 9. Although the projects are standalone, they will inform the wider agricultural economics community on issues mainly concerning the supply of FAnGR.

## 5.1 Determining farmer preferences for FAnGR conservation schemes in Romania

5.1.1 Background

Since joining the EU in 2007 Romania has seen structural reform across a range of sectors, particularly agriculture (Mikulcak et al., 2013). Romania is focusing on upgrading its production systems through genetic improvements; however unregulated crossbreeding remains a serious threat to agrobiodiversity (Draganescu, 2003). Currently support is now offered to farmers in Romania under the 2014-2020 RDP Agri-environment-climate Measure (M10.2, art 28) to support rare and endangered breeds under EU Regulation 1305/2013. Commitment to this RDP option is expected to be limited given Obligation 3.0 requires that the animals in consideration are purebred and registered in the genealogic register of that breed. This obligation is likely to be particularly challenging for small scale farmers given their informal breeding strategies (Draganescu, 2003). There are currently 21 local ‘at risk’ breeds supported under the new RDP, of which seven are in ‘critical condition’ (Programul National De Dezvoltare Rurala, 2014).

5.1.2 Project aims

We propose to undertake fieldwork in The Tarnava Mare region (Transylvania); much of which is classified as High Nature Value (HNV) farmland as a result of the traditional agricultural practices (low input systems, extensive grazing) which have acted to increase biodiversity in the area. The harsh environmental characteristics here have resulted in increased levels of breeds diversity, compared to other, more productive farming areas in Romania.

We hope to determine *‘farmer preferences for FAnGR conservation schemes in Transylvania.’* The six specific objectives of our study include:

1. An assessment of genetic resource stocks in Transylvania and their geographical distribution
2. Determination of key factors influencing farmer’s breed choices
3. Assessment of key institutional barriers which may reduce uptake in conservation schemes
4. Evaluation of support measures which may contribute to the increased uptake of conservation schemes though a CE
5. Determination of farmers WTA conservation contracts through a CE
6. Recommend policy implications which may act to reduce genetic erosion

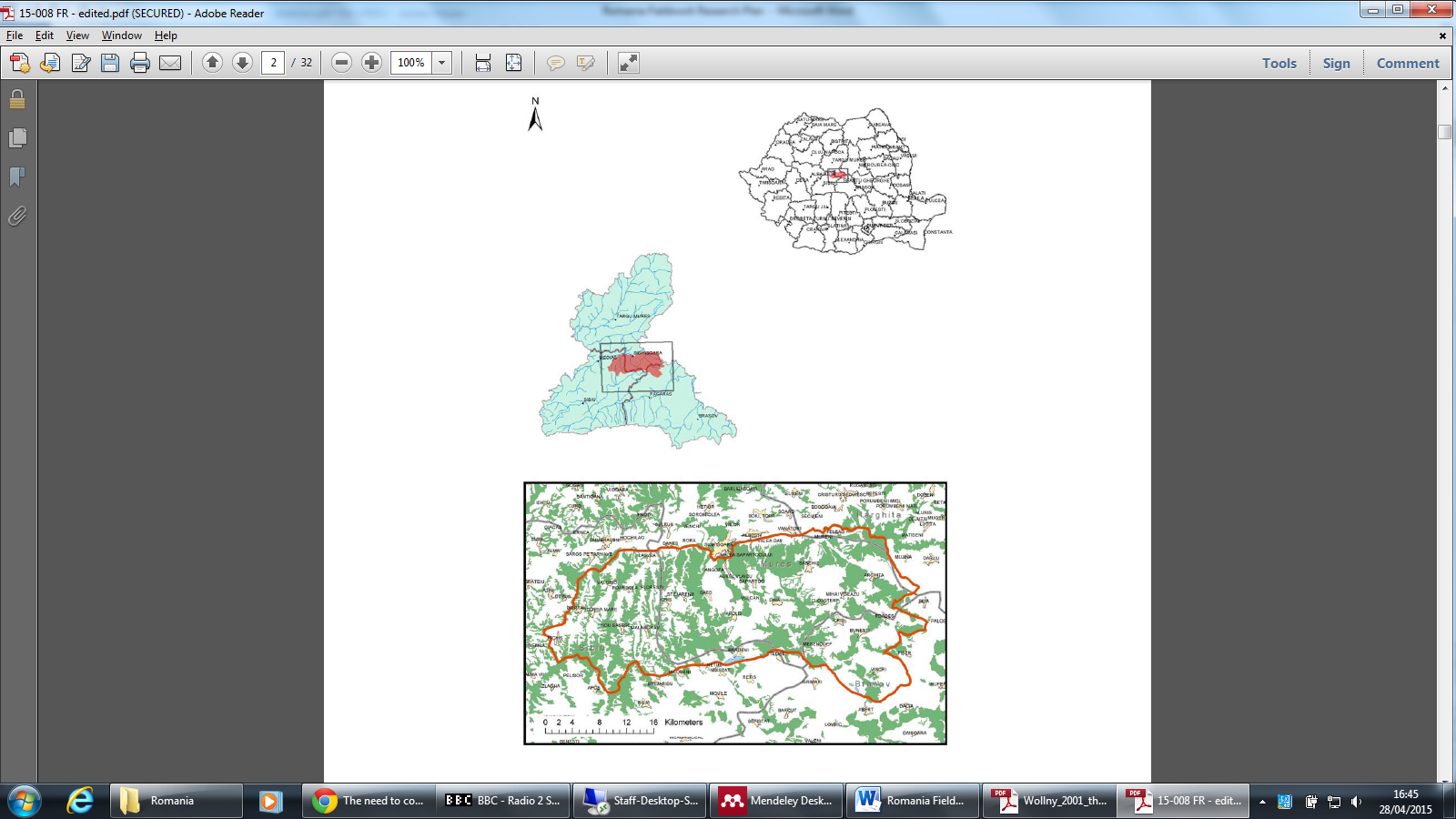


Figure 7: Map of Tarnava Mare HNV region (Banaduc *et al.*, 2008)

5.1.3 Methodology

We plan to undertake fieldwork from mid June to mid August. The survey team plans to visit 8 villages dispersed around the region. The CE consists of three attributes each with two different levels. Four choice tasks will be administered to each participant. The attributes in question are:

* Length of the contract
* Importance of community integration within a conservation programme
* Level of support (consultant) offered to farmers during the programme

Three scenarios will be used. Option A and B where by the attributes in question will take one of two different levels reflecting different designs of conservations schemes, or an opt out option (no scheme). A monetary attribute will measure farmers WTA a conservation subsidy and will take one of four levels for bovines and equines (90; 270; 530; 890) or sheep and goats (5; 15; 25; 45) Lei. Subsidy amounts represent percentages of support proposed in the EU RDP (10; 30; 60; 100%). The survey instrument has taken the following design (detailed in Appendix 13.4):

Section A: About you and your farming

Section B: Farm Animal Genetic Resources in Tarnava Mare

Section C: Evaluation of benefits you might obtain from protecting FAnGR

Section D: Future options for protecting FAnGR in Tarnava Mare

Section E: Choice tasks for future protection scenarios of FAnGR

Section F: About you (socioeconomic characteristics of respondents)

5.1.4 Potential findings

Much work on farmer decision making attempts to model the economic aspects of decisions assuming economic rationality on behalf of the farmer. Such approaches may be appropriate for profit-oriented farming systems but are unlikely to be able to explain FAnGR management decisions by those in semi-subsistence systems (Narloch et al., 2011; Zander and Drucker, 2008).

To date, few studies have assessed farmer preferences for FAnGR conservation schemes independent of livestock preferences. We believe this is a key data gap which needs further investigated. Farmers have a range of household, cultural and business preferences which are likely to influence the validity of a conservation programme. We hope to investigate this to determine the optimum design of a conservation scheme, based on the preferences elicited by farmers.

## 5.2 Investigating the applicability of Competitive Tender contracts for FAnGR conservation

5.2.1 Background

There has been little exploration of the incentives underpinning supply of genetic diversity and by extension the best economic mechanisms to ensure continued supply. Funds which supply genetic resources tend to be limited whilst the true costs of conservation schemes and ways to best maximise spend are poorly understood. We hope to address this by identifying the most efficient economic mechanisms for delivering conservation contracts thus reducing genetic erosion.

5.2.2 Project Aims

1. Improve our understating of cost estimates associated with FAnGR conservation and by extension the cost of increasing FAnGR supply
2. Identify the most suitable spatial and organisational targeting of economic instruments for administering PACS
3. Consider the economic geography of breeds and relevant institutional barriers that distort incentives to farmers interested in conserving FAnGR

5.2.3 Methodology

Competitive tender requires farmers to bid against one another for conservation contracts, thus eliciting true opportunity costs (i.e. WTA) for conservation schemes. Economic theory dictates that the heterogeneity in landowner’s opportunity costs revealed in the competitive tender means a discriminatory price mechanism is likely to be more efficient at matching programme costs with direct environmental benefits thus maximising outcomes.

Workshops will be established to facilitate discussions in the Pantanal region (distinguished for FAnGR diversity) in coordination with EMBRAPA (Brazilian partners) to derive cost estimates. Case study sites will be used for administering the tender mechanism in a workshop setting, with a binding auction style approach (Lusk and Shogren, 2007). The supply perspective will consider how changing farm structures in response to conservation contracts may ameliorate the “at risk” status of breeds – e.g. how these may affect numerical scarcity, geographic concentration, introgression, inbreeding and effective population size of breeds.

5.2.4 Potential findings

Collection of field data in conjunction with economic modelling will enable the following:

1. Explicitly consider the spatial heterogeneity in landowners opportunity cost and farm specific costs (e.g. site conditions) associated with conservation payments
2. Determination of least cost methods for administering PACS which consider economic geography and “at risk” status of breeds
3. Assessment of incentives and disincentives influencing supply of FAnGR and how these can be modified to enhance genetic conservation
4. Adaption of competitive tender as a uniform tool underpinning assessment and delivery of PACS which considers a SMS approach

The findings of this research will be highly relevant to the agricultural and economic community interested in genetic resources. While there is much research considering animal productivity, there is much less cross disciplinary work exploring the socioeconomic dimensions of intensification. While the demand for breed conservation can be easy to define and measure, the costs are much less tangible and vary greatly between farm systems.

## 5.3 Weitzman approach

5.3.1 Background

FAnGR conservation suffers from a lack of targeting concerning the eligibility of specific breeds for conservation (Reist‐Marti et al., 2003). This has reduced the effectiveness of conservation funds (Kompan et al., 2014). It is important a decision making framework is implemented to direct funds more appropriately towards specific breeds and projects which deliver the greatest overall benefits relative to cost. We propose to use the Weitzman approach to target funds more appropriately through consideration of genetic, geographical, cultural and economic considerations (Zander et al., 2009).

5.3.2 Project aims

1. Determine which criteria to incorporate into an optimal Weitzman model
2. Assess the most suitable candidate breeds for conservation based on the Weitzman model
3. Identify the appropriate use and targeting of funds to deliver conservation goals

5.3.3 Methodology

We plan to collect data on at risk breeds in Brazil (Pantanal region) within a pre-determined geographical range, which can subsequently be used to inform the analysis. Zander et al., (2009) proposed a novel use of this method to identify how different types of Borana cattle might be prioritised for conservation in East Africa. We propose to use a similar methodology here, based on Weitzman’s cost effective methodology which is written as follows (Weitzman, 1998):

(1)

where:

= ranking value of breed

= distinctiveness of represents how unique or different is

= direct utility of is a result of how much a person values per se

= by how much can the survivability of be improved by assuming the conservation scheme makes the breed safe

= cost of improving the survivability of

Weitzman assumed that extinction of a species was exactly equal to the distinctiveness of that species. This means the uniqueness of a species depends on the genetic distance between itself and its nearest relative. Weitzman (1998) described as the expected marginal distinctiveness plus utility per dollar whilst van der Heide et al., (2005) used the term “performance index” for ; however Zander et al., (2009) use to rank priorities which represent the conservation value of Borana subtype (the higher this value, the higher the subtypes priority for conservation). However, can only be determined if data exist (i.e. molecular markers) characterising the genetic distinctiveness. If unknown, this value should be set to zero, or another proxy for distinctiveness used (Zander et al., 2009).

Survival probabilities () can be estimated by using data for population size, Ne, inbreeding coefficients, predicted future trends as well as expert opinion regarding the genetic merit of the breed in question (Reist‐Marti et al., 2003). Data for the underlying economic parameters; and can be gathered through a range of either RP or SP methods. We propose to use a meta-analysis of SP and RP methods to value use and non-use values associated with case study breeds.

5.3.4 Potential findings

Both Reist‐Marti et al., (2003) and Simianer et al., (2003) used the Weitzman approach and found that optimal allocation of funds was not achieved by giving priority to those breeds most endanger. Rather, optimal funds were allocated when priority is given to those breeds with the highest marginal diversity. However, these studies did not consider within breed diversity which are important components in the analysis and highlights the difficulty of obtaining sufficient data to utilize the Weitzman modelling approach fully.

We hope to build on such studies and use this novel method, potentially in combination with a competitive tender mechanism, to both identify appropriate breeds for conservation and livestock managers with lowest opportunity cost. Delivering such a novel approach will contribute to a limited pool of literature concerning Weitzman’s approach.

## 5.4 Auction data and Social Network Analysis (SNA) in the UK

5.4.1 Background

Auction data concerning livestock sales is a valuable data set which is likely to reveal a range of important information concerning both breeds sold at livestock markets and information about buyers and sellers themselves. Auction datasets have received little attention within the field of FAnGR analysis (Roosen et al., 2005). Analysis of preferences observed in livestock keepers could be a promising opportunity to target conservation schemes at livestock keepers with specific preferences given a breed’s value is derived from both its phenotypic and genetic components (Roosen et al., 2005).

Social Network Analysis (SNA) is a strategy for investigating social structures through characterisation of network structures (see Figure 9) in terms of nodes (e.g. individual actors) and ties or edges (e.g. relationships) that connect them (Knoke and Yang, 2008). Our technological and economic systems have become dependent on networks of enormous complexity.

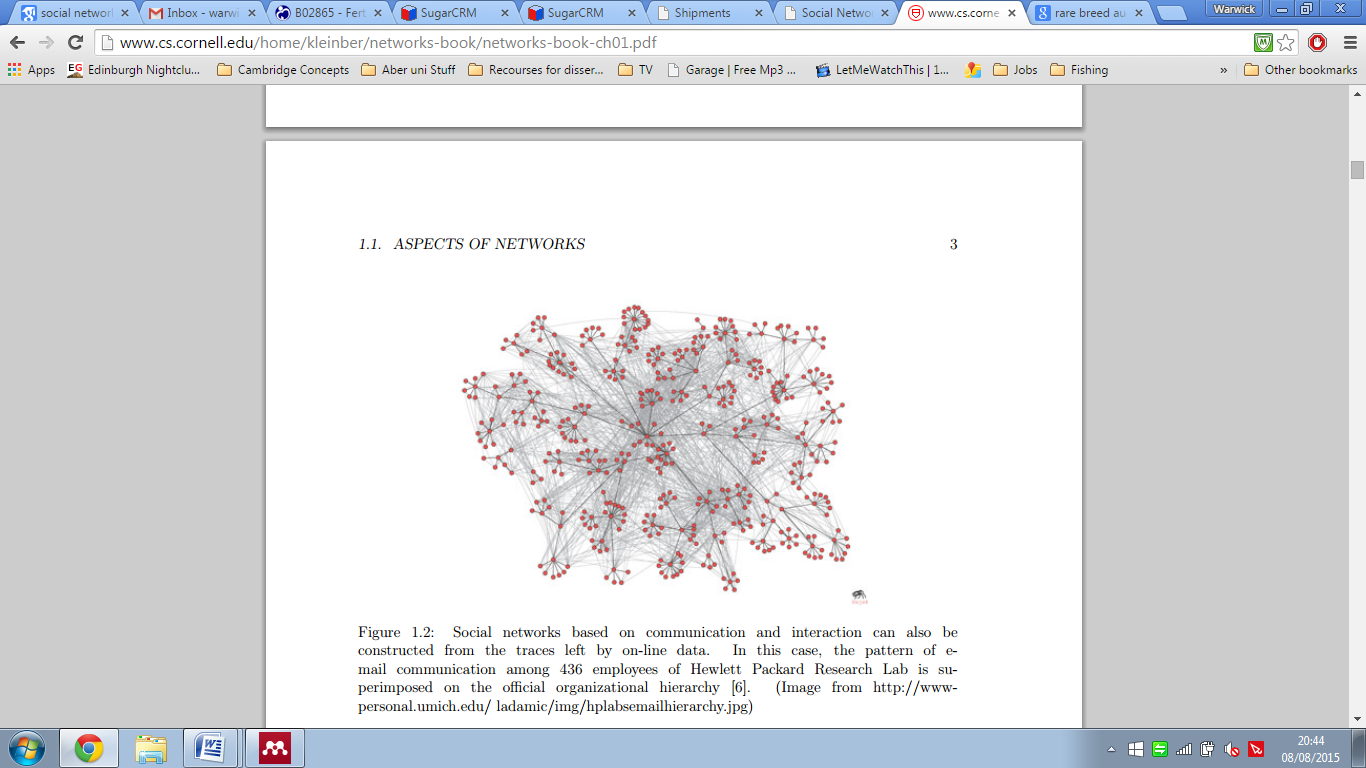


Figure : SNA based on email communication among 436 employees of Hewlett Packard (Easley and Kleinberg, 2010)

SNA could be applied to auction data to determine the significance of key actors (e.g. buyers and sellers) and their relationships within the market. Determining how social networks (i) influence the value and desirability of specific breeds and (ii) contribute to overall stakeholder interactions could aid in strengthening weak connections or linkages between key market actors.

5.4.2 Project aims

* Does rarity of livestock breeds equate to value
* Which traits or characteristics are most desirable within traditional FAnGR
* Who are the key actors (buyers and sellers) within the market
* How might SNA contribute to determination of the relationships between key actors in the market place and their influence on FAnGR conservation
* Assessment of institutional responses identifying areas within the SNA which might serve to strengthen FAnGR conservation outcomes

5.4.3 Methodology

Rare breed auctions occur in the UK among a number of auctioneers (e.g. Harrison & Hetherington). Annual data sets are held by auctioneers and permission can be sought to access such data sets. We intend to apply both HP and SNA analysis to identify significant breed (phenotypic) and social factors (networks) which may be influencing supply of FAnGR. HP analysis will require classification of breeds by their implied attributes (through review of literature). HP modelling will be applied to the data to regress key variables (e.g. rarity, trait analysis, etc) against value and perceived demand.

SNA encompasses theories, models, and applications that are expressed in terms of relational concepts or processes. Questionnaires will be sent to market actors (buyers and sellers) at auctions to establish further socio economic data concerning individuals in networks for demographic profiling. Collaboration graphs will be used to interpret SNA data describing relationships (positive, negative) and their strength between market actors across different breeding clusters (Hanneman et al., 2001).

5.4.4 Potential findings

SNA is a growing field with increasing potential for wide ranging applications (Hanneman et al., 2001). Identifying the structure of social networks allows identification of important factors (e.g. information dissemination, influential figures and motivations) underpinning the working of different institutions. These factors are likely to be highly relevant to FAnGR management across stakeholders.

# 6.0 Fieldwork Justification

Funding for fieldwork is still to be sourced, so only provisional plans can be outlined at this stage. We plan to undertake fieldwork in the UK, Romania and Brazil or Peru.

## 6.1 United Kingdom

6.1.1 Overview

In the UK, a farm animal breed has not gone extinct since the formation of the RBST in 1973(Simm et al., 2004). This is testament to the effectives of the RBST and their strong relationships with the British Pig Association (BPA) and the National Sheep Association (NSA); alongside many breed societies. Using annual auction data in the UK means we can undertake an SNA on the relationship networks between key actors in the UK FAnGR market. Undertaking this analysis in the UK is useful because it demonstrates how a successful network should “potentially” look, given a breed has not gone extinct since 1973.

6.1.2 Data overview and collection

In the UK we have pre-established connections with staff at the RBST (Ruth Dalton), Grassroots (Elizabeth Henson) and various member of the UK’s FAnGR Standing Committee (Julian Hosking). Fieldwork per se would require travel or attendance to rare breed auctions to administer questionnaires to farmers in the market for rare breeds. Auctioneers (e.g. Harrison & Hetherington) will be contacted for data acquisition, some of which can be obtained through pre-existing connections at the RBST and Grassroots. In is anticipated this project would commence in 2017 should funding be sourced.

## 6.2 Romania

6.2.1 Overview

Romania is an interesting case study site given their recent entry into the EU in 2007 which has put increasing pressures on the agricultural sector to increase competitiveness (and intensification) with neighbouring countries. This threatens FAnGR stocks and is likely to exacerbate genetic erosion. Agrobiodiveristy conservation here is also supported by the Prince of Wales Trust, Fundatia Adept (local NGO) and Operation Wallacea which gives us a good platform to work from.

6.2.2 Data overview and collection

Fieldwork in Romania commenced from June 10th to August 13th in Tarnava Mare, Central Transylvania (see Figure 7). Funding was sourced from Operational Wallacea in partnership with a local NGO (Fundatia ADEPT). The survey team visited 8 villages dispersed around the region including:

* Richis
* Nou sasesc
* Mesendorf
* Viscri
* Crit
* Daia
* Malancrav
* Apold

We also took samples in wider Transylvania to determine the representativeness of our sample, in light of more intensive areas of agriculture. A translator at all surveys was present to administer the questionnaire and CE tasks. Results will subsequently feed into on-going work by Fundatia Adept.

## 6.3 Brazil or Peru

6.3.1 Overview

Brazil and Peru represent interesting case studies to use both competitive tender mechanisms and the Weitzman approach. Both these countries are particularly appealing given the scale of livestock production. A high proportion of the population are employed in agriculture and breed diversity is reported to be relatively high in the Peruvian Andes (Kristjanson et al., 2007) and the Pantanal region (Mariante et al., 2009).

We have connections with officials at EMBRAPA (the agricultural ministry) in Brazil and Biodiversity International in Peru. A focus of Biodiversity International’s work in Peru is rare Camelid populations; whilst EMBRAPA are currently working on projects with Pantaneiro cattle. Developing PACS like mechanisms is a stated priority in countries where agricultural intensification is happening at a rapid pace, particularly in Brazil (Costales et al., 2006). Furthermore, PACS mechanisms can contribute towards poverty alleviation, particularly in remote communities which farm in undesirable or harsh landscapes not suited to intensive production (Kristjanson et al., 2007). We are currently in the process of applying for funding grants for these projects to work with our potential partners in either host country.

6.3.2 Overview

Data will be collected on a select number of breeds within a predetermined geographical radius to inform parameters to use in the Weitzman approach. The economic parameters will be sourced from a range of market and non-market data. Genetic parameters will be sourced from both published literature and consultations with FAnGR experts in the relevant countries. Analysis of the Weitzman approach will be used to inform a competitive tender mechanism.

The tender will be administered to identify farmers with the lowest opportunity cost to conserve specific breeds (Stoneham et al., 2003). We plan to target a range of livestock producers through workshops which will be used to facilitate the auction process, through sealed bids made by farmers within pre-defined contractual terms which will be selected for approval based upon a specific criteria (Narloch et al., 2011) with binding terms. The use of competitive tenders has been undertaken by Adam Ducker (Biodiversity International) in the past and so training can be acquired here. A translator will be required within the workshops given language barriers will be present. `

# Data acquisition

Here, we outline a number of data sources which will contribute towards successful completion of the aims and objectives outlined for the PhD.

## **7.1. Domestic Animals Diversity Information System (DAD-IS)**

The DAD-IS database is an information tool for implementing strategies for the management of FAnGR and is maintained by the FAO (FAO, 2007). The database provides information on global breed population levels, geographical distribution and endangerment status. National Co-ordinators provide this information to the FAO who are responsible for maintaining the database. A library also holds a comprehensive database of publications on breeds.

## **7.2 European Farm Animal Biodiversity Information Service (EFABIS)**

The EFABIS network feeds information directly into the DAD-IS database and is a rich information source describing breeds in textual and numerical values (e.g. population sizes, structure over time, geographical ranges and existence of conservation schemes).

## **7.3 Auction data**

The RBST, Grassroots and a range of auctioneers can provide useful datasets concerning sales of rare livestock breeds. These will be rich sources of data to inform our proposed SNA and HP analysis.

## **7.4 ‘The Ark’ RBST journal records**

The ‘Ark’ is the RBST’s quarterly journal and contains a wealth of information concerning conservation projects for rare breeds, auction sales data dating back to the 1980’s, and a wealth of information concerning progress updates on specific breeds. Potentially, we hope to use some data contained in the archives for the ARK.

## 7.5 Natural England’s ‘NBAR’ payment data

Natural England (NE) holds data concerning the administration of NBAR payments across the UK. This concerns receivers of payments, total level of payments, geographical distribution of subsides level of subsides associated with particular breeds. This is likely to be very useful to assess the effectiveness of UK subsides (i.e. do they alleviate ‘at risk’ status). We have now been granted permission by NE to access this data.

## **7.6 Key organisations**

Further to the above, a number of key organisations are likely to represent a key source of information through reports and data sets which they contain. These are as follows:

* The UK FAnGR Committee & DEFRA
* The European Association for Animal Production (EAAP)
* Biodiversity International
* The International Livestock Research Institute (ILRI)
* The FAO
* The SAVE (Safeguard for Agricultural Varieties in Europe) foundation
* The Consultive Group for International Agricultural Research (CGIAR)
* RBST
* EMBRAPA

# 8.0 Timeline plan

Figure 10 outlines a Gant Chart of the proposed timeline associated with this PhD project; from December 2014 to April 2018 in quarterly intervals.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Task** | **Dec-14** | **Apr-15** | **Aug-15** | **Dec-16** | **Apr-16** | **Aug-16** | **Dec-16** | **Apr-17** | **Aug-17** | **Dec-17** | **Apr-18** |
| Writing for 3 month progress report |  |  |  |  |  |  |  |  |  |  |  |
| Planning methodology for Romania CE fieldwork |  |  |  |  |  |  |  |  |  |  |  |
| Fieldwork in Romania |  |  |  |  |  |  |  |  |  |  |  |
| Planning and writing confirmation report |  |  |  |  |  |  |  |  |  |  |  |
| Confirmation panel for report |  |  |  |  |  |  |  |  |  |  |  |
| Analysis of CE data |  |  |  |  |  |  |  |  |  |  |  |
| Writing paper from CE data |  |  |  |  |  |  |  |  |  |  |  |
| Source funding for Peru or Brazil |  |  |  |  |  |  |  |  |  |  |  |
| Begin planning methodology for Weitzman |  |  |  |  |  |  |  |  |  |  |  |
| Obtain data from databases for Weitzman |  |  |  |  |  |  |  |  |  |  |  |
| Plan methodology for competitive tender |  |  |  |  |  |  |  |  |  |  |  |
| Undertake fieldwork in Peru or Brazil |  |  |  |  |  |  |  |  |  |  |  |
| Analysis of Weitzman data |  |  |  |  |  |  |  |  |  |  |  |
| Analysis of competitive tender data |  |  |  |  |  |  |  |  |  |  |  |
| Paper writing for Weitzman and competitive tender |  |  |  |  |  |  |  |  |  |  |  |
| Undertake internship for PhD |  |  |  |  |  |  |  |  |  |  |  |
| Planning methodology for SNA analysis in UK |  |  |  |  |  |  |  |  |  |  |  |
| Administration of questionnaires at auctions |  |  |  |  |  |  |  |  |  |  |  |
| SNA data analysis |  |  |  |  |  |  |  |  |  |  |  |
| SNA paper writing |  |  |  |  |  |  |  |  |  |  |  |
| Chapter writing for PhD thesis |  |  |  |  |  |  |  |  |  |  |  |
| Final PhD thesis draft |  |  |  |  |  |  |  |  |  |  |  |

Figure : Gant Chart detailing approximate timeline associated with key steps in the PhD project

# 9.0 Interim progress

Here, interim progress in the PhD is detailed according to those factors which have been completed, area in progress or planned in the future. Training records can be found in Appendix 13.2.

## 9.1 Completed

Table 8 details currently completed key tasks completed within the PhD so far.

Table : Key stages completed to date within PhD

|  |  |  |
| --- | --- | --- |
| **Task** | **Description** | **Date completed** |
| Review of literature | Comprehensive review of literature undertaken and key points documented in a spread sheet database of materials read | Nov-14 |
| Three month progress report | Progress report written detailing a literature review, provisional data presentation and possible areas of future research | Dec-14 |
| Research plan for CE fieldwork | Research plan for fieldwork describing data collection plans, methodological approach and sampling locations | Apr-15 |
| CE fieldwork methods defined | Methodology for the CE design completed and made using Ngene | May-15 |
| Meeting with potential future project partners | Meeting with Irene Hoffman (FAO) and Adam Drucker (Biodiversity International) | May-15 |
| CE data collection | Data collected in Romania June to August | Aug-15 |

## 9.2 In progress

Table 9 details key tasks currently in progress within the PhD and proposed completion dates.

Table : Key tasks currently in progress within the PhD to date

|  |  |  |
| --- | --- | --- |
| **Task** | **Description** | **Completion date** |
| Literature review for confirmation report | A comprehensive literature review has been undertaken and a database of literature created | Aug-15 |
| Writing confirmation report | Writing of the confirmation report | Sep-15 |
| Logging fieldwork data | Logging of fieldwork data ready for analysis | Sep-15 |
| Identifying funding sources for Brazil or Peru | Identify and apply to funding sources for Peru of Brazil fieldwork | Dec-15 |
| Planning paper writing | Planning CE paper including identification of appropriate journals and potential layout the paper may take | Oct-15 |

## 9.3 Planned

Table 10 details tasks planned for future elements of the PhD with proposed completion dates.

Table : Future tasks planned for the PhD

|  |  |  |
| --- | --- | --- |
| **Task** | **Description** | **Completion date** |
| CE data analysis | Analyse data using a Multinomial Logit Model in Ngene | Oct-15 |
| CE paper writing | Write paper for publication of ecological economics | Dec-15 |
| CE paper review and submission | Finalise reviewer comments for paper | Jan-16 |
| Attend genetics MSc course | Attend lectures on MSc course covering genetic theory and conservation genetics | Jan-16 |
| Review literature on Weitzman approach | Comprehensive literature review on methodological approaches associated with Weitzman approach | Mar-16 |
| Review literature on Competitive tender | Review literature on competitive tender and methods for optimal design of auction | Mar-16 |
| Design fieldwork plan for Weitzman and competitive tender | Written fieldwork plan for sampling and data collection using both Weitzman approach in conjunction with a competitive tender mechanisms for conservation contracts | Apr-16 |
| Design methodology for Weitzman | Assess availability of data for use in Weitzman model | Jun-16 |
| Design Methodology for competitive tender | Design method for competitive tender auction workshops | Jun-16 |

# 10. Research challenges

A number of research challenges are likely to impact methodological design and data collection. Table 11 outlines these potential challenges and mitigation strategies.

Table : Key challenges which need to be addressed during the PhD, alongside mitigation measures

|  |  |  |
| --- | --- | --- |
| **Task** | **Challenge** | **Mitigation measure** |
| GIS analysis for CE data | Need to refine skills within GIS for spatial analysis of data | Attend lectures and basic online tutorial videos for using Arc9 GIS for spatial analysis of data |
| Use of R statistics for data analysis | General analysis of data in R is required and improved understanding of the software | Attending a NERC training course in late August for training for advanced data analysis in R |
| Fieldwork funding | Funding needs to be sourced for fieldwork plans | Work with Dominic Moran and supervisory team to apply and source funds for proposed fieldwork |
| Data collection in Peru or Brazil | Lack of knowledge regarding native languages in Peru and Brazil | Attend training classes for Spanish and Portuguese at UoE. Use translators for fieldwork |
| Weitzman analysis | Lack of knowledge regarding the Weitzman approach and genetic principles | Attend genetics course to learn genetic principles for the analysis. Skype meeting with Kirsten Zander who has previously applied this method to FAnGR conservation |
| Competitive tender | Lack of knowledge regarding experimental auctions | Training class attended in Crete on experimental auctions outlining key theoretical steps to implementing a conservation auction. |
| SNA | Lack of knowledge regarding SNA principles and theory | Reading on SNA principles and potential attendance of a workshop on SNA theory |

# 11. Proposed papers

Table 12 outlines the proposed papers for the duration of the PhD which meet the methodological approaches outlined in Section 5.0.

Table : Proposed papers for research publication in peer reviewed journals

|  |  |  |
| --- | --- | --- |
| **Proposed title** | **Description** | **Target journal (s)** |
| Determining farmer preferences for FAnGR conservation schemes in Romania | This paper will use a CE to determine farmer preferences in Transylvania from a sample of ~170 respondents. Data should inform policy deign and the appropriate mechanisms for designing a conservation scheme | Ecological economics |
| Application of Weitzman approach to determine livestock breed conservation priorities in Peru / Brazil | This paper will employ Weitzman's approach to conservation to determine conservation priorities for rare breeds in Peru or Brazil | Livestock Science or Journal of Agricultural Economics |
| Application of the Competitive tender mechanism to determine least cost conservation suppliers in Peru / Brazil | Here we plan to employ the Competitive Tender mechanism to identify farmers with the lowest opportunity cost for conserving rare livestock breeds in either Peru or Brazil, following Weitzman analysis | Ecological Economics |
| Social Network Analysis (SNA) of FAnGR actors in the UK | This paper will describe a SNA of key market actors in the UK FAnGR conservation market and outline the institutional relationships between such actors | European Review of Agricultural Economics |

# 12. Conclusion

Irreversible loss of genetic diversity reduces opportunities for future breeding programmes to improve food security, reduce poverty and shift towards sustainable agricultural practices ( Hoffmann, 2010). FAnGR represent an important component within sustainable livestock production systems and influence the ability of such systems to respond to changing economic and environmental conditions (Jackson et al., 2010; Pattison et al., 2007; Zander et al., 2009). Genetic resources are a product of market failure and therefore requires provision by both market and policy instruments (Drucker et al., 2001).

The decline of genetic diversity will most likely continue if economic incentives are not established, through the medium of policy interventions and targeted payment schemes. Utilising economic instruments such as PACS, SMS, competitive tender and the Weitzman conservation approach are likely to contribute towards FAnGR conservation; however the most appropriate mechanism to administer breed conservation remains up for debate. Future work in this area is necessary to identify the most appropriate delivery vehicle for the continued supply of FAnGR which will yield the greatest conservation benefits relative to the cost.

Hoffman (2011) identified economic and market drivers as the most important threats to global FAnGR. Economic interventions which can reduce market failure and increase agrobiodiveristy is a stated priority (Zander, 2006). Calculating the costs associated with conservation programmes for various breeds has been identified as key area of research by Drucker (2004) and Pattison et al., (2007). Determining a consistent decision making framework associated with breed selection for conservation schemes is likely to offer a more stable, transparent platform from which to implement FAnGR conservation. Addressing these research gaps will strengthen a very narrow pool of economic literature concerning optimal conservation of FAnGR.

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# 14. Appendices

## 14.1 Zootechnical regulations for UK ‘breeds at risk’

|  |
| --- |
| **Box 1: Definitions for use in the UK National Breed Inventory (DEFRA, 2012)**  The following definitions have been used by Defra and the FAnGR expert Committee for the UK National Breed Inventory. They were developed through a series of detailed deliberations over the course of more than two years, taking into consideration other definitions that were available. Definitions have been refined to ensure that they are practical, reasonable and proportionate for our UK circumstances.  ***Definition of a breed for the purpose of the UK National Breed Inventory***  A livestock **breed**, in the UK context, is an interbreeding population of husbanded or formerly husbanded domesticated animals of consistent genotype and phenotype with a recognised history and administrative framework.  ***Eligibility of a “breed” for inclusion in the UK National Breed Inventory***  To be included in the UK National Breed Inventory a breed should satisfy both of the  following conditions:  • It fulfils, or potentially fulfils, a role in the rural economy. This condition may be satisfied by  evidence that the breed has been, at some time in the past, viable in numbers that exceed criteria for being at risk by UN FAO standards.  • Less than 10% of the aggregate genetic contributions to the population over the last 4 generations are derived from other resources distinct from foreign herd books recognised as representing the same breed.  ***Definition of a “native breed”***  For a breed to be considered **native**, the breed should satisfy all of the following criteria:  • The breed satisfies the criteria for inclusion in the UK National Breed Inventory described above.  • Breed history documents the breed origin within the UK (including from an amalgamation of native breeds) and the UK has formed the primary environment for the development of the breed.  • Breed history documents its presence in the UK in its current adapted form for a qualifying  period of at least 40 years or 6 generations whichever is the longer period of time.  • Less than 10% of the aggregate genetic contributions to the population over the qualifying  period are derived from other resources distinct from foreign herd books recognised as representing the same breed.  • A minimum of 80% of the genetic contributions from any generation of ancestors within the qualifying period must come from ancestors that were (i) registered in the breed’s herd book and (ii) born in the UK. An exception to this may be granted as part of an approved conservation scheme. Henceforward, all conservation schemes that may threaten native status should be notified to Defra and the Devolved Administrations through the Expert Committee for prior approval.  ***Definition of “feral”***  The following series of tests should be used to define **feral** FAnGR in the UK National  Breed Inventory:  • the breed itself satisfies the criteria for inclusion in the UK National Breed Inventory as  defined above; and  • the breed is not subject to routine handling of any kind; and  • more than 90% of the population have been born to feral parents, over two generations.  ***Definition of “exotic breed globally at risk”***  • the breed does not qualify as a UK native breed; and  • the breed is considered to be “at risk” worldwide, according to UN FAO definitions for numerically scarce breeds.  ***Criteria for breeds “at risk” in the UK***  The UK Government has produced two lists of breeds considered to be at risk in the UK, which are based on whether a breed is scarce in terms of actual numbers, measured using the number of pedigree breeding females. These lists and their criteria are explained in greater detail below.  a) **UK Native Breeds at Risk (UK NBAR).** All UK native breeds that are eligible for support under agri-environment schemes through EU rural development programme legislation are included within the lists of eligible Native Breeds at Risk in the UK. There are separate lists of such eligible breeds for agri-environment schemes in England, Scotland, Wales and Northern Ireland. Under these schemes (Higher Level Stewardship in England, Glastir in Wales, the Scotland Rural Priorities Scheme and the Northern Ireland Countryside Management Scheme) a grazing supplement may be paid for suitable grazing with native breeds at risk. The native breeds at risk thresholds for agri-environment schemes are [less than] 7,500 registered purebred breeding females for cattle, 10,000 for sheep and goats, 5,000 for equines, 15,000 for pigs, and 25,000 for poultry. There are [199] UK Native breeds on the most recent UK NBAR list which was published in July 2012. The current list of UK Native Breeds at Risk for use in UK Rural Development Programmes is available at: [http://www.defra.gov.uk/fangr/breeds-at-risk-register/]; and    b) **UK Breeds at Risk (UK BAR).** These breeds are potentially at particular risk in the event of outbreaks of exotic disease in the UK and may be considered for sparing from culling, provided that disease control is not compromised. The population thresholds for a Native Breed to be included on this list are less than 3,000 registered purebred breeding females for cattle, sheep, goats and equines, 1,500 for pigs, and 1,000 for poultry. These threshold figures are further increased by 20% for any breed where fewer than 80% of the registered purebred females are bred with registered purebred males of the same breed. There are also a number of breeds that have been identified as being at especial risk due their geographic concentration within the UK. There are [179] UK Native Breeds on the most recent UK Breeds at Risk list, which was most recently published on 4 July 2012 and is available at: http://www.defra.gov.uk/animal-diseases/controls/culling-exemptions/. |

## 14.2 Training and conferences

The following subsections and appropriate tables outline lecture modules attended; seminars attended; conferences attended and training courses attended during 2014 and 2015.

14.2.1 Lecture modules attended

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Module** | **Institute / Dept** | **Comments** |
| Semester 1 (2014) | Research Planning and Management | UoE / Geosciences | A lecture series identifying approaches to research management within Geosciences |
| Semester 1 (2014) | Frontiers in Geosciences | UoE / Geosciences (NERC) | A lecture series surrounding a broad spectrum of topics within the Geosciences remit |
| Semester 2 (2015) | Numerical modelling and data management | UoE Geosciences (NERC) | Lecture series using different software (R, Python and GIS) for analysis of numerical and spatial data. The course also covered methods for managing data and big data sets |

14.2.2 Seminars attended

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Seminar** | **Institute / Dept** | **Comments** |
| 28/11/2014 | Improving production efficiency in beef cattle | SRUC (Bush) | Full day of lectures and seminars addressing most effective ways to improve efficiency of production in beef cattle. Useful demonstration to current technological advances in the field. Some focus on the role of genetics in improving yields and reducing environmental impacts |
| 26/01/2015 | Ecosystem services and Health | UoE (ECCI) | Lecture assessing how provision of ecosystem services may positively influence health |
| 11/03/2015 | GHG emissions in agriculture | SRUC (Pentlands Science Park) | Seminars and introduction into methods SRUC are deploying to combat and reduce GHG emissions in agriculture through innovative technology and precision farming. Genetic breeding presentations provided insight |

14.2.3 Conferences attended

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Date** | **Organiser / Venue** | **Title** | **Student role** | **Comments** |
| 15/12/2014 | DEFRA / Nobel House, London | Consumers and food basket conference | Delegate | Conference assessing factors which may improve supply chain sustainability and potential consumer response |
| 4-5/2/2015 | Natural England / Droitwhich Spa Hotel | Conservation Grazing | Delegate | Conference on conservation grazing and the impact of different stocking rates and livestock systems used in conservation grazing. Strong attendance from the Rare Breeds Survival Trust (RBST) so useful for making connections and meeting with staff. RBST also held a presentation on grazing marginal lands with rare breeds. Field visits to local farmers and demonstration of conservation grazing in practice. |
| 13/03/2015 | Eftec / London | Applied Environmental Economics conference | Delegate | A range of presentations covering natural capital assets, policy implementation, economic valuation and ecosystem services assessments |
| 19-20/3/15 | SRUC / Kings Buildings | SRUC Postgraduate Conference | Presenter | Postgraduate conference for SRUC students |
| 13-15/4/15 | AES / Warwick University | Annual AES Conference | Presenter | Agricultural Economics society conference, covering livestock and crop economics, including agri environmental schemes. Presentation was focused on introduction to FAnGR conservation |
| 28-29/4/15 | School Of Geosciences / Edinburgh | Geosciences Grad School Conference | Presenter | Student conference for Geosciences Graduate School. I presented an introduction to FAnGR conservation and some key research questions we hope to address |
| 26-27/5/15 | University of Dundee / Dundee | Facing the Future Conference | Delegate | A broad conference with a funded scholarship assessing key challenges facing the environmental sector through policy initiatives. The course was particularly focused on interdisciplinary working between institutions and various researchers |
| 8-10/6/15 | Rome Economics Institute, Rome | EAAE PhD Conference | Presenter | The conference addressed a number of economic factors attributed to and surrounding agriculture across Europe. I presented a preliminary research plan for fieldwork in Romania. The feedback was useful and has subsequently been factored into the fieldwork plan |

14.2.4 Training courses attended

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Institution / department** | **Title** | **Summary** |
| 29/10/2014 - 02/11/2014 | NERC / SAMS Institute | NERC DTP Year 1 Training & Induction programme | Course outlining the NERC DTP programme, involving presentations from researchers at SAMS and UoE on career paths, research tips, time management and PhD planning. Also involved 1 day workshop outlining how to write a funding application. |
| 04/11/2014 | UoE / IAD | Writing an effective literature review | Workshop addressing effective analysis of literature and strength in writing literature reviews |
| 18/11/2014 | UoE / IAD | Poster production for conferences | 1 day training course on effective and clear design of posters for conference presentation. |
| 24/11/2014 - 26/11/2014 | SAGES Foundation | SAGES Graduate School | Graduate school with a strong focus on writing and designing strong funding proposals for research application. Useful networking session with fellow PhD students in Scotland |
| 23-24/02/2015 | James Hutton Institute | Experimental design and analysis | A course focusing on experimental design and analysis using Gemstat. Course gave a good introduction to importance of experimental design from a statistical perspective |
| 18/03/2015 | James Hutton Institute | Getting Started in R | An introduction to using R for statistics |
| 4-8/5/15 | SLU / Umea | Stated preference methods in R | An introductory course for stated preference methods in R (CE and CV). The course covered a range of materials, including model analysis, econometrics, experimental design, using R for application |
| 7-14/7/15 | MAICh / Crete | An introduction to Experimental Auctions and consumer food preference analysis | The training course addressed key topics within the experimental economics field, focusing on experimental auctions. A key understanding was gained as to the positives and negatives of using auctions to measure WTP or WTA. We received an introduction to using Z tree and Stata software for design of auctions and analysis of auction data |

## 14.3 Ethics Form Consent

The appropriate ethics form has been sent to the Ethics Secretary.

## 14.4 Romania Questionnaire and CE tasks

14.4.1 Farm questionaire

**Farm Questionnaire**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Location & GPS: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Section A: About you & your farm**

1. **Which livestock species do you currently farm with?**

|  |  |  |
| --- | --- | --- |
| **Species** | **Breed?** | **Total animals?** |
| Sheep |  |  |
| Goat |  |  |
| Pigs |  |  |
| Buffalo |  |  |
| Cows |  |  |
| Poultry |  |  |
| Other |  |  |

1. **How big is your farm?**

1-2 hectares  3-6 hectares  7-20 hectares  >20 hectares

1. **Do you currently farm with rare or traditional native breeds (not cross breeds)?**

Yes  No

1. **If answered YES to question 3, which rare or traditional breeds do you keep?**
2. **IF you keep rare breeds, why do you maintain them?**

Cultural significance  Quality of products

Level of endangerment  Ease of management

Level of hardiness  Adaptability

Tradition  Tourism

1. **IF you now keep cross breeds instead of rare / traditional breeds then why is this?**

Better yields  Better quality products

Perceived reputation  Social status

1. **IF you do not currently farm with rare / traditional breeds, would you consider doing so in the future if conservation subsides were in place?**

Yes  No

1. **IF you answered YES, which species would you consider keeping?**

Sheep  Buffalo  Cows

Goat  Horses  Pigs

1. **Which traits do you consider most important when deciding which breed to farm? Please rank these statements (1=most important, 8= least important) according to how important they are to you.**

*Rank*

Cultural tradition associated with the breed \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Level of yield (e.g. milk) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Fertility and ease of breeding \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Adaptability to terrain \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Resistance to disease and parasites \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Low veterinary bills \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ease of management & handling \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Quality of products produced \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **IF you farm or would consider farming with rare breeds, we want to know which factors you think are most important for ensuring their continued preservation. Please rank the following statements (1=most important, 6= least important) according to how important they are to you.**

*Rank*

Maintaining traditional farming practices \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cultural and historic factors associated with the breed \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ensuing continued supply of genetic material \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Potential contribution of breed to tourism \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Maintain adaptive traits for future breeding programmes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Continued production of traditional, local products \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Section B: Rare breeds and conservation support measures**

1. **Do you currently receive Romanian agri-environment support payments on your farm?**

Yes  No

1. **If you answered yes, which payments do you receive?**

(e.g. HNV)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **Did you know there is currently support available for farming with rare breeds under Romania’s Rural Development Programme (RDP)?**

Yes  No

1. **Would you consider applying for this support in the future if you decide to / are farming with rare breeds?**

Yes  No

IF NO, why not?

1)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Section C: Future Options for conservation schemes**

**Choice set: \_\_\_\_**

***Choice Task 1:***

I prefer: Option A Option B Nothing

***Choice Task 2:***

I prefer: Option A Option B Nothing

***Choice Task 3:***

I prefer: Option A Option B Nothing

***Choice Task 4:***

I prefer: Option A Option B Nothing

1. **Which statement best describes how you made your choice of Option?**

I chose randomly

I chose the ‘Nothing’ plan because I wouldn’t benefit from conserving rare breeds

I never chose the ‘Nothing’ plan because I don’t want to see breed diversity decline

I chose the most expensive option

I chose the plan which provided the greatest overall benefits relative to my opportunity cost

I chose the plan which provided greatest overall benefits irrespective of my opportunity cost

Other (Please specify)……………………………………………………………………

**Section D: About you**

1. **Gender**

|  |  |  |  |
| --- | --- | --- | --- |
| Male |  | Female |  |

1. **Please tell us which age group you are in**

|  |  |  |  |
| --- | --- | --- | --- |
| Under 20 |  | 50 - 59 |  |
| 20 - 29 |  | 60 - 69 |  |
| 30 - 39 |  | Over 70 |  |
| 40 - 49 |  |  |  |
|  |  |  |  |
|  |  |  |  |

1. **What is the highest level of education you have attained?**

|  |  |  |  |
| --- | --- | --- | --- |
| Secondary |  | University degree |  |
| Foundation degree/HND |  | Professional qualification |  |

1. **Please indicate your main sources of household income. Please rank your income sources from a scale of most to least (1=most)**

|  |  |  |  |
| --- | --- | --- | --- |
| EU support payments |  | Off farm income |  |
| Sale of milk |  | Sale of meat products |  |
| Sale of local food products |  | Government subsides |  |
| Other, please state: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | |  |

1. **Please indicate your monthly household income (Lei / month)**

|  |  |  |  |
| --- | --- | --- | --- |
| Less than 200 |  | 201-400 |  |
| 401 - $800 |  | 801-1,600 |  |
| 1,601-3,000 |  | More than 3,000 |  |

14.4.2 CE Tasks

Romania Rare Breeds Conservation Information Booklet

Set A

Bovines and horses

Please do not write on this Information booklet

**Background:**

The Romanian Government have an obligation to conserve livestock breed diversity in Romania. However, many rare or traditional breeds in Romania are now threatened with extinction due to their less favourable status because of lower yields. Therefore, the Romanian government would like to implement a conservation programme for the protection of rare breeds in Romania. To aid the design of this conservation programme, the government would like to talk to you [the farmers] to know which future options of a conservation scheme are most appealing to farmers in Transylvania.

Therefore, we have designed a number of “choice tasks” which we would like you to complete, based upon YOUR personal preferences. These “choice tasks” illustrate various designs of future conservation programmes, along with a subsidy payment which farmers would be paid for breeding and maintaining rare breeds. We would like to know your preferred option within these “choice tasks”.

However, it is likely that maintaining and breeding rare breeds would reduce your overall yields from livestock, as rare breeds are likely to be lower yielding than cross breeds. As such, we need you to consider the potential loss of yields you may face when making your decisions. However, we would also like you to consider the benefits that you may obtain from farming with rare breeds (e.g. cultural factors, quality of meat and milk products, aesthetic aspects and reduced management requirements).

**Design of conservation schemes:**

Depending on how the government designs these schemes, it can target delivery of different attributes which might make a scheme more of less appealing. These different factors have been summarised in the table below: For example, the government may offer conservation schemes which provide a high level of external support to farmers but with a short contract length. Alternatively, the government could offer conservation schemes with a long contract length but with lower levels of support to farmers. Thus, there is flexibility in terms of how the government targets funds and designs conservation programmes for farmers.

**Options for the design of future conservation programmes**

|  |  |  |
| --- | --- | --- |
| Factor |  |  |
| Contract length | https://blognumbers.files.wordpress.com/2010/09/5.jpg  5 years | http://www.zero360marketing.com/images/10.png  10 years |
| Scheme support | http://www.livingreadyonline.com/wp-content/uploads/Mutual-Assistance-Group-Application.jpg  Application assistance only | http://cdn.retirehappy.ca/wp-content/uploads/Working-With-Advisors.jpg  Independent agricultural advisor / consultant |
| Structure of conservation scheme | http://bsaefiling.fincen.treas.gov/images/individual.jpg  Scheme managed on individual basis | http://images.clipartpanda.com/structure-clipart-projects.jpg  Schemes managed as community conservation projects |

**Where do you fit in?**

As already indicated, the government is undecided as to how best administer rare breed conservation programmes. It has therefore asked us to assess which attributes of a conservation programme might be more or less appealing to farmers, by interviewing farmers in Transylvania.

**Proposed contract:**

In answering our questions, please think about the likely requirements which will be included in the conservation contract. You would be required to:

* Agree to participate in the scheme for no less than 5 years
* Maintain at least 1 animal from a selection of species and breeds (listed below)
* Breed the animal with other pedigree animals of the same breed (not cross breeds)
* Feed and maintain the animals health
* Assist in monitoring objectives of the scheme

**Species and breeds supported:**

**Cow:** Steppe Grey

**Buffalo:** Romanian Buffalo

**Equidae:** Romanian semi-heavy

Nonius

Gidran

Huțul

Furioso North Star

Arabian Shagya

Lipizzan

\*\*Please note, it would be mandatory for you to comply with the requirements of the contract. Non-compliance could result in subsidy payments being with held.

**How you can help!**

We will present you with a series of ‘choice tasks’, in which we ask you to indicate your preferred option for the design of conservation programmes. An example of a typical ‘choice task’ is presented below.

**Example choice task**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option A | Option B | Nothing |
| Contract Length | https://blognumbers.files.wordpress.com/2010/09/5.jpg  5 year | http://www.zero360marketing.com/images/10.png  10 year | -- |
| Scheme support | http://www.livingreadyonline.com/wp-content/uploads/Mutual-Assistance-Group-Application.jpg  Application assistance | http://cdn.retirehappy.ca/wp-content/uploads/Working-With-Advisors.jpg  Independent agricultural advisor / consultant | -- |
| Structure of conservation scheme | http://images.clipartpanda.com/structure-clipart-projects.jpg  Schemes managed as community conservation projects | http://bsaefiling.fincen.treas.gov/images/individual.jpg  Scheme managed on individual basis | -- |
| Subsidy  (per animal / per year) | Lei 200 | Lei 400 | -- |

**I prefer:** Option A Option B Nothing

❑ ❑ ❑

**Things to think about:**

Before you complete the choice tasks, there are a few other things that you should remember when making your choices:

* ***Be honest!*** The experience from other surveys similar to this is that people have a tendency to respond in one way but in reality would act differently. We believe this is due to the fact that they do not really consider how choices might affect their income and time.
  + You need to ***consider the subsides seriously***!
  + ***Would you really accept the subsidy amounts on offer?***
  + ***Would you really be able and willing to participate in the conservation programmes?***
  + ***If both programmes in Options A and B are lower than what you think you are willing and able to accept, then you should choose the ‘Nothing’ option.***

Once you have completed all the choice tasks, you should indicate the thought process you went through when making your choices.

Choice Set A

Choice Tasks 1 – 4

Please record the ‘Choice Set’ number in your answer sheet.

Then recorded your choices from the following 5 choice sets in your answer sheet.

**Choice Task 1:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option A | Option B | Nothing |
| Contract Length | https://blognumbers.files.wordpress.com/2010/09/5.jpg  5 years | http://www.zero360marketing.com/images/10.png  10 years | -- |
| Scheme support | http://www.livingreadyonline.com/wp-content/uploads/Mutual-Assistance-Group-Application.jpg  Application assistance only | http://cdn.retirehappy.ca/wp-content/uploads/Working-With-Advisors.jpg  Independent agricultural advisor | -- |
| Structure of conservation scheme | http://images.clipartpanda.com/structure-clipart-projects.jpg  Schemes managed as community conservation projects | http://bsaefiling.fincen.treas.gov/images/individual.jpg  Scheme managed on individual basis | -- |
| Subsidy  (per animal / per year) | Lei 90 | Lei 270 | 0 |

**I prefer:** Option A Option B Nothing

❑ ❑ ❑

**Choice task 2:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option A | Option B | Nothing |
| Contract Length | http://www.zero360marketing.com/images/10.png  10 years | https://blognumbers.files.wordpress.com/2010/09/5.jpg  5 years | -- |
| Scheme support | http://cdn.retirehappy.ca/wp-content/uploads/Working-With-Advisors.jpg  Independent agricultural advisor | http://www.livingreadyonline.com/wp-content/uploads/Mutual-Assistance-Group-Application.jpg  Application assistance only | -- |
| Structure of conservation scheme | http://bsaefiling.fincen.treas.gov/images/individual.jpg  Scheme managed on individual basis | http://images.clipartpanda.com/structure-clipart-projects.jpg  Schemes managed as community conservation projects | -- |
| Subsidy  (per animal / per year) | Lei 530 | Lei 890 | 0 |

**I prefer:** Option A Option B Nothing

❑ ❑ ❑

**Choice task 3:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option A | Option B | Nothing |
| Contract Length | https://blognumbers.files.wordpress.com/2010/09/5.jpg  5 years | http://www.zero360marketing.com/images/10.png  10 years | -- |
| Scheme support | http://www.livingreadyonline.com/wp-content/uploads/Mutual-Assistance-Group-Application.jpg  Application assistance only | http://cdn.retirehappy.ca/wp-content/uploads/Working-With-Advisors.jpg  Independent agricultural advisor | -- |
| Structure of conservation scheme | http://images.clipartpanda.com/structure-clipart-projects.jpg  Schemes managed as community conservation projects | http://bsaefiling.fincen.treas.gov/images/individual.jpg  Scheme managed on individual basis | -- |
| Subsidy  (per animal / per year) | Lei 270 | Lei 530 | 0 |

**I prefer:** Option A Option B Nothing

❑ ❑ ❑

**Choice task 4:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option A | Option B | Nothing |
| Contract Length | http://www.zero360marketing.com/images/10.png  10 years | https://blognumbers.files.wordpress.com/2010/09/5.jpg  5 years | -- |
| Scheme support | http://cdn.retirehappy.ca/wp-content/uploads/Working-With-Advisors.jpg  Independent agricultural advisor | http://www.livingreadyonline.com/wp-content/uploads/Mutual-Assistance-Group-Application.jpg  Application assistance only | -- |
| Structure of conservation scheme | http://bsaefiling.fincen.treas.gov/images/individual.jpg  Scheme managed on individual basis | http://images.clipartpanda.com/structure-clipart-projects.jpg  Schemes managed as community conservation projects | -- |
| Subsidy  (per animal / per year) | Lei 890 | Lei 90 | 0 |

**I prefer:** Option A Option B Nothing

❑ ❑ ❑

1. Although this graph refers to PAGR it is directly applicable to FAnGR and follows the same general principles [↑](#footnote-ref-1)