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Added Value of Local Sheep Breeds in Alpine Agroecosystems

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Abstract: This study is part of a project (Sheep Al.L. Chain, RDP Veneto Region) aiming to improve the competitiveness of local sheep breed farms through valorization of their links with mountain agroecosystems. We considered two local sheep breeds of the eastern Italian Alps, "Alpagota" and "Lamon", which have a population of 400 and 3000 heads, respectively, and are used to produce lambs for typical products. A total of 35 farms (17 for Alpagota, with a total of 1652 heads; 18 for Lamon, with a total of 337 heads) were surveyed to collect data on farm organization, flock structure and management (farm questionnaire), land use management (GIS approach), and value chain organization (participatory processes). The link between the two local sheep breeds and mountain agroecosystems is very strong: land use is characterized by a large number of small patches of grasslands in marginal areas. Moving from the results of this study, a set of strategies aiming at improving the competitiveness of these systems have been proposed. Communication to the consumers and to the relevant stakeholders of the added value of local sheep breeds in marginal mountain agroecosystems can contribute to favor the resilience of small ruminant farms and the conservation of Alpine sheep breeds.

Keywords: mountain livestock systems; value chains; ovine biodiversity; genetic resources; typical lamb production

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1. Introduction

The Commission on Genetic Resources for Food and Agriculture recognized the contribution of animal genetic resources to food security for present and future generations and their benefits to the environment, humanity and to cultural heritage [1]. Indeed, local breeds guarantee not only provisioning Ecosystem Services (ES) (food, genes, fibers etc.) but also cultural services, such as traditions and cultural heritage maintenance [2,3]. However, in recent years there has been a significant loss of animal genetic resources, which has led to the development of new strategies to improve sustainable use and ensure their conservation [1]. For instance, in situ preservation should be preferred since it allows safeguarding of the characteristics of each breed [4], keeping the animals in their original area and valorization of the associated typical local products [5,6], which are also important from a cultural and traditional perspective. Local breeds are farm animals linked to a specific geographical area [7], often characterized by adaptability and resilience to extreme climatic conditions [8]. In the Alpine region, most local breeds are raised in grassland-based livestock farming systems which deliver multiple ES, especially cultural ES [9]. In the Italian Alps, specifically in Veneto and the Trentino Alto-Adige regions, several areas are characterized by the presence of local breeds [9]. The limited population size increases the risk of inbreeding [4,10], and new strategies are being developed for the sustainable use of genetic resources, such as breeding schemes [11], which allows selecting, for mating plans, the most genetically distant ram. In European Mediterranean regions, traditional grassland-based livestock systems are mostly located in mountainous areas and other unfavourable areas [12,13], and involve small ruminants which are able to manage marginal areas better with respect to other livestock systems [14,15], to maintain the biodiversity and fragmented landscape, to control the forest encroachment [16,17] and to improve the forage's quality [18,19].

Pasture-based livestock systems are considered low input systems, presenting a high feed self-sufficiency with low production costs [14,20,21]. Indeed, herbivores use natural resources that couldn't be directly consumed by humans, transforming it into food and non-food products, such as meat, milk and wool [20,22,23], as well as a series of services and public goods [24,25]. However, in the last decades, European mountain areas have been affected by a massive abandonment of livestock farming [26], mainly driven by increasing competition with other economic sectors, especially where the geographical and topographical conditions are less favorable [27,28], and by the lack of generational turnover [14,29]. The consequences of this abandonment, which has strongly affected marginal and harsh pastures and meadows [30], are loss of traditional landscape, cultural heritage and biodiversity [31,32] and an increase in natural hazards, e.g., forest fires in Mediterranean areas [30,33]. The European Union recognizes the important role of livestock farming systems to maintain pastures and meadows [34,35] and to manage High Nature Value Farmland (HNVF) [13,36] and, hence, provides financial aid to farmers.

Indeed, the implementation of new strategies to preserve animal genetic resources should integrate socio-economic aspects [37]. The added value of local sheep breeds can be sustained with different strategies; among these, the conversion to organic farming can represent a good opportunity for grassland-based farming systems. The European Commission, within 2030, aims to convert 25% of total Europe farmland into organic farming [38]. In the developed countries, consumer interest in organic products is rapidly growing, demonstrating a willingness to pay more from a perspective of food safety and health [39], with a consequent increase in the market value [40]. The European Union's financial aids also support new marketing opportunities, including sponsorship and communication instruments to promote campaigning and organic labelling [39]. Furthermore, the European Green Deal recognizes the importance of guiding consumers' choice, through a sustainability food labelling framework to move towards the development of new business strategies for farmers [38].

In this perspective, small ruminant farms are characterized by low income compared to other farm production sectors [41]; thus, new marketing strategies should be found to ensure fair remuneration for farmers [42]. The challenge is to create an added value in the sheep supply chain recognizing the importance of the role of sheep farming systems, which guarantee public goods and services [43,44]. These farms are characterized by low mechanization and strong links with the territory [41]; furthermore, the products represent a specific geographical area, including its cultural identity and heritage [45].

This study presents the results of Sheep Al.L. Chain's project (Sheep Alpagota Lamon Chain), funded by the European Agricultural Fund for Rural Development (EAFRD) (Rural Development Program of Veneto Region). The project aims at improving the competitiveness of local sheep breed farms through the valorisation of their links with mountain agroecosystems. Two local sheep breeds of the eastern Italian Alps were considered: Alpagota and Lamon, both located in Belluno province. In this area, pastoral activity and land management are strongly linked and land use is characterized by a large number of small patches, often with high slopes and reduced accessibility. One of the main goals is to promote cooperation between smallholders. Furthermore, moving from a local to a global perspective, the link between local genetic resources and mountain agroecosystems could be a factor in ensuring the resilience of traditional livestock systems.

Using an approach based on participatory processes, we surveyed a representative sample of farms with three specific goals. Firstly, we developed and implemented a smartphone application for the sustainable use of genetic resources with the purpose of limiting the risk of inbreeding and supporting cooperation between farmers. Specifically, the aim was to increase both the population size and the number of farmers involved and to preserve and valorise local genetic resources through an in vivo in situ conservation program. Secondly, we developed a "territorial marketing" strategy based on clear communication to the consumer of the farms' features and links with their mountain agroecosystems and landscape. Finally, through a SWOT analysis, we identified the strengths, opportunities, weaknesses and threats related to the potential conversion to organic farming for the Alpagota breed.

2. Materials and Methods

2.1. Study Area

The study area (Figure 1) is located in the province of Belluno (Veneto region, in the north of Italy, between 45°50′ N and 46°40′ N), which covers an area of 3610 km^2 [27]. It is predominantly a mountainous area, with an average altitude of 1276 m a.s.l. (ranging from 257 m a.s.l. to 3313 m a.s.l.) and is characterized by the presence of the Piave river, which is the main river [46]. Specifically, the study was conducted in the south-western (Lamon-Feltrino) and south-eastern (Alpago-Cansiglio) portions of the province. According to Geiger R. 1954 [47], the climate is classified as Cfb (Oceanic climate with mild summers and cool winters) with an annual average rainfall of 1869 mm (average values range between 64 mm in January and 229 mm in July) and an average temperature of 9.5 °C (ranging between −0.7 °C in January and 18.7 °C in July), and mean relative humidity of 78–82%. Forest (58%, from deciduous to mixed and to coniferous following elevation) dominates land cover, followed by grassland (17%, mostly permanent meadows and pastures under extensive management, with a high biodiversity value) and arable crops (8%, mostly maize), while unproductive land (rocky or bare land, water bodies, urban) accounts for the remaining 12% of the surface [48,49].

Between 1982 and 2010, the area was affected by an abandonment of farming activity, with a reduction of 84% of cattle farms, 70% of sheep farms and 81% of goat farms. Cattle heads decreased by 48%, whereas sheep and goat heads were increased, respectively, by 71% and 34% (Table 1) [50–53].

Table 1. Number of farms and heads of cattle, sheep and goats in the Belluno province. Source: ISTAT, 1982, 1990, 2002, 2012. Data from the last general agricultural census, held in Italy in July 2021, are not yet available.

	Years			
	1982	**1990**	**2002**	**2012**
Cattle				
Farms	4763	2562	1137	717
Heads	35,830	27,161	20,606	18,293
Sheep				
Farms	431	316	342	127
Heads	4099	4638	5615	13,943
Goats				
Farms	399	211	244	74
Heads	1354	1795	2318	2069

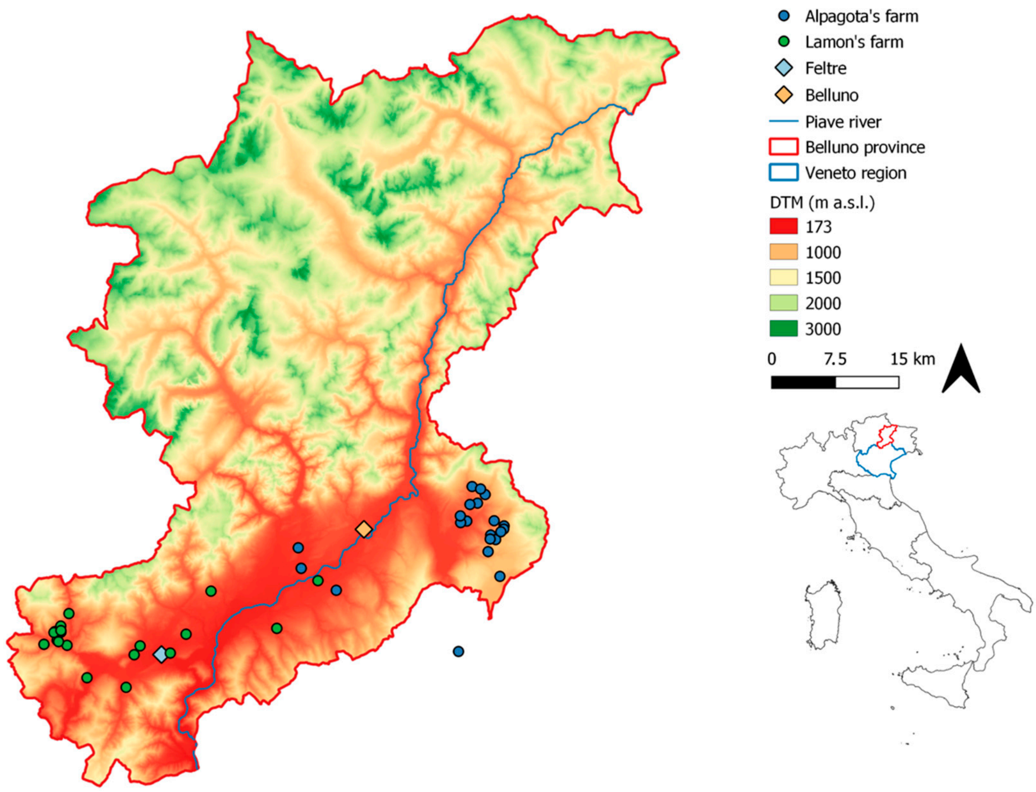

Figure 1. Study area. Blue dots indicate the Alpagota farms, located in the eastern part of Belluno province, while green dots indicate the Lamon farms, located in the western part of Belluno province.

2.2. The Alpagota and Lamon Breeds

The Alpagota (Figure 2a) is an autochthonous breed of the "Alpago-Cansiglio" area, located in the south-eastern portion of the Belluno province (Figure 1). In the past, it was used as a triple-purpose breed, whereas nowadays the main product that comes from the breed is meat (mostly obtained by lambs) [54]. Milk production is very low (0.8–1.2 kg/sheep/day) along with the production of wool (2.5–3 kg/head/year); prolificacy is about 1.46 lamb/sheep whereas the average live weight is about 50 kg [55]. The population size of the Alpagota breed is about 3000 heads (DAD-IS, www.fao.org/dad-is/en, accessed on 18 September 2021), divided into 59 herds, 41 of which are located in the Belluno province and the remaining in the western part of Friuli-Venezia Giulia Region (overall Pordenone's province) (BDN, www.vetinfo.it, accessed on 24 September 2021). The "Fardjma" association involves several breeders, who raise the Alpagota breed following strict rules established by the production's technical policy "Fardjma/Slow Food Presidium". The use of silage and animal feed is not allowed; feeding is mainly based on grazing (during the favorable season) and on in-house forage (during the winter).

The Lamon breed (Figure 2b) is an autochthonous population of the south-western part of the Belluno province (Figure 1). Like the Alpagota breed, the Lamon was a triple-purpose breed, although in this breed the main product is currently meat [54]. All the milk produced daily is used to feed the lambs, and wool production is about 4.5–5 kg/head/year; the prolificacy is about 1.5 lamb/sheep and the average live weight is 66 kg [55]. The population size of the Lamon breed is about 400 heads (DAD-IS, www.fao.org/dad-is/en, accessed on 18 September 2021), divided into 25 herds, 21 of which are located in the Belluno province and the few remaining in the Trento province (BDN, www.vetinfo.it, accessed on 24 September 2021). The "Fea de Lamon" association deals with the protection and valorization of the Lamon breed and related meat production. Specifically, the association involves several members (farmers, Lamon municipality, economic operators, etc.) and the main goal is to give an added value to the whole supply chain.

(**a**) (**b**)

Figure 2. On the left (**a**), the Alpagota breed; on the right (**b**), a Lamon sheep.

According to the Italian National Guidelines for the conservation of plant, animal and microbial biodiversity of agriculture, the Alpagota and Lamon breeds are included in the Anagraphic Registrer of autochthonous sheep and goats with limited population size [56]. The Anagraphic Register is managed by national breeders' associations or by a public institution operating in the sector, and includes information about breeding rams and their precursors, with the aim of avoiding inbreeding. The in situ conservation and productive use of the two breeds now depends on smallholders, with a large percentage of part-time farmers. There is also a program of ex situ, in vivo conservation, which is conducted by two public centers, Veneto Agricoltura (Villiago, province of Belluno) and the Agricultural High School "IIS Della Lucia" (Feltre, province of Belluno). These centres are able to preserve the functional and morphological characteristics of both breeds through mating plans which aim to counter the inbreeding within the population.

2.3. Project Description

The data collection, analysis or treatment, and the relative contribution of the information obtained to the achievement of the project's aims are shown in Figure 3. Data were collected by surveys between August 2019 and January 2020, and involved 35 farms which were representative of the study area production's context. Genomic mapping of rams was performed and the results used to assess a matrix of relationships between rams, which allowed the development of a smartphone application supporting the farmers in the choice of rams exchanged and the consequent mating plans. Farm surveys and the collection of cadastral and land cover maps were used to build a geodatabase of farm management and geographical features. The genetic information, as well as the information regarding farm management and geographical features, was integrated into the development of the smartphone application. Indeed, a description of each farm was used in QR code-based labelling of the products. Finally, the outputs of meeting with farmers and stakeholders (tourism operators, restaurateurs, representatives of the local association, local policy makers) were used in conducting a SWOT analysis to obtain a better insight into the feasibility of organic farming conversion of Alpagota farmers. This task was developed only for the Alpagota breed since the population size justified the interest towards organic farming and the relative costs with respect to the Lamon breed. This breed is characterized by a smaller population size and couldn't address the certification and traceability fees.

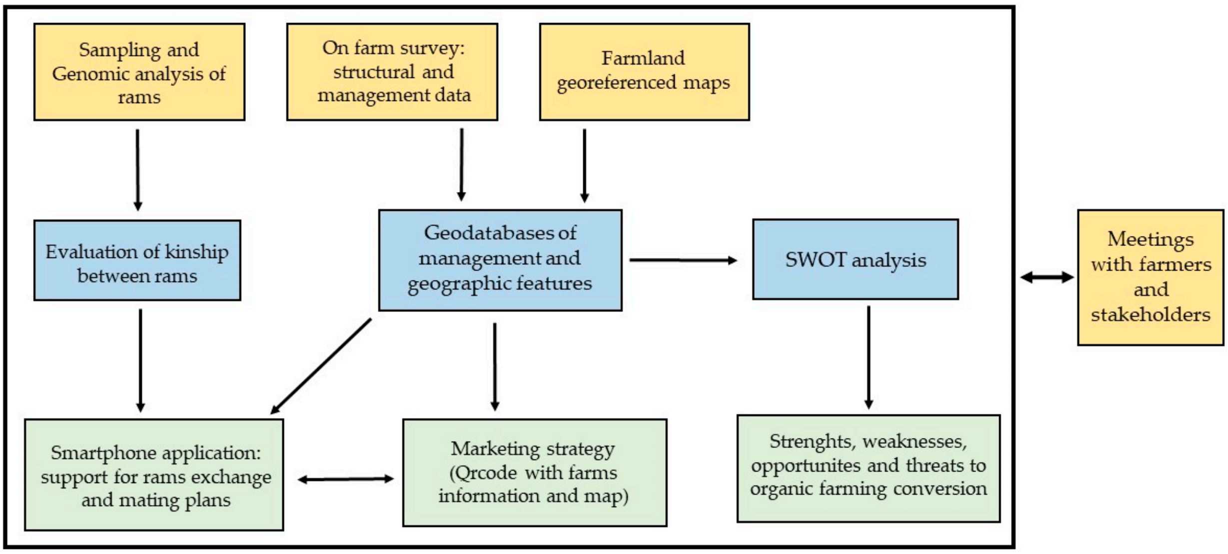

Figure 3. Description of the main steps of the project. Light blue panels relate to data collection and meetings; yellow panels relate to data analyses or (geo)database production; green panels indicate the three main goals and outputs of the project. The arrows indicate the flows of information.

2.4. Genetic Analysis of Rams

The blood samples were collected from all the breeding rams belonging to the 35 farms during the period of the survey (August 2019–January 2020). We collected data only from rams since the males represented the factor limiting genetic variability. In this way, we optimized the ratio between costs (few samples) and benefits (many offspring); in small ruminants, the collection of data from the whole female population is not convenient due to reduced economic income. Specifically, tubes with K3EDTA anti-coagulant were used to collect blood samples which had been preserved at a temperature of −20 °C. In May 2020, the extraction of genomic DNA from the blood samples was carried out following the SIGMA® protocol. A total of 81 rams (41 for Alpagota and 40 for Lamon) of the two local breeds (Alpagota and Lamon) were genotyped with the OvineSNP50 BeadChip (Illumina, San Diego, CA, USA). Autosomal markers presenting minor allele frequency (MAF) less than 0.10, significant deviations from the Hardy–Weinberg equilibrium ($p \leq 10^{-5}$) and with call rate less than 0.90 were removed, as well as samples with a call rate lower than 0.90. After quality control, 39,162 SNP markers remained in the genomic dataset. Population substructure was evaluated by performing a Principal Component Analysis (PCA) based on the genomic matrix using the ade4 R package [57]. The similarity between animals based on genomic information was assessed using a hierarchical cluster based on Ward's hierarchical clustering method with a Euclidian distance analysis.

The genomic inbreeding estimate was based on the genomic relationship matrix (F_{GRM}); the genomic relationship was obtained using the method described by VanRaden (2008) [58]. The genomic matrix was estimated as $G = ZZ'/2\sum p(1-p)$ where Z is the SNP marker matrix assuming 0, 1 and 2 for genotypes AA, AB and BB, respectively.

2.5. On Farm Survey and Farmland Mapping

The on-farm survey lasted about two hours per farm and was divided into three parts. It was based on a questionnaire defined and tested with the project partners (see Table S1 in Supplementary Materials). The first part dealt with general information (species and number of animals reared, land management, etc.) and farmers (age, other employments besides livestock activity, etc.). Secondly, specific data about sheep flocks and their management were collected, such as indoor and grazing periods, diet composition (amount of forages and concentrates used during the indoor period) and lambing seasonality. Farmers were also asked to mention the most critical issues for the management of the flock. Finally, we obtained from the Veneto Agency for Payments in Agriculture (AVEPA) and the Regional

Centre for the Veterinarian Epidemiology (CREV) the cadastral and land cover maps (in two broad categories: grassland and cropland) of each surveyed farm and implemented them in QGIS [59]. We extracted the altitude and slope for each parcel from the DTM with a resolution of 10 m (https://www.regione.veneto.it/web/ambiente-e-territorio/ctr, accessed on 4 May 2021).

The data obtained by the on-farm survey and farmland mapping were organized into geodatabases that provided information for all three goals of the project.

We generated a QR code for each participating farm to link with, including all the information collected on the farm (surface and type of land use managed, number of animals, type of products, farm's location in Google Maps, etc.) in order to develop new territorial marketing strategies and to give added value to local sheep production.

2.6. Meeting with Farmers and Stakeholders and SWOT Analysis for Organic Farming Conversion

One of the aims defined with the project partners was to explore the potential added value generated by the certification for organic labelling. Based on organic farming systems regulations and on the information collected during the survey, a SWOT analysis was carried out to evaluate the potential for conversion to organic farming for Alpagota breed farmers. We focused on the Alpagota sheep breed because the farmers showed interest in applying for this certification, whereas for Lamon this opportunity needs to be further explored. Data on farm management were collected during the on-farm survey. The data were used to collect information on potential difficulties in the transition towards organic labelling for each single farm. The SWOT analysis allowed for identification and evaluation of internal factors (strengths and weaknesses) and external ones (opportunities and threats) in order to evaluate the opportunity of conversion to organic production systems.

3. Results

3.1. Genetic Analysis and Genomic Information

Principal Component (PC) analysis identified genetic stratification among Alpagota and Lamon breeds and the two PC explained 37.8% of the genetic variation across the breeds (Figure 4A,B). As expected, differences between Alpagota and Lamon were large, although Lamon exhibited more genetic similarity, whereas Alpagota showed more dissimilarity, indicating more variability within this population compared with Lamon. These results reflect directly on the relationship between animals in the population as observed by plotting the G matrix by the difference in the subgroups within the population, in which it is observed that Lamon had the highest proportion of closed related animals in comparison with the results observed in the Alpagota breed (Figure 5). Alpagota showed 10 subpopulations that are more related to each other; in Lamon, 8 groups were observed that are more related to each other (Figure 5).

This relationship indicated more animals with inbreeding rates higher than 0.01 for Lamon (n = 23); while, in Alpagota, only 10 animals showed values above the threshold of 0.01. Thus, the great variability observed for Alpagota occurred by an increase in heterozygosity within the evaluated population (Figure 6).

3.2. Farming Systems and Integration with Agroecosystems

Table 2 reports the descriptive statistics and farmer features. Data were collected in 17 farms with the Alpagota and 18 with the Lamon breed, managed by farmers of average age 47 ± 15 year, with a workforce of 1.8 ± 1.3 units, and little difference between the farms of the two breeds. The differences between the two breeds were tested with a one-way non-parametric ANOVA (Kruskal–Wallis test). In most cases, the farmers had other employment (72% for Lamon and 82% for Alpagota), and livestock farming was conducted part-time. Moving to flock sheep characteristics and management, the total number of heads surveyed was 1989 (337 of Lamon and 1652 of Alpagota breed, respectively). The Alpagota flocks were characterized by a small flock size (14.6 ± 18.6 LU/farm), and those of the Lamon breed by a very small flock size (2.8 ± 1.9 LU/farm), although the total LU/farm did not differ since other animals of different breeds and/or species, such as cattle and horses, were considered. The average amount of forage administered was 1.81 ± 0.5 kg DM/head/day, 88% of which was on-farm, indicating a high level of self-sufficiency. The average amount of concentrate administered per day was low and, in general, was produced off-farm. No statistically significant differences were found between Alpagota and Lamon breeds, except for the variable LU, according to the population size previously reported (DAD-IS, www.fao.org/dad-is/en, accessed on 18 September 2021). Lambings were mostly concentrated in winter, spring and autumn.

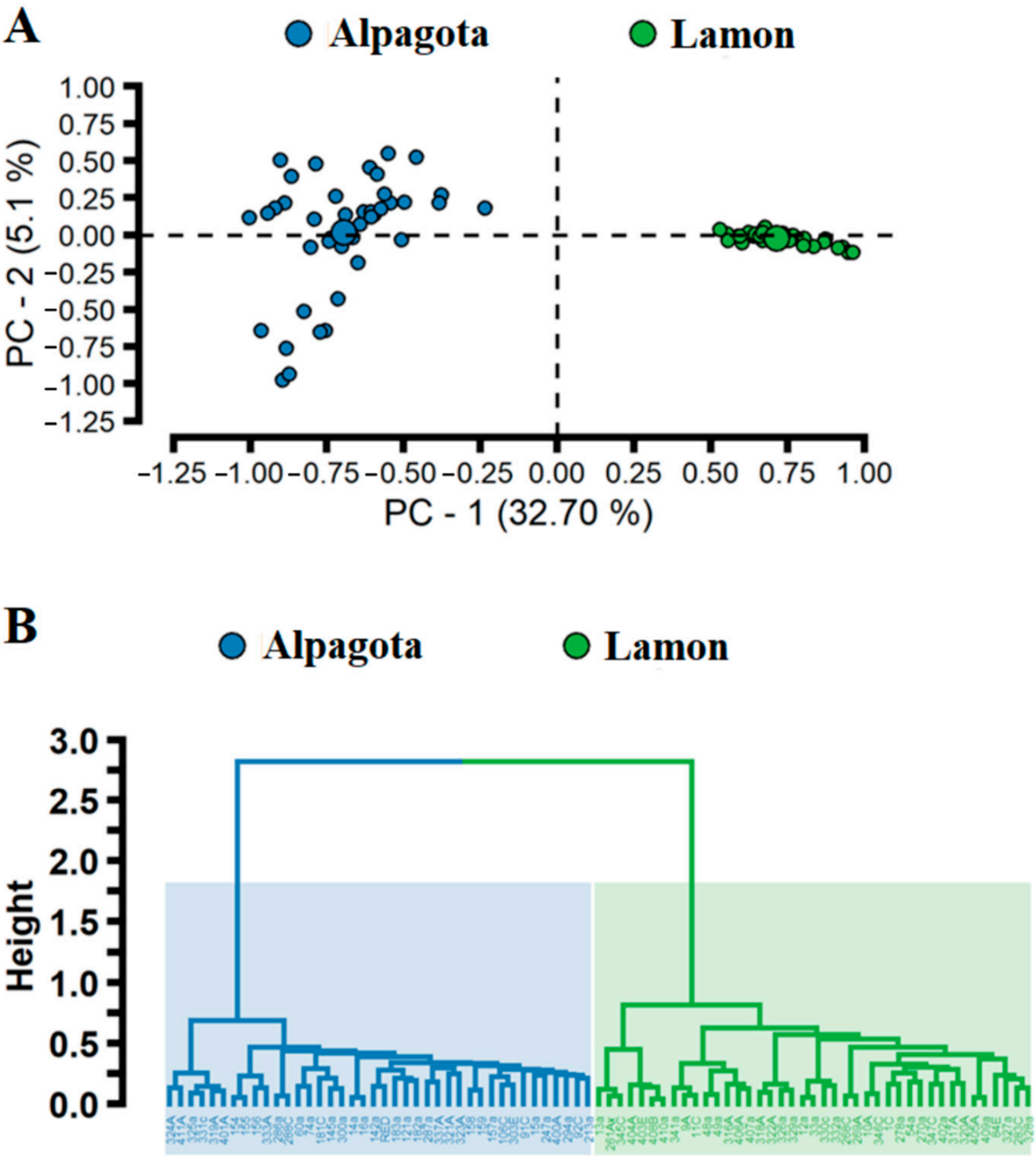

Figure 4. Alpagota and Lamon population structure based on genomic information. Above, (**A**) Principal Coordinate Analysis based on the genomic kinship coefficient. Below, (**B**) hierarchical cluster based on Ward's hierarchical method from genomic matrix, for Alpagota (n = 40) and Lamon (n = 41).

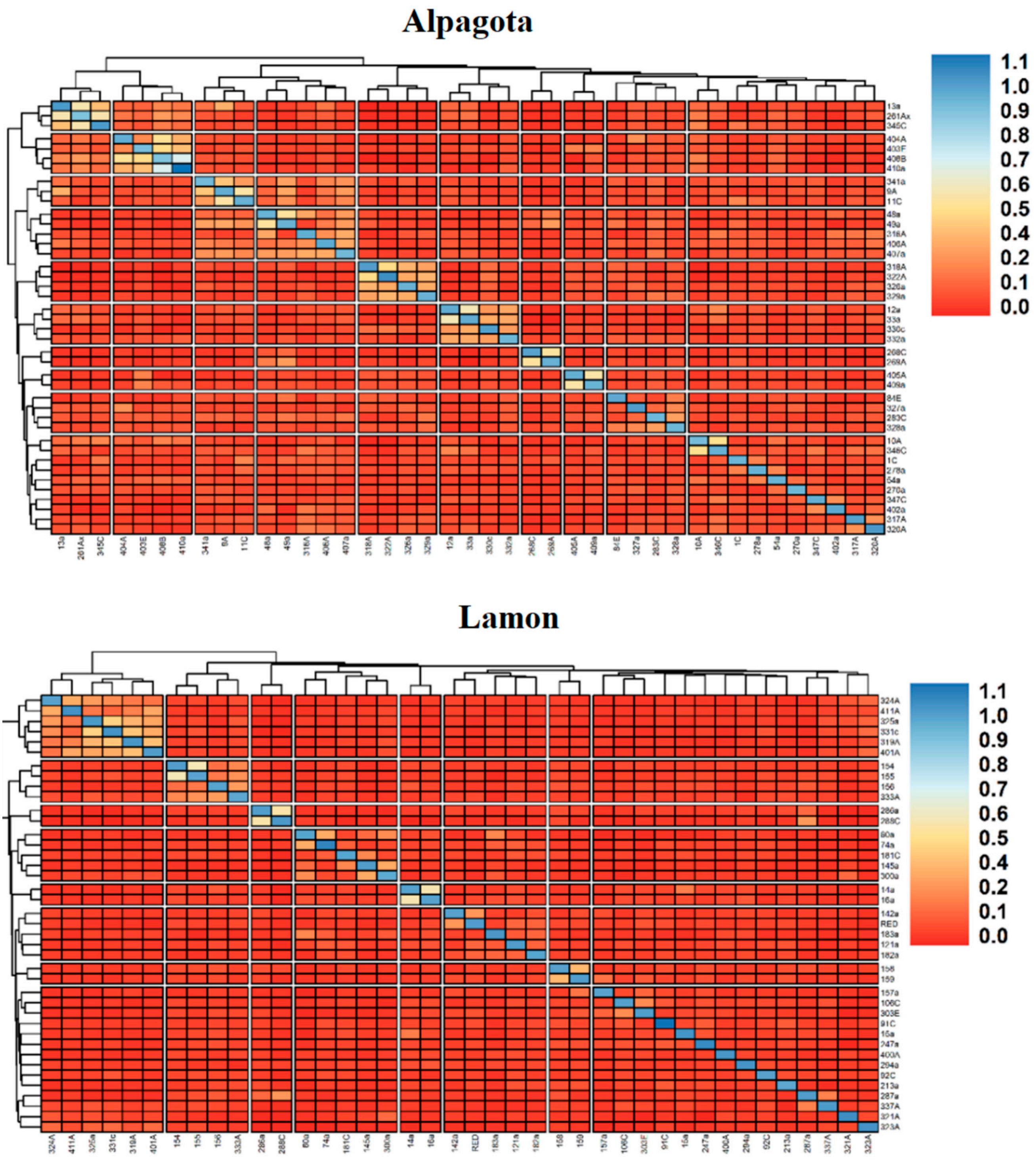

Figure 5. Relationship matrix based on genomic information. The genomic relationship matrix, built according to VanRaden (2008), both for Alpagota and Lamon.

Table 3 reports the data describing farmland management. On average, the farms managed 30.2 ha of Utilized Agricultural Area (UAA), with a great variation (SD = 34.3 ha). The farms managed 21.6 ± 26.7 ha of grassland followed by forest 7 ± 14.9 ha and by arable land 1.6 ± 2.5 ha; the average LU/UAA and LU/grassland were 0.7 and 1.0 unit/ha, with greater values in Lamon than in Alpagota farms. Regarding grassland, the patches were 3335 (mean value of 95 patches/farm) with an average surface of 0.2 ± 0.8 ha and an average altitude of 682 ± 292 m a.s.l. whereas the average slope was 11 ± 8°, without great differences between the regions considered (Figure 7).

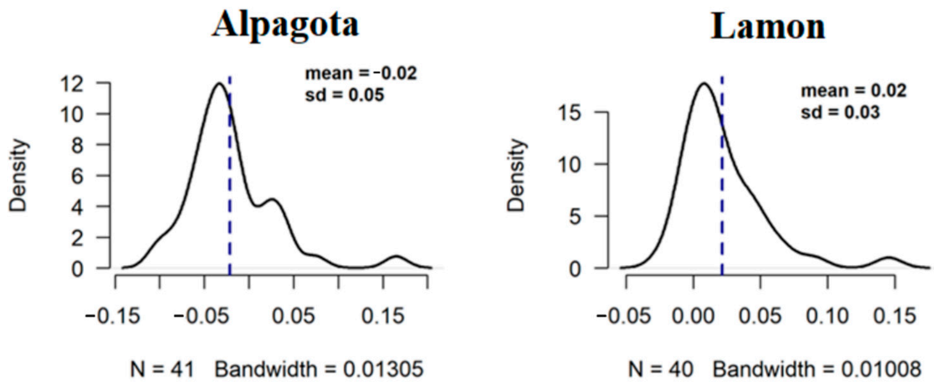

Figure 6. Inbreeding estimation based on diagonal of G matrix (A) for Alpagota and Lamon.

Table 2. Descriptive statistics of farms, LU, farmers' features and local sheep breed's features, management and feeding.

Variable	Unit	All Farms	Alpagota	Lamon
Farms	N	35	17	18
Farmers' features				
Worker units, mean	N	1.8 ± 1.3	1.8 ± 1.5	1.8 ± 1.1
Farmer age, mean	N	47 ± 15	49 ± 15	45 ± 15
Other employment	%	77	82	72
Local sheep breeds				
Number of sheep [1,2], total	N	1989	1652	337
LU [4] of local sheep breed/farm	N/farm	8.5	14.6 ** [3]	2.8 ** [3]
Total LU [4,5]/farm	LU/farm	21.8 ± 40.5	22.0 ± 26.7	21.6 ± 51.1
Forage, mean	kg DM [6]/head/day	1.81 ± 0.50	1.81± 0.54	1.80 ± 0.40
Forage self-sufficiency	%	88	91	84
Concentrate, mean	kg DM [6]/head/day	0.24 ± 0.22	0.19 ± 0.17	0.40 ± 0.24
Concentrate self-sufficiency	%	10	6	13

[1] The farms which raise only local sheep breeds are 15 in total (9 for Alpagota breed and 6 for Lamon breed). [2] Sheep included also rams; [3] ** p-value < 0.01; [4] LU: Livestock Unit; [5] The LU included all the animals raised in the farms: cattle, horses and sheep (including local and other breeds); [6] DM: Dry Matter.

Table 3. Geographic data, land use, land cover surface and land management features of the study area.

Variable	Unit	All Farms	Alpagota	Lamon
Farms, mean				
UAA [1]	ha	30.2 ± 34.3	40.2 ± 40.9	20.2 ± 1.6
Grassland [2]	ha	21.6 ± 26.7	27.4 ± 31.1	16.2 ± 21.4
Arable land	ha	1.6 ± 2.5	1.3 ± 2.7	1.6 ± 2.3
Forest	ha	7 ± 14.9	11.5 ± 19.5	1.9 ± 2.7
LU [3]/UAA	N/ha	0.7	0.6	0.9
LU/Grassland	N/ha	1.0	0.8	1.3
Patches of grassland				
Number	N	3335	2131	1204
Patches/farm		95	125	67
Surface, mean	ha	0.2 ± 0.8	0.2 ± 1.0	0.2 ± 0.4
Altitude, mean	m a.s.l.	682 ± 292	680 ± 255	684 ± 350
Slope, mean	°	11 ± 8	12 ± 7	11 ± 9

[1] UAA: Utilized Agricultural Area; [2] Grassland including pasture and meadows; [3] LU: Livestock Unit.

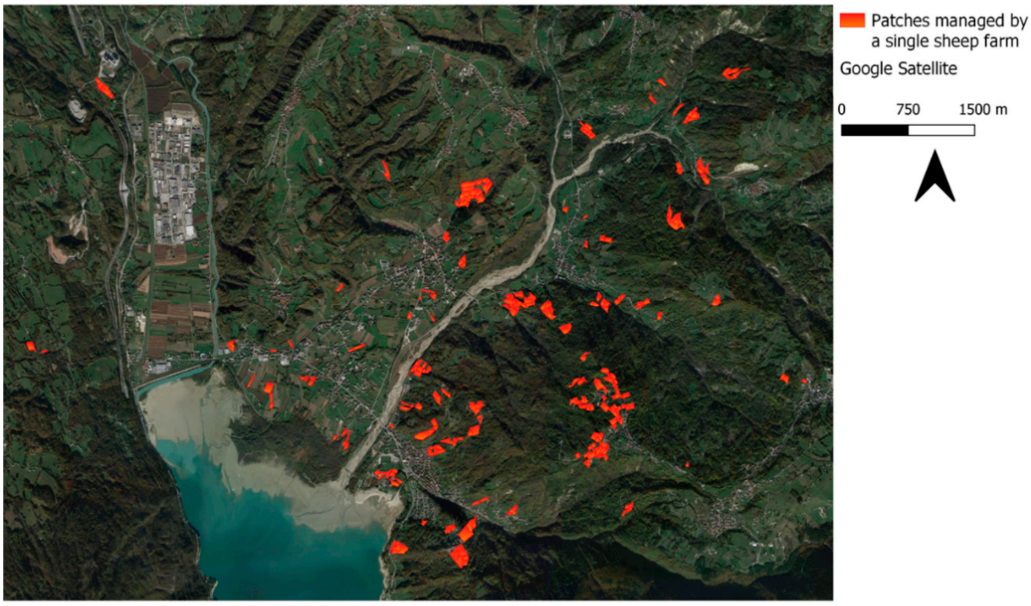

Figure 7. Patches managed by a single farm involved in this study.

The georeferenced data were implemented in QGIS software to highlight the patches managed by these livestock systems. Figure 7 shows an example of the patches managed by a single farm, located in the Alpago region. Moving from the lake to highland pastures, following an altitudinal gradient, the patches with a red color were identified. As can be seen from the map, a single farm was able to manage a large number of small patches of grassland in the most marginal areas, with several ES linked to this traditional livestock system activity. The patches are characterized by important slopes and reduced accessibility, which only small ruminants were able to graze.

Smartphone Application: Development and Implementation

The smartphone application provides three functionalities. The first concerns the registry of rams and ewes: farmers can report all information regarding the code of rams and ewes, date of lambing, number of ram and ewe lambs born and their weight. Information about the slaughtering (slaughterhouse code, number of heads slaughtered, carcass weight) and other deaths or culling and their causes are reported and can be modified and updated by farmers. The second feature deals with the ram evaluation, which allows farmers to calculate the offspring's inbreeding risk of using a given ram from another flock in their flock. This kind of communication between farmers allows them to favor the use of rams with less kindship with respect to the flock, reducing the risk of inbreeding and promoting the conservation and the sustainable use of genetic resources. The last functionality regards marketing: a QR code for each farm was implemented to enable consumers to obtain information regarding environmental markers (pasture, meadows, arable land surfaces), type of products (overall meat), and presence of agritourism. It even allows for notification as to whether the farms have joined the associations of Fardjma (Alpagota breed) or Fea de Lamon (Lamon breed) and location of the farm in Google Maps. Data can be modified and updated by farmers.

3.3. Conversion to Organic Farming and SWOT Analysis

The results of the survey performed to explore the potential of Alpagota sheep farms to conversion to organic labelling are reported in Figure 8, with a SWOT analysis approach. The strengths are mainly related to the strong link between livestock farming systems and grasslands (including pasture and meadows) and local breeds and their link to local traditions, mountain landscape and marginal areas. Another strength is the cooperation between smallholders. Organic regulation for ruminants requires the use of pastures, a high level of self-sufficiency and promotes the use of local genetic resources. In this sense, Alpagota sheep farms have all the characteristics to be converted to organic production, with the added value of cooperation, which can help to overcome the technical problems for smallholders. The opportunities regard the positive implications related to the commercialization of organic products and the link with eco-green tourism. In fact, consumers and tourists show favorable attitudes towards this kind of production [60]. Moving to the negative aspects, we identified as weak aspects burdens and costs related to the certification and traceability needs, since their management is expensive and complicated for smallholders. The main threats are lack of infrastructure, services and plants for wool valorization. Moreover, the land available is very fragmented and harsh. In recent years, there were also several wolf predations and the sheep sector is very marginal with respect to other livestock (agri-food) chains.

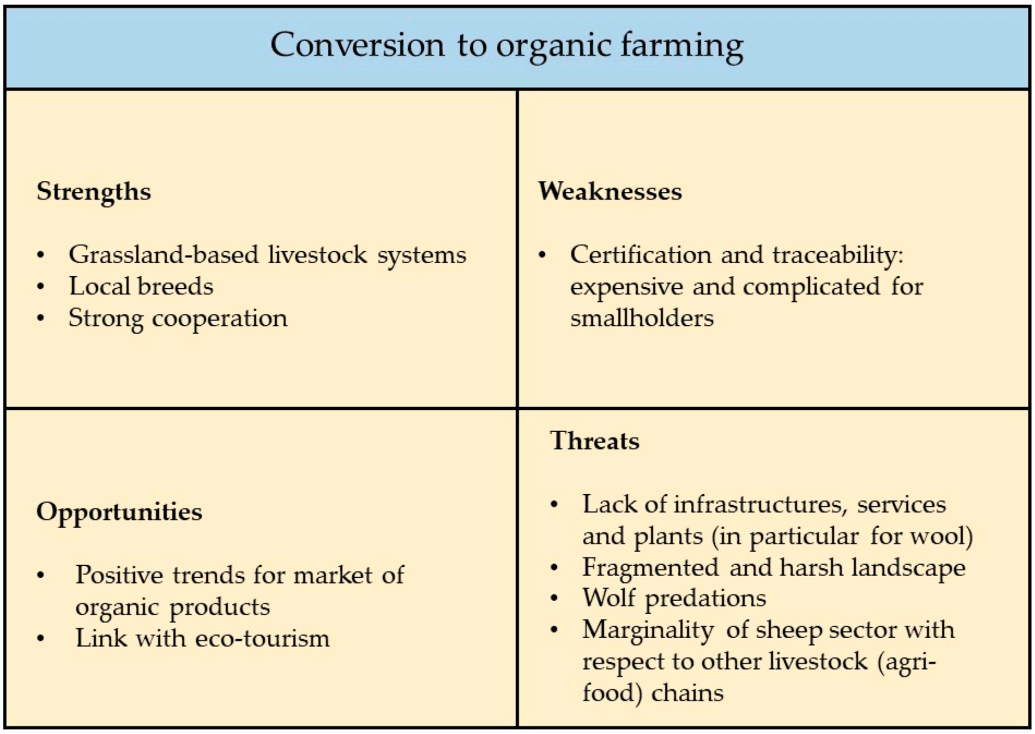

Figure 8. Chart illustrating the strengths, weaknesses, opportunities and threats identified by SWOT analysis.

4. Discussion

Alpagota and Lamon are local breeds typical of Alpago and Lamon-Feltrino areas, both located in the south of Belluno province [55]. All the farms considered in this study demonstrated a strong link with the territory, maintaining a mosaic landscape and providing high quality products.

Both breeds are classified as "at risk" [61] in the Farm Animals Diversity Information System (DAD-IS, www.fao.org/dad-is/en, accessed on 18 September 2021), mainly because of the low number of animals, especially for the Lamon breed. The genomic analysis showed a low level of inbreeding and a good genetic variability between the sampled rams, which belonged to the two populations of Alpagota and Lamon. The Alpagota rams had generally null relationships with the Lamon rams, with testimony as to the absence of recent genetic exchange between the two populations and testimony also to the genetic individuality of the two populations. On the other side, it is worth noting that the two breeds are also phenotypically different, especially in terms of size and external conformation. The Lamon is a large-size, long-legged sheep breed used in the past in large transhumance flocks, whereas Alpagota is a medium size sheep breed reared in the past especially in small mountain farms [54]. As reported in the results, the genetic variability is due to correct management of mating plans which allow for reducing the risk of genetic erosion [1,62]. In the Global Plan of Action, published by FAO in 2007 [1], the importance of animal genetic resources is recognized as a basic human need of food and livelihoods and their conservation is essential to ensure global and food security [37]. In addition, Leroy et al. [8] highlighted the important role of local breeds to provide ES. For this reason, in Alpago-Cansiglio and Lamon-Feltrino areas, an in situ conservation project was adopted in order to promote sustainable use of genetic resources, to preserve all the features typical of each breed and to valorize their products [5,55]. The development and the implementation of a smartphone application, provided by the project "Sheep Al.L. chain", aimed to further support the farmers in order to monitor the inbreeding and to increase the population size of sheep breeds as well as the number of farmers involved. Data can be constantly updated by farmers, who could report in the application the changes in the numbers of animals (births, deaths, animals sold or culled for various reasons, etc.). Moreover, in the ram function, in addition to the genealogical data, they can add all the genetic characteristics of the rams with the aim of favoring specific mating plans in order to maintain genetic distance and variability by involving other farms. The application will be further developed, and it can facilitate not only communication but also cooperation between smallholders.

Regarding the farm features and management, the results showed that, on average, LU/farm (including all the species raised in the farms) was similar in the two areas, but lower if compared with studies focused on different regions, e.g., Sturaro et al. [63] and Riedel et al. [64]. The majority of farmers worked part-time, since livestock activity alone was not sufficient for their livelihood, with a consequent employment in other sectors, such as services and industry [27]. The purchases of external feeds mostly resulted in concentrates with low off-farm inputs of forage, which indicated high self-sufficiency, according to other studies conducted in Mediterranean areas by Ripoll-Bosch et al. [20] and de Rancourt et al. [41]. The results show that the patches are characterized by small areas of reduced accessibility and are located in marginal areas, which only small ruminants are able to graze. The managed surfaces were mostly grassland (including pasture and meadows), whereas the areas covered by arable land were smaller, as they are extensive livestock farms based mainly on the use of meadows and pastures. Results regarding the georeferenced data show that the sampled farms were able to manage a large number of patches with respect to mountain dairy farms, e.g., Sturaro et al. [65]. Small ruminants were able to graze pasture and meadows located in marginal areas with limited forage resources [66] and the majority of small ruminants were represented by local breeds. As can be seen in Figure 7, sheep, belonging to a single farm, could graze patches with high slopes and reduced accessibility, guaranteeing not only the maintenance of a certain type of landscape, but even a series of ES. Several studies demonstrated that a fragmented landscape prevents forest fire and protects natural habitat, plant and fauna species [33,67,68], such as the conservation of dung beetle diversity [69]. Therefore, this type of livestock system, on the one hand, conserves the genetic resources of local breeds and, on the other, maintains a mosaic landscape, as well as a high level of biodiversity, these giving added value to the system.

Finally, according with that stated above, a SWOT analysis was conducted to assess the possibilities of conversion to organic farming of the Alpagota breed. This type of analysis is a valuable tool for understanding potential marketing strategies to give added value to the whole supply chain. The opportunities identified by SWOT analysis pointed out positive trends in the marketing of organic products and links with eco-tourism. New marketing strategies should be found, considering that consumers had different perceptions of local and sustainable products [70,71], with a consequent willingness to pay more for organic products [39]. Nevertheless, the main weaknesses highlighted by SWOT analysis were the costs of traceability and certification. According to Escribano et al. [72], financial aid should be provided to support farmers since they were not able to sell their products at a price which allowed for coverage of production costs. A threat emerging during the analysis was the marginality of the sheep sector compared to other livestock farming systems; thus, new strategies to create added value to the local sheep supply chain should be found. The challenge was to combine economic and ecological performance by implementing management practices respecting agro-ecological principles [10,73]. In agreement with Cabo P. et al. [74], a collaboration between educational and research institutions and between associations of farmers and local stakeholders could be considered to valorize local production. The diversification of farms' income (e.g., agritourism and the direct sales of products) and the management of HNVF should be evaluated to create added value [75]. In France, label and territory imagery were used to give added value to local production and consumers demonstrated a willingness to pay for high quality local products [76]. Moreover, the main restrictions linked to their production were due to the lack of infrastructure and services, as estimated by SWOT analysis, and by the decline in native sheep herds [74]. For this reason, the Farm to Fork strategy, established in 2020 by the European Commission, provides new tax incentives to support pasture-based livestock systems located in marginal areas, the conversion to organic farming and the promotion of organic products.

5. Conclusions

Results from this case study involving local sheep breeds reared in the eastern Italian Alps highlighted a strong link between traditional sheep farming systems and mountain agroecosystems. Alpagota and Lamon are local breeds associated to a specific geographical area (Alpago and Lamon-Feltrino, respectively) and their products are strictly related to the local tradition and the cultural heritage.

This type of livestock system provides a series of contributions to society and the environment (production of high quality food, such as lamb and sheep meat, maintenance of biodiversity, conservation of genetic resources, etc.) that give added value to the whole supply chain of the Alpagota and Lamon breeds. Moreover, the smartphone application showed a good potential in application and acceptance for farmers, who can update and upload farm information at any time and promote their products and activities such as agritourism, creating new territorial marketing strategies. Indeed, the application is not only a support tool during mating plans to avoid inbreeding, but also a means of communication to convey information about the areas managed by the farms and grazed by the animals and the relative contributions to the environment and to society related to this type of management (such as the ES mentioned above).

Regarding the SWOT analysis related to the potential conversion to organic farming of the Alpagota breed, results show a strong cooperation between farmers as well as a link between local sheep breeds and mountain agroecosystems. However, certification and traceability for organic products can be complicated and expensive for smallholders, while also lack of infrastructure and the marginality of the sheep sector were considered as threats. The positive and negative aspects detected suggest that financial aid to support farms should be provided; the conversion to organic farming can create added value to the supply chain, valorising the typical local products and links with eco-green tourism.

In according with the Farm to Fork strategy, conversion to organic farming could be an opportunity to generate added value to farms involved in these projects, in terms of food safety also.

The results of this project represent an initial step in favoring the competitiveness of local breed sheep chains. There is a fundamental need to guarantee the sustainability of the tools and networks developed throughout the project. In this perspective, the participatory process will be further developed to involve policy makers and other relevant stakeholders (advisory services, producers, tourist operators, consumers, etc.), with the aim of generating added value for these farming systems.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14084698/s1, Table S1: Information collected during the survey about farm characteristics and products, herd size and composition of local sheep breed, herd size and composition of other species, land use and surface.

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