European Regional Focal Point for Animal Genetic Resources

Development of models assessing the breeds risk status by utilization of population and relevant georeferenced data

Final Project Report

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Project members

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ERFP

The European Regional Focal Point for Animal Genetic Resources (ERFP) is the regional platform to support the in situ and ex situ conservation and sustainable use of animal genetic resources (AnGR) and to facilitate the implementation of FAO's Global Plan of Action for AnGR.

The ERFP objectives are:

- to support the *in situ* and *ex situ* conservation and sustainable use of AnGR in European countries
- to facilitate the implementation of the Global Plan of Action for AnGR in Europe
- to assist and enhance the AnGR activities of NCs at the European level
- to develop and maintain regular contact and exchange of relevant information on AnGR between European NCs and EAAP and with the Global Focal Point in Rome
- to stimulate the funding and organisation of regional projects, research, workshops and national programmes for AnGR within the European Region
- to maintain an appropriate liaison with the European Commission, the FAO Commission on Genetic Resources for Food and Agriculture, the Secretariat of the Convention on Biological Diversity and regional and international NGOs. For scientific aspects, it is supported by the European Association of Animal Production's Working Group on Animal Genetic Resources (EAAP WG-AGR)
- to stimulate and coordinate the maintenance and further development of national and regional AnGR databases and to encourage European information networking on AnGR

In the 2010 ERFP Call for Action, the project proposal with the title "Development of models assessing the breeds risk status by utilization of population and relevant georeferenced data" has been accepted for support, and the present report is the outcome of this study.

Executive Summary

The aim of this project, following the first strategic priority of the Global Plan for Action (GPA), is to find a common base on the information that should be collected including the spatial dimension of the data, propose ways that such information can be utilized and investigate the feasibility of an index that will combine the different threatening factors to classify the breeds according to their degree of endangerment.

These tools could be used by NCs. to monitor breed risk and evaluate the biodiversity status of the country to take decisions relevant with the management of animal genetic resources and enable a better methodology to analyse breed distribution and utilization.

The degree of risk of a breed can be defined as a measure of the likelihood that, under current circumstances and expectations, the breed will become extinct in a specified period of time, and/or that it will lose through time its genetic variation at a non-sustainable rate.

The risk status of a breed usually has been evaluated by numerical and population data criteria, although other factors have been discussed.

The integration of these additional types of information (demography, phenotypes, husbandry practices, socio-economic status, environmental data, etc.) into the estimation process of risk status and trends of the breeds may clarify the influence of the diverse factors and contribute to the future sustainability of the breeds.

Geographic Information Systems (GIS) are very important in relation to the mentioned types of information with spatial dimension, as they have been designed and developed specifically to allow visualization, management and analysis of data having geographical reference (i.e. coordinates information). Geographical referencing can be derived from different sources at different scales, such as coordinates, post codes, and municipality location.

For this purpose several breed cases have been studied and different approaches have been simulated. Data used for the analysis refer to 10 local breeds from United Kingdom, Greece, Slovenia, Poland, Portugal and Italy. The following breeds are included: Rough Fell sheep (UK), Boreray sheep (UK), Brachykeratiki cattle (Greece), Frizarta sheep (Greece), Bela Krajina sheep (Slovenia), Bovec sheep (Slovenia), Jezersko-solcava sheep (Slovenia), Rendena cattle (Italy), Maronesa cattle (Portugal) and Olkuska sheep (Poland).

The results evidenced that in some cases the geographic approach confirmed the risk level due to the population size (see Bela Krajina and Bovec sheep). In other situations we observed breeds with a large population size and a very concentrate geographic distribution (Maronesa cattle and Rough fell sheep) or with a small population size and a wide geographic

distribution (Boreray and Olkuska sheep). The inclusion of geographic distribution represents a useful tool for the integrated evaluation of the breed risk status.

A first approach in order to assess the risk status of a breed is to put the breed in a risk status category according to the criterion of the maximum risk, according to the parameters (genetic, demographic and geographic).

In a further refinement of the decision process, we accept that between the 4 categories of risk of extinction (not at risk, vulnerable, endangered, critical) intermediate scores might exist resulting from a weighting according to the importance of the criteria applied (population size, geographical concentration, inbreeding) and could be summarized to an integrated relevant Risk Extinction Score.

It should be noticed that the selection of the relevant categories of information to be included in the models and their relative weighting can be defined only by competent multidisciplinary and experts in different disciplines through a joint effort.

The possibility of including additional parameters (factors) that might give complementary information when evaluating the breed's development opportunities or its risk status has been discussed. Several parameters, such as environmental and socio-economic that could be used additionally to the genetic, demographic and geographic criteria have been identified.

The above additional parameters are not applicable in all breeds situations. The ERFP WG should initiate the discussion on the relevance of these factors and identify criteria to evaluate their applicability under the specific situation in each country.

Further investigation is also needed to assess the relation between the factors and how a routine system for collection of information, weighting of the parameters could be developed.

Conclusions and recommendations of the project are summarised in the following:

- *In AnGR, decision making about assessing the breeds risk status should be based on the simultaneous analysis of several different criteria that may contribute to long-term sustainable breeding conditions, such as genetic and demographic characteristics, environmental conditions, and role of the breed in the local or regional economy.*
- *The most appropriate tool to integrate these different data sets and highlight problems related to interdisciplinary comparisons, as it is indicated in the above statement, is the use of Geographic Information Systems (GIS).*
- *A number of factors are to be taken into account to assure a correct comparability of data (projection system, scale), and a number of conditions to be respected to carry out correct*

statistical analysis (sampling, geographic representativeness, statistical significance), or to produce a relevant inter-thematic integrated index.

- *The selection of the relevant categories of information to be included in the models and their relative weighting can be defined only by competent multidisciplinary and international teams of experts in different disciplines through a joint effort.*
- *Further topics of investigation are: to identify the most appropriate sources from the huge amount of all categories of information relevant to AnGR management and conservation that is produced and is public available and to propose the ways to make them accessible for the GIS in order to assess the risk status of the breeds and to examine the differences between countries.*

Foreword

The Convention of Biological Diversity (CBD, 1992) has engaged countries to conserve farm animal genetic diversity. The management of Biodiversity in livestock genetic resources and, closely related to it, the monitoring of breeds are very complex tasks. It requires continuous investigation and consideration of numerous factors, before starting activities.

Because animal breeding and conservation is a long term and very expensive procedure, optimization of processes to establish priorities in the conservation of livestock genetic resources as well as support to decision makers, are highly needed.

The European Regional Focal Point for Animal Genetic Resources (ERFP) is the regional platform to support the in situ and ex situ conservation and sustainable use of animal genetic resources (AnGR) and to facilitate the implementation of FAO's Global Plan of Action for AnGR. Within its possibilities, ERFP supports the project "Development of models assessing the breeds risk status by utilization of population and relevant georeferenced data". The present report is the outcome of this study.

Conservation and in particular conservation of rare breeds, should be based on objective data, reflecting the expected future value of a breed. Prioritizing conservation activities requires a very good monitoring of breeds and sound definition of their degree of endangerment or risk. In Europe, there is already good knowledge available of the inventory of breeding animals within breeds and their phylogenetic structures. However, when it comes to information on effective population size and risk status, more detailed information such as genetic and demographic characteristics, environmental, socio-economic and socio-demographic criteria that may contribute to long-term and sustainable breeding conditions is required. It is a fact, that large but regionally concentrated populations are for instance just as much endangered as small populations widely distributed.

The use of geographic information systems (GIS) is a key to integrate such information, combining sets of different sources on breeds in order to categorize them according to their risk status. Thereafter, necessary actions can be undertaken for long term conservation.

All participants of this project have contributed to the proposal for developing an index to assess the breed's risk status. So much expertise, knowledge and experience of National Coordinators, scientists and decision makers has been integrated in this project, which will certainly help to continuously better assess the breeds development potential and its risk status. But still more investigation is needed, as cost efficiency of conservation strategies must *be improved in the future. Indeed, the civil society is willing to support conservation costs, if decisions on activities are taken on an appropriate base. This project shall contribute to further improve decision-making.*

Catherine Marguerat
Chair ERFP Steering Committee

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Drago Kompan	Slovenia
Oya Akin	Turkey
Lawrence Alderson	UK

Context of the project

Introduction

The aim of this project is to find a common base on the information that should be collected and their format, including the spatial dimension of the data, in order to evaluate their impact (application) including the possibility of developing models that will combine the different threatening factors into an index appropriate to classify the breeds according to their degree of endangerment. Furthermore these models could be used as an efficient tool to take decisions relevant with the management of animal genetic resources and enable a better method to analyse breed distribution and utilization.

The project's objective is to propose ways that such parameters can be utilized by NCs to monitor breed risk status and evaluate the biodiversity status of the country.

We have carried out case studies in several countries for breeds of different species using different methods of geographical referencing. All models produced comparable outcomes. The project aimed to develop reliable tools that will be made available for countries for their consideration and use.

For the development of this work and specifically the part of the additional parameters that should be considered to evaluate the threats to the breeds, the project team was interacting with the ERFP TF risk status and indicators.

The first strategic priority of the Global Plan for Action (GPA) refers to the characterisation of animal genetic resources (AnGR), the monitoring of trends and risks and the establishment of country based early warning and response systems. In this respect, the Geographical Information Systems may provide a better understanding of the situation in and between the countries in the case of transboundary breeds and consequently the development of proper tools for early response to coming threats.

The geographical dimension of livestock diversity has different practical implementations, apart from being an important additional criterion for a breed's status classification. Geographical concentration of the population in a restricted area or in a limited number of herds may place it at greater risk of extinction. It demonstrates also the link of local breeds to a specific environment and the adaptive characteristics of the breeds, while the spatial data are very useful in order to compare and enhance the breeds' position in the market.

For this purpose several breed cases have been studied and different approaches have been simulated. The geographical concentration is proposed as an additional criterion for the definition of breed status, complementary to demographic and genetic criteria. Furthermore, we investigated supplementary parameters related to the geographical location, primarily classified as environmental and socio-economic parameters that could be included in assessing the breed's risk status and trends.

Assessment of breeds' risk status

According to the last Status and Trends Report from FAO (2012), from a total of 8262 breeds are reported, 7202 are local breeds and 1060 are transboundary (509 regional transboundary and 551 are internationally transboundary). A total of 1881 (22 %) breeds are classified as being "at risk" according to the FAO risk status classification criteria (CGRFA-14/13/Inf.16, 2012). From the above data is obvious that the assessment of the risk status of livestock breeds and populations is an important step to the management of livestock diversity.

The effective management and conservation of livestock biodiversity is complex issue and vital to ensure the global food security, the sustainable development and secure the livelihoods of millions of people. The importance of livestock diversity is increasingly recognised and can be viewed under different aspects, ranging from the importance of livestock diversity to the livelihoods of 70% of the world's rural poor to the provision of non-productive services such as the maintenance of grasslands, marginal areas and ecosystems with high natural values (Hoffman, 2011), and the conservation of cultural value (Gandini and Villa, 2003).

One of the key points in the conservation of AnGR diversity, recognized in the Global Plan for Action (GPA) (FAO, 2007), is the need to enhance monitoring of trends and risks that threaten the diversity, and establish early warning systems. The categorization of breeds according to their risk status gives us the information that indicates whether action is necessary. In the GPA countries agreed to establish or strengthen country - based early warning and response systems. The degree of risk of a breed can be defined as a measure of the likelihood that, under current circumstances and expectations, the breed will become extinct in a specified period of time, and/or that it will lose through time its genetic variation at a non-sustainable rate (Gandini et al., 2004). The risk status of a breed usually has been evaluated by numerical and population data criteria, although other factors have been discussed. Previously geographical distribution was not considered in the definition of risk status, but now has been recognized in the *In vivo conservation of Animal Genetic Resources guidelines* (FAO, 2013).

Geographical isolation or concentration of breeds is an important factor for determining the risk status. An outbreak of an epidemiological disease can cause a dramatic decline in livestock populations concentrated in small areas, and isolated nucleus of population can experience critical levels of inbreeding. In the UK the foot-and-mouth outbreak in 1967/1968 caused the Blue Albion cattle breed to become extinct as the population was concentrated in a small area. As a result a policy was adopted of encouraging wider distribution of breeds with small populations during the following two decades. Despite this a more widespread outbreak of the foot and mouth disease in 2001, together with severe control measures, drastically reduced the population of several endangered breeds. Geographically concentrated breeds were primarily affected (Whitebred cattle 40% of the population loss, Teeswater sheep 35% loss, Herdwick sheep 35% loss, Rough Fell sheep 40% loss), but some breeds with a wider distribution also suffered severe loss (e.g. British Milksheep 40% loss). Table 1 presents the categorization of breeds as vulnerable, endangered, or critical, according to the criteria describe in "*In vivo conservation guidelines*", (FAO 2013).

Table 1. Criteria for classification of breeds' risk status (*In vivo conservation guidelines*, FAO 2013)

	Vulnerable	Endangered	Critical
Numerical (e.g. poultry/pigs)*	2000	1000	100
(cattle/sheep/goats/horses)**	6000	3000	300
Geographical (75% of the population within)	50 km	25 km	12,5 km
ΔF	0,5% - 1%	1%-3%	>3%

*high-reproductive species

** low-reproductive species

According to these criteria, a breed with 75% of population included in a buffer with 25 km of radius should be defined as endangered. The proposed distance is taken as reference for the expansion of an epidemiological disease before the measures of control became efficacious (Alderson, 2009). The level of 25% of the population in a local breed is the minimum percentage able to guarantee the recovery after an epidemiological outbreak.

Geographic Information Systems and their role in assessing breed risk status

Geographic Information Systems (GIS) have been designed and developed since the 1980s specifically to allow visualization, management and analysis of data having geographical reference (i.e. coordinates information). GIS science comprises a set of methods, approaches (spatial statistics) and technologies (GIS) constituting a relatively new area of science, that allow the storage, retrieval, analysis and display of large volumes of spatial data. GIS is used in several fields for scientific investigations, resource management, and development planning. Also in livestock science a growing interest in use of GIS has recently emerged. GIS are very important when simultaneous comparisons are required between complementary data useful in the context of decision-making support for livestock conservation. Topics focusing mainly on relationships between livestock and environment, land use management, disease monitoring, biodiversity and genetic conservation are today fields of active research (Joost et al., 2010). The integration of different types of information (demography, phenotypes, husbandry practices, socio-economic status, environmental data, etc.) may clarify the influence of the diverse factors to the future sustainability of the breeds and contribute to the estimation of risk status and trends of the breeds (Ligda et al, 2010). Geographical referencing can be derived from different sources at different scales, such as coordinates, post codes, municipality location, as shown in the case studies.

Additional parameters that can be used linked with the geographical region having impact on the trends of the breeds, specifically local breeds, are environmental parameters and also socio- economic and socio-demographic data. Concerning socio-economic and socio-demographic data, these can characterise the whole geographic unit, which is presented more often at NUTS3 level. The NUTS classification (Nomenclature of Territorial Units for Statistics) is a hierarchical system for dividing up the economic territory of the EU, and NUTS 3 level correspond to small regions for specific diagnoses. In this case the socio-economic characteristics influence all the farms of the region. The socio economic data can be also considered at farm level, and it can be collected by the use of specially designed questionnaires on-field survey. In the case of data that are described on the whole unit, the information can be found on specific databases (official statistics obtained by censuses, thematic maps, etc.) or by collecting information by the relevant authorities, at national or regional level (veterinarian services, agencies for payment in agriculture, producers associations, etc.).

Furthermore, geo-environmental data can be used to map disease-risk areas and predict parasite outbreaks (FAO 1998). In addition, the description of the production environment (PE) will allow the better interpretation of performance data, and to characterise breeds' adaptation as a result of the selective pressure imposed by the PE (Pilling, 2008). Therefore such information is essential for many decisions in AnGR management and conservation and such approaches have gained importance during the recent years.

Such information can also be provided by two main categories of sources, existing mapped datasets which describe the natural environment where the breed is raised, and by detailed questionnaire addressed to the farmers. In the Report of the FAO Workshop (2008) on Production Environment Descriptors there is detailed reference on the criteria that describe the natural environment and management environment.

Cases studies

Breeds studied and data collection

Data used for the analysis refer to 10 local breeds from United Kingdom, Greece, Slovenia, Poland, Portugal and Italy. The following breeds are included: Rough Fell sheep (UK), Boreray sheep (UK), Brachykeratiki cattle (Greece), Frizarta sheep (Greece), Bela Krajina sheep (Slovenia), Bovec sheep (Slovenia), Jezersko-solcava sheep (Slovenia), Rendena cattle (Italy), Maronesa cattle (Portugal) and Olkuska sheep (Poland).

The breeds have been selected as representative cases of the different patterns of geographical distribution of local breeds.

For each breed the following data were collected: number of breeding females (or at least when exact numbers of the breeding females were not available the flock/herd size), the location of the farm identified by the municipality (or village) and the geographic coordinates of farms. The most appropriate option for analyzing the geographical data is to use the exact geographic coordinates of each farm. When this information is not available, the model could be implemented using the geographic coordinates of the centroid of the municipality. In this study, the information at farm level were available for the three examples from Slovenia, the Post Code level was used in UK and Polish examples, in all the other cases the geographic coordinates of the centroid of the municipality were used.

GIS implementation

GIS analyses were performed using gvSIG open source software (http://www.gvsig.com). In the cases where the exact geographic coordinates were available, each farm was implemented as a point in GIS software. The mean centre of the geographical distribution of farms was calculated, weighted for the number of heads or breeding females reared in each farm. The successive step was the calculation of matrix of distances of each farm from the weighted mean centre. Finally, a buffer including 75% of the population was implemented in GIS. When geographical data at farm level were not available, the analyses were applied at municipality/post code level: we calculated the sum of heads (or breeding females) per municipality/post code, and each municipality/post code was implemented as a point in GIS. The successive steps repeated the same procedure previously described.

The following breeds were included in the case studies:

	**Country**	Slovenia
	Species	Sheep
	Breed	Bela Krajina Pramenka

	**Country**	Slovenia
	Species	Sheep
	Breed	Bovec

	**Country**	Slovenia
	Species	Sheep
	Breed	Jezersko-solcava

	**Country**	UK
	Species	Sheep
	Breed	Rough Fell

	**Country**	UK
	Species	Sheep
	Breed	Boreray

<table>
<tr><td rowspan="3"></td><td>Country</td><td>Greece</td></tr>
<tr><td>Species</td><td>Sheep</td></tr>
<tr><td>Breed</td><td>Frizarta</td></tr>
</table>

<table>
<tr><td rowspan="3"></td><td>Country</td><td>Greece</td></tr>
<tr><td>Species</td><td>Cattle</td></tr>
<tr><td>Breed</td><td>Brachykeratiki</td></tr>
</table>

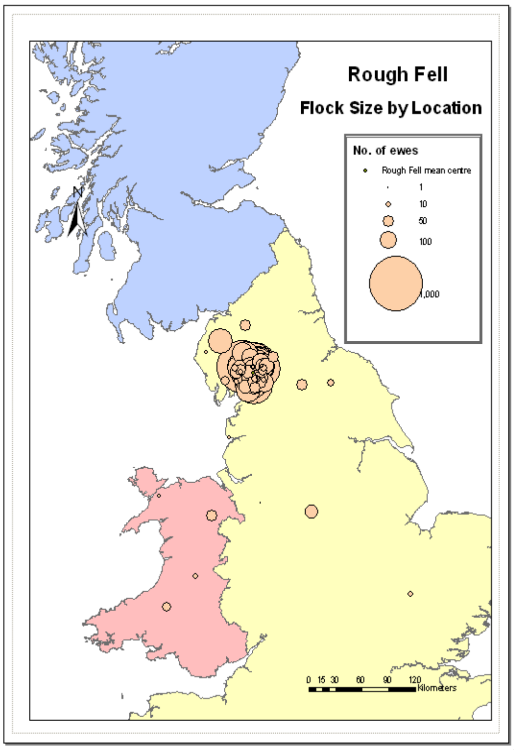
	Country	Poland
	Species	Sheep
	Breed	Olkuska

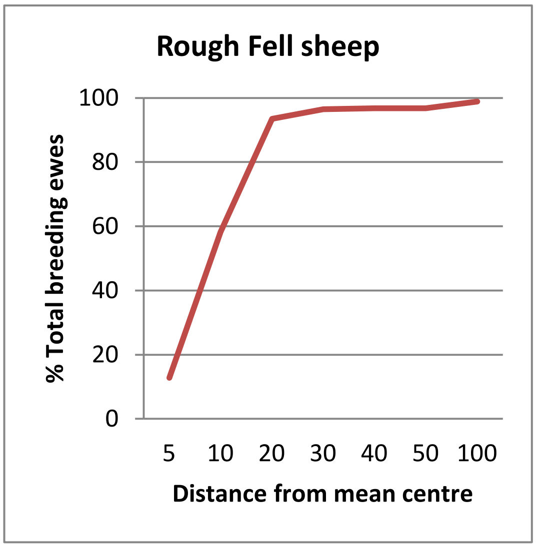
	Country	Portugal
	Species	Cattle
	Breed	Maronesa

	Country	Italy
	Species	Cattle
	Breed	Rendena

Geographical representation of the breeds studied

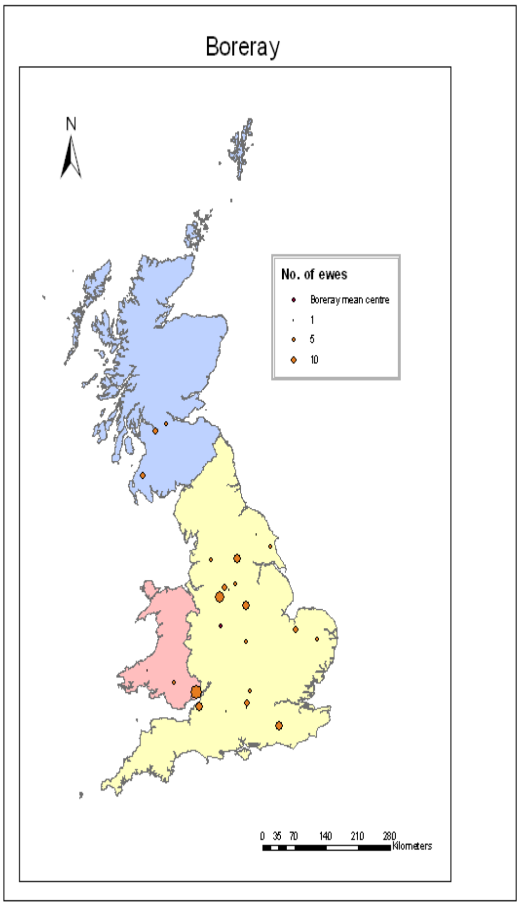
Rough Fell sheep

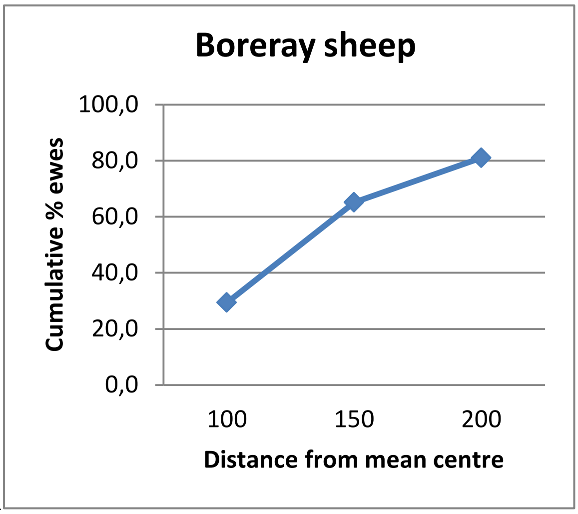




More than 90% of the population of Rough Fell sheep is concentrated in a small area in North-West England where they are particularly adapted to areas of Silurian shale.

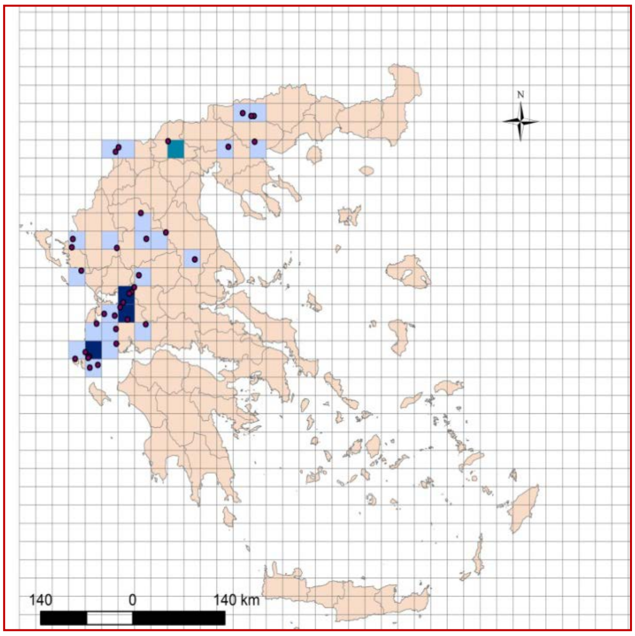
Boreray sheep

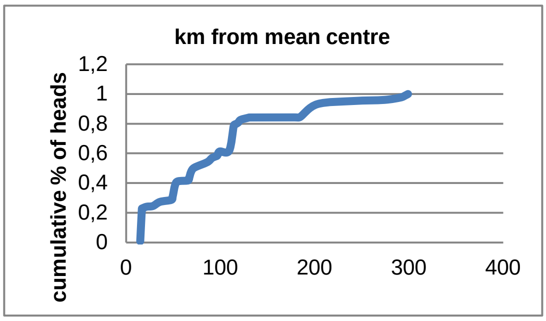




Boreray sheep originated on a small island in the St Kilda archipelago but breeding animals brought to the mainland have been distributed throughout the UK.

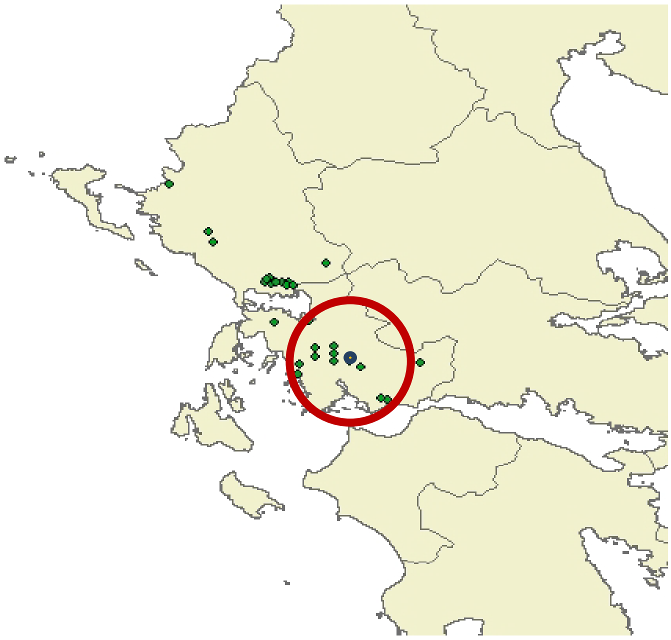
Bracykeratiki cattle

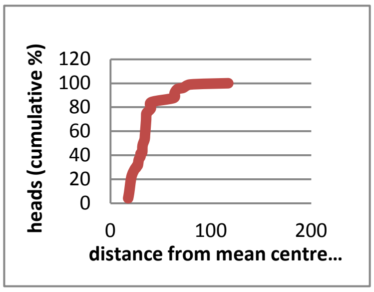




For Brachykeratiki cattle the radius of buffer including 75% of population is 114 km, with no particular risk. The spatial distribution evidence at least two distinguished clusters, with a large number of farms located on an island and the weighted mean centre quite far from several farms location. For this reason another GIS approach was tested. A grid of 25x25 km was overlapped to the map, and the relative incidence (percentage) of number of heads on population size was calculated. The dark blue color indicate the area with a high percentage of the breed population, the light blue color indicate the area with a low percentage. Comparing the results from the two approaches, it can be confirmed that even in non conventional spatial distribution the proposed model is a reliable tool to assess the risk status.

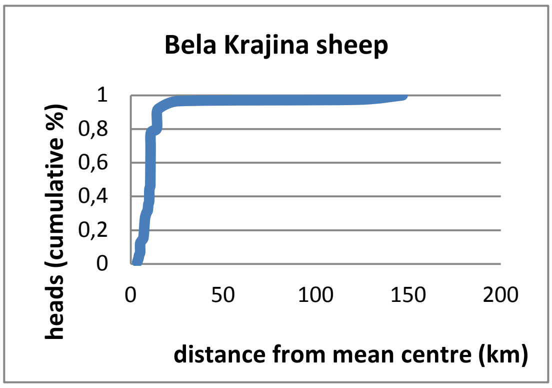
Frizarta sheep



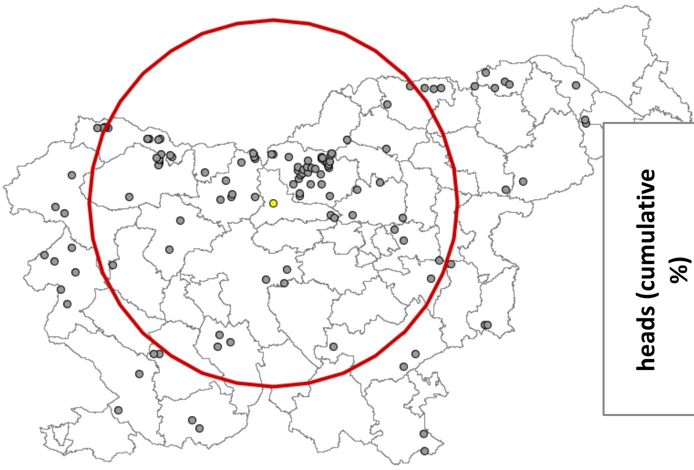


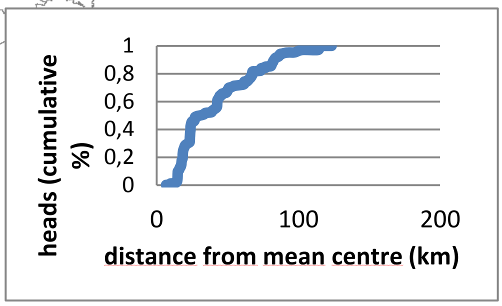
For Frizarta sheep the data used referred only to the 10000 sheep that are recorded over the 50000 of the total breed population. The relative small radius of buffer including 75% of population indicates a concentration of the flocks. In this case we were sure that the overall distribution of the breed overlaps the results of the analysis on the partial dataset; generally, the completeness of the database is fundamental for the reliability of the results.

Bela Krajina sheep

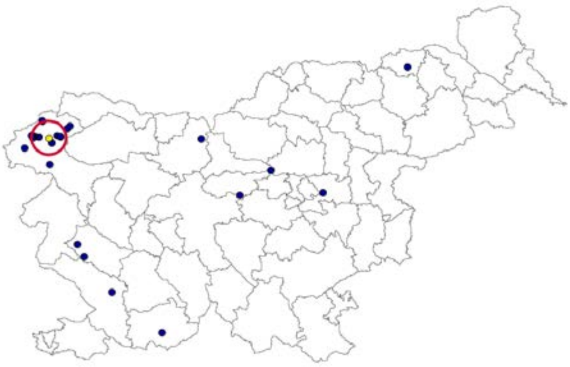


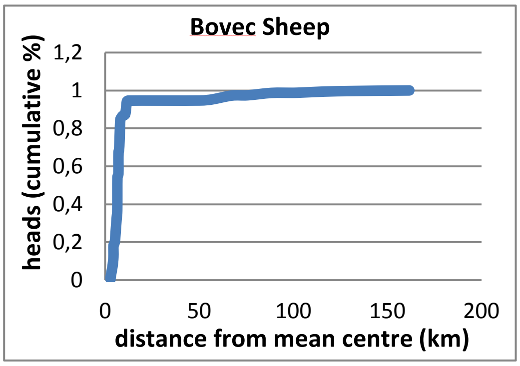
Jezersko-solcava sheep





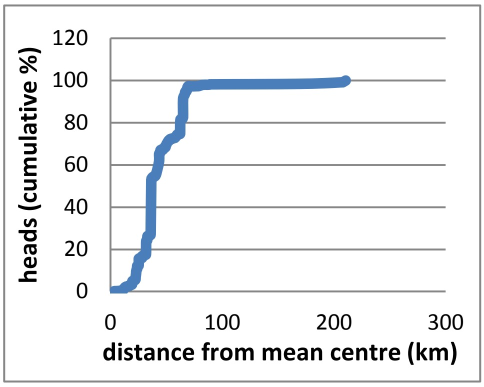
Bovec sheep





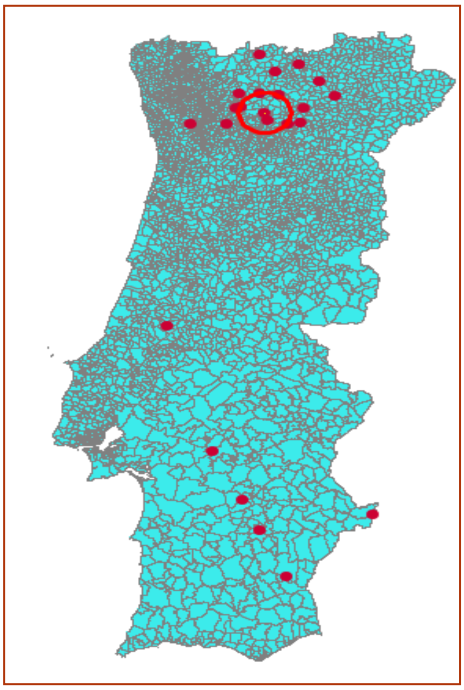
The results obtained for the three breeds from Slovenia illustrate of different situations. The flocks of Bela Kranjia sheep are concentrated in a small area in the south-east of Slovenia, indicating that the risk status in terms of geographic distribution is high. Jezersko-solcava sheep flocks are located in a large area of Slovenia, without particular criticism. The case of Bovec sheep is characterized by a small population size distributed in little flocks, located in different areas of Slovenia. The concentration of a high percentage of ewes in few flocks cause a high risk status for this breed.

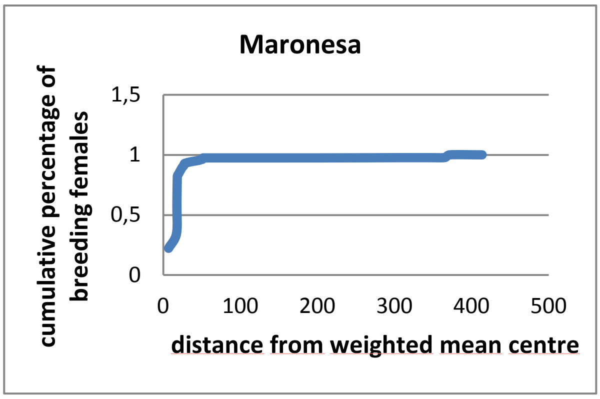
Rendena cattle



The map presented shows that the mean weighted centre of Rendena distribution is located out of the valley of origin of the breed, and the highest concentration of dairy cows is a lowland area of the Veneto Region. As a consequence, the productive environment exploited by this breed has changed with respect the area of origin. However, the trend of the cumulative percentage of breeding females at the increasing of the distance from the weighted mean centre evidenced that almost the entire population is included in a buffer with less than 70 km of radius. The distribution of this breed can be taken as example to consider the "transhumance effect". Almost all the herds of Rendena cattle breed are partially or totally moved to highland pastures during summer. This means that replacement or dairy cattle are reared for 9 months in the farms, and for 3 months are moved to summer farms that in some case are quite far from the farm center. This complicates the assessment of the risk status, because it is difficult to follow the movement of the herds and could be necessary to considered "summer" and "winter" distribution. The same situations could be observed in other countries, both with the separation between summer and winter distribution and in some cases with a nomadic transhumance all around the year (rare but still present for small ruminants).

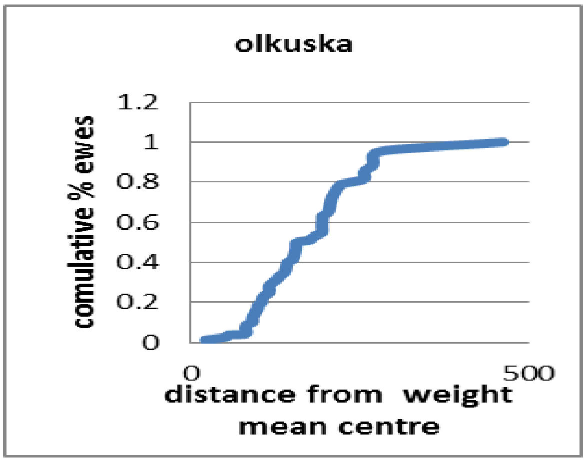
Maronesa cattle





The Maronesa breed region is restricted almost exclusively to the Northern Portugal in Vila Real district, with 75% of the breeding females include in a buffer of 18 km of radius. This means that, although the breed is characterized by quite large population size (5210 cows), the level of risk due to the geographic concentration is high.

Olkuska sheep



Distribution of flocks in 2005

Distribution of flocks in 2012

In the case of Olkuska sheep rapid changes in the population size were observed in the last 10 years. While in 2005 there were only 10 flock and 232 ewes under conservation program, in 2012 these numbers increased to 48 and 876 respectively. The total ewe population registered in the flock books in 2012 was even higher, reaching 1413 ewes kept in 69 flocks.

A rapid population growth resulted in migration of the breed beyond its region of origin. It is a positive development from the perspective of eventual disease outbreak, however such situation requires more coordination to support the exchange of breeding material among flocks. Increased fragmentation of the population could also impose a higher risk of loss of genetic diversity due to genetic drift.

The Olkuska sheep breed is distributed in a large area of the south-eastern Poland. The distance from the weighted mean centre including the 75% of the population is 219 km: in this case the risk due to the population size is relevant, the one due to the geographic distribution is absent.

Table 2. Geographical distribution of the investigated breeds

Breed / Species	Country	Reference year	Population size (breeding females)	Radius of buffer including 75% of population (km)
Rough Fell sheep	UK	RBI / 2008	14100	15
Boreray sheep	UK	RBI / 2008	221	180
Brachykeratiki cattle	Greece	Ministry of Rural Development and	4143	114
Frizarta sheep	Greece	Food, 2008	50000	36
Bela Krajina sheep	Slovenia		695	11
Bovec sheep	Slovenia		2002	8
Jezersko-solcava sheep	Slovenia		4469	64
Rendena cattle	Italy	ANARE 2012	3998	63
Maronesa cattle	Portugal	ACM 2012	5210	18
Olkuska sheep	Poland		876	219

The general results of the GIS analyses are presented in Table 2. Ten case studies from six countries were considered, with the aim to test the proposed model in different conditions, even in the “non-conventional” cases. The results evidenced that in some cases the geographic approach confirmed the risk level due to the population size (see Bela Krajina and Bovec sheep). In other situations we observed breeds with a large population size and a very concentrated geographic distribution (Maronesa cattle and Rough Fell sheep) or with a small population size and a wide geographic distribution (Boreray and Olkuska sheep). The inclusion of geographic distribution represents a useful tool for the integrated evaluation of the breed risk status. The case studies were based on different levels of details in data collection; the use of location based on the post code or on the municipality (geographic data) and the number of breeding females (population data) seems the solution able to guarantee both a sufficient level of precision and a good feasibility.

Potential Additional Parameters linked to the geographical location

The possibility of including additional parameters (factors) that might give complementary information when evaluating the breed's development opportunities or its risk status has been discussed. Several parameters, such as environmental and socio-economic that could be used additionally to the genetic, demographic and geographic criteria have been identified.

These are factors that could be linked to the geographic location of the breed, however further studies are required. It should be recognized that certain breeds remain in the region of origin, while others are more widespread and the impact of the factors is more difficult to assess. Where a breed has remained in its region of origin, or in other areas with similar features, local environmental and socio-economic factors can be defined accurately. However, only a more generalized definition can be applied when a breed has spread outside its area of origin into new areas of different character.

The first set contains parameters that describe the physical environment and can be retrieved from existing Databases (i.e. Corine database). These parameters can be grouped in two categories, terrain features and climate.

Terrain features

- Elevation
- Slope
- Type of vegetation / land use
- Natura 2000 area

Climate

- Mean temperature of the hottest month
- Mean temperature of the coldest month
- Precipitation
- Water availability
- Feed availability
- Seasonal variability

The second part deals with the socio-economic parameters that are linked also with the geographical location of the breed. The breeds are dynamic as they evolve following decisions made by breeders that are influenced notably by the general social and economic environment. Such parameters vary within a country and also between countries, and requires a separate approach in collaboration with socio-economics experts. It is important to define such parameters at local level, but also to identify parameters that can be comparable across countries.

Socio - economics parameters

- Slaughter houses and processing plants
- Population density, unemployment
- Agritourism development
- Special markets
- Urban centers
- Income indicators
- Definition of the area (marginal, unfavourable)
- Number/Density of farms
- Number/density of livestock (divided into cattle, sheep, goat, etc..)

Identification and description of these factors can be based on a variety of sources (existing databases, or by the relevant regional authorities). More detailed information can be collected either at farm or at breed level, using a specially designed questionnaire.

It should be noticed, the additional parameters are not applicable in all breeds situations. The ERFP WG should initiate the discussion on the relevance of these factors and identify criteria to evaluate their applicability under the specific situation in each country.

Further investigation is also needed to assess the relation between the factors and how a routine system for collection of information, weighting of the parameters could be developed.

Proposal for developing an index to assess the breeds' risk status

A first approach in order to assess the risk status of a breed is to put the breed in a risk status category according to the criterion of the maximum risk, according to the parameters (genetic, demographic, geographic).

The following procedure was followed:

In Table 3 the breeds are classified into different categories (scores) of risk of extinction. These categories are:

- Not at risk – Vulnerable – Endangered – Critical.

The breeds' classification into the above categories is done with the following criteria:

- Population size – Geographical concentration – Inbreeding.

Table 3. Classification of the investigated breeds in categories of Risk of Extinction

Breed /species	Using Population Size		Using Geographical Distribution	
	Population size (breeding females)	Status of Endangerment	Radius of buffer including 75% of population, km	Status of Endangerment
Rough Fell sheep	14100	Not at Risk	15	Endangered
Boreray sheep	221	Endangered	180	Not at Risk
Brachykeratiki cattle	4143	Vulnerable	114	Not at Risk
Frizarta sheep	50000	Not at Risk	36	Vulnerable
Bela Krajina sheep	695	Endangered	11	Critical
Bovec sheep	2002	Endangered	8	Critical
Jezersko-solcava sheep	4469	Vulnerable	64	Not at Risk
Rendena cattle	3998	Not at Risk	63	Not at Risk
Maronesa cattle	5226	Vulnerable	18	Endangered
Olkuska sheep	826	Endangered	219	Not at Risk

A breed is classified in to a certain category of risk status, independently according to the criterion that applies each time. E.g. with the Population Size criterion, the breed Rough Fell Sheep is classified as "Not at risk" and Boreray Sheep breed in the category "Endangered".

Following this procedure, when applying the criterion of Geographical Concentration the breed Rough Fell Sheep is classified as "Endangered" and the breed Boreray Sheep in the category "Not at Risk". Therefore the question that arises is what would be the most appropriate criterion for the decision of risk status.

One way of approaching the issue would be to classify each breed in the most endangered category, without assessment of the criterion applied, E.g. the breed Rough Fell Sheep is classified as Endangered on the basis of Geographical Concentration and Boreray Sheep breed in the category Endangered but with the Population size criterion. Both breeds are in the same category regardless of the criterion applied.

In this case, it should be clarified whether,

- Both breeds should be classified at the same risk status. In other words the Population Size has the same impact on the real danger for extinction with the Geographical Concentration?
- In the case financial resources need to be allocated for the rescue of the breeds in which of the two breeds priority should be given?

At the same time, however, the following questions come up:

- Does a correlation exist between the different criteria to be applied in the breed?
- When more criteria reach the same risk status, is the real threat of extinction multiplied, e.g should be considered that the breed is facing higher threats?
- When more criteria give different degrees of risk, should the real risk considered as reduced?

In accordance with the above, we should accept that between the 4 categories of risk status (not at risk, vulnerable, endangered, critical) intermediate scores should exist resulting from a weighting according to the importance of the criteria applied (population size, geographical concentration, inbreeding) and summarized to an integrated relevant Risk Status Index.

The next step is to evaluate the importance of each factor by experts. This approach involves various criteria of different origin and content, which should be weighted according to their respective importance, in order to assess the breeds risk status.

To apply the above statement of the index development we applied the following procedure:

Each category that characterize the degrees of risk of extinction (4 categories: not at risk, vulnerable, endangered, critical) was given a score of, 0, 1, 2, 3, respectively. The scores are linear, double the risk of extinction from one category to the next and express in a quantitative mode the importance of each category of threat.

Weighting factors, which reflect their impact in forming the risk status of the breed, are allocated to the criteria (population size, geographical concentration, and inbreeding) for the classification of the breeds into the different categories. At current stage the weights proposed are subjectively without a prior assessment and are used for illustration only. The proposed weights are 1, 0.75 and 0.50, for the Population Size, Geographical Concentration and Inbreeding respectively. Each category is weighted according to the factor applied and the resulting values are summarized to form the aggregated index. The final score (index) of each breed is applied to classify breeds according to an aggregate risk status, aiming to create a priority table, according to the following general formula:

RSI= P (C1/C2/C3/C4) +GC (C1/C2/C3/C4)+ F(C1/C2/C3/C4)

The procedure described above is presented in the following tables for the breeds considered in the case studies. The criterion of Inbreeding was not included in the final calculation of the index for each breed because it was not estimated due to lack of sufficient data.

Table 4. Index evaluation of the breeds status of endangerment

Breed/ species				Not at Risk	Vulnerable	Endangered	Critical		
				CN 0	CV 1	CE 2	CC 3	Score by criteria	Final Score
Rough Fell sheep	Population size (Numerical)	P	1.00	0	-	-	-	0	1.5
	Radius of buffer (Geographical)	R	0.75	-	-	2	-	1.5	
	Rate of inbreeding (D-F)	F	0,50						
Boreray sheep	Population size (Numerical)	P	1.00	-	-	2	-	2	2
	Radius of buffer (Geographical)	R	0.75	0	-	-	-	0	
	Rate of inbreeding (D-F)	F	0,50						
Brachykeratiki cattle	Population size (Numerical)	P	1.00	-	1	-	-	1	1

	Radius of buffer (Geographical)	**R**	**0.75**	0	-	-	-	0	
	Rate of inbreeding (D-F)	**F**	**0,50**						
Frizarta sheep	**Population size (Numerical)**	**P**	**1.00**	0	-	-	-	0	**0.75**
	Radius of buffer (Geographical)	**R**	**0.75**	-	1	-	-	0.75	
	Rate of inbreeding (D-F)	**F**	**0,50**						
Bela Krajina sheep	**Population size (Numerical)**	**P**	**1.00**	-	-	2	-	2	**4.25**
	Radius of buffer (Geographical)	**R**	**0.75**	-	-	-	3	2.25	
	Rate of inbreeding (D-F)	**F**	**0,50**						
Bovec sheep	**Population size (Numerical)**	**P**	**1.00**	-	-	2	-	2	**4.25**
	Radius of buffer	**R**	**0.75**	-	-	-	3	2.25	

	(Geographical)								
	Rate of inbreeding (D-F)	**F**	**0,50**						
Jezersko-solcava sheep	**Population size (Numerical)**	**P**	**1.00**	-	1	-	-	1	**1**
	Radius of buffer (Geographical)	**R**	**0.75**	0	-	-	-	0	
	Rate of inbreeding (D-F)	**F**	**0,50**						
Rendena cattle	**Population size (Numerical)**	**P**	**1.00**	0	-	-	-	0	**0**
	Radius of buffer (Geographical)	**R**	**0.75**	0	-	-	-	0	
	Rate of inbreeding (D-F)	**F**	**0,50**						
Maronesa cattle	**Population size (Numerical)**	**P**	**1.00**	-	1	-	-	1	**2.5**
	Radius of buffer (Geographical)	**R**	**0.75**	-	-	2	-	1.5	

	Rate of inbreeding (D-F)	**F**	**0,50**						
Olkuska sheep	**Population size (Numerical)**	**P**	**1.00**	-	-	2	-	2	**2**
	Radius of buffer (Geographical)	**R**	**0.75**	0	-	-	-	0	
	Rate of inbreeding (D-F)	**F**	**0,50**						

Table 5. Breeds studied presented according to the Integrated Index of endangerment status

Breed /species	Final evaluation of the endangerment status	
	Ind_endg	Rank (place)
Rough Fell sheep	1.5	4
Boreray sheep	2	3
Brachykeratiki cattle	1	5
Frizarta sheep	0.75	6
Bela Krajina sheep	4.25	1
Bovec sheep	4.25	1
Jezersko solcava sheep	1	5
Rendena cattle	0	7
Maronesa cattle	2.5	2
Olkuska sheep	2	3

The proposed Index and the method of calculation based on the results of the application of GIS, should be considered as a 'proposal in principle' in order to motivate further investigation on the issue, also regarding the weighting of the relevant factors, but also on deciding on the parameters themselves that should be included in such an index. The impact of socio economic factors could be included also in this calculation, by setting a value analogous to the range proposed (-1 0 1) that could "improve" or not the risk status of a breed. Obviously, an overall assessment of the several socio-economic factors that impact on the breed's status has to be completed before. How such assessment of the socio economic factors could be done is commented in the chapter.

Table 6. Rank of the breeds with 1 indicating highest priority and 7 the lowest

Species / Breeds	Ind_endg	Rank (place)
Bela Krajina sheep	4,25	1
Bovec sheep	4,25	1
Maronesa cattle	2,5	2
Boreray sheep	2	3
Olkuska sheep	2	3
Rough Fell sheep	1,5	4
Brachykeratiki cattle	1	5
Jezersko-solcava sheep	1	5
Frizarta sheep	0,75	6
Rendena cattle	0	7

Conclusions and Recommendations

The discussion that has been held during the project meetings when the results of the different case studies were analysed, can be summarised into the following conclusions and recommendations.

- The assessment of breeds' risk status should be based on the simultaneous analysis of several different criteria that may contribute to long-term sustainable breeding conditions, such as genetic and demographic characteristics.
- Geographical concentration is a primary indicator as it is objectively measured and can be used to identify breeds' risk status.
- The methodology applied is efficacious and simple to apply, considering the following key points:
- Uniformity of data collection: municipality or farm level, geographic coordinates (UTM better than national coordinates system), completeness of the dataset.
- The question of using breeding females or flock / herd size remains open, but this is an everlasting discussion.
- The following cases should be considered as non-conventional:
    - Large herd size, wide distribution, but few farms
    - Geographical concentration in more than one location.
- Additional parameters may be used to further refine the assessment of the breed's development potential or the risk status. Such parameters are categorized as environmental and socio-economic factors and can be provided from different information sources.
- The most appropriate tool to integrate these different data sets and highlight problems related to interdisciplinary comparisons is the use of Geographic Information Systems (GIS).
- Based on the results of the application of GIS the use of an index for the classification of the breeds according to an aggregate risk status (Risk Status Index) has been explored. In this index, the categories that characterise the risk status are given linear scores which are weighted according to the importance of the criteria used for the classification of the breeds.
- A number of factors are to be taken into account to assure the comparability of data (projection system, scale), and a number of conditions to be respected to carry out statistical analysis (sampling, geographic representativeness, statistical significance).

- The selection of the relevant categories of information to be included in the models and their relative weighting can be defined only by competent multidisciplinary and experts in different disciplines through a joint effort.

Further topics for investigation:

- identify the most appropriate sources from the huge amount of all categories of information relevant to AnGR management and conservation that is produced and is publicly available
- propose the ways to make them accessible for the GIS in order to assess the risk status of the breeds
- further determination of the linear scores given to the categories of the risk of extinction and the weighting factors of the criteria for classification
- examine the applicability of the additional criteria on the basis of breed cases
- examine the differences between countries
- the impact of the other factors (additional parameters) needs to be investigated concerning their influence on the risk status of the breed, the actions are needed to modify positively their impact and how could include such factors in the regular monitoring.

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Annex I

List of some UK Livestock breeds and their geographical concentration

Geographic Concentration: UK breeds

Breed	Population*	75% radius**
Cattle:		
Whitebred Shorthorn	190	103,17
White Park	727	144,59
Goat:		
Bagot	317	170,00
Sheep:		
Brecknock Hill Cheviot	26294^	13,18
Exmoor Horn	13907	13,39
Rough Fell	14100	13,55
White Face Dartmoor	1578	14,88
South Wales Mountain	4000^	16,83
Herdwick	50000^	17,14
Devon Closewool	5385	18,08
Welsh Hill Speckled	4000^	30,03
Hill Radnor	1040	30,57
Dalesbred	27500^	32,12
Cheviot	45000^	35,23
Lonk	4000^	42,11
Teeswater	669	62,04
Clun Forest	4212	62,20
Devon & Cornwall Longwool	1334	85,00
Boreray	221	180,00

* breeding females (2007 RBI livestock breeds survey)

^ estimations necessary for some mountain/hill breeds

** radius of circle (km) containing 75% of the population

Annex III

ASSESSMENT OF BREEDS RISK STATUS BY INVESTIGATING THEIR GEOGRAPHIC DISTRIBUTION

Enrico Sturaro, Drago Kompan, Lawrence Alderson and Christina Ligda

Agricultural Sciences, 13: 147-150

http://www.au-plovdiv.bg/cntnr/AI/agricultural_sciences_13.pdf