OPTIONS méditerranéennes

Pastoralism and Sustainable Development

Proceedings of the international e-workshop organized
in the framework of PACTORES project
Valenzano, Bari, 14-15 July 2021

Edited by:
R. Capone, F. Bottalico, H. El Bilali, G. Ottomano Palmisano,
G. Cardone, A. Acquafredda

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Foreword

Dear colleagues,

I am very pleased to introduce the Proceedings of the International Workshop *Pastoralism and Sustainable Development*.

The two-day e-workshop takes place online (via the Zoom platform) on July 14-15, 2021. The international e-workshop was organized in the framework of PACTORES project (Pastoral ACTORs, Ecosystem services and Society as key elements of agro-pastoral systems in the Mediterranean) (http://www.pactores.eu), funded within ERANET-MED program (project code: ERANETMED2-72-303). The workshop is organized with the financial support of the Italian Ministry of Education University and Research (MIUR).

The e-workshop served as a forum for the exchange of insights, ideas and good practices regarding the multifaceted nexus between pastoralism (including agro-pastoralism, silvo-pastoralism, and agro-silvo-pastoralism) and sustainable development (including the Sustainable Development Goals - SDGs) in the Mediterranean and beyond.

The workshop was organised by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM Bari) in collaboration with the following institutions: Center for Agro-food Economics and Development (CREDA), Spain; University of Vic (UVIC), Spain; Aristotle University of Thessaloniki (AUTH), Greece; Polytechnic University Marche (UNIVPM), Italy; National Research Council (ISPAAM), Italy; Institut des Regions Arides (IRA), Tunisia; Algerian National Agronomic Research Institute (INRAA), Algeria; Sétif University (UFA), Algeria; and Suleyman Demirel University (SDU), Turkey.

The e-workshop consisted of a keynote plenary session and four thematic sessions that address the connections between pastoralism and sustainable development: (1) environment, ecology and ecosystem services; (2) society and culture; (3) economy and finance; and (4) policy, institutions and governance. The keynote speeches addressed trends and challenges for sustainable development of sheep and goat systems as well as agro-ecology and agro-pastoral systems in Corsica and in the argane tree area in Morocco.

The results of the e-workshop should inform evidence-based actions and policies for the sustainable development of pastoralism in the Mediterranean and beyond. Such a sustainable development model considers and valorises the environmental, social, cultural and economic benefits of pastoralism and takes into account the political and governance determinants that shape and affect not only the activities of pastoralists but also their outcomes in terms, among others, of livelihoods and food security. The ultimate aim is to ensure the sustainability and perpetuity of pastoralism and the improvement of the living conditions and livelihoods of pastoral communities in line with the ambition of the SDGs.

I take this opportunity to thank all people that contributed to the success of the e-workshop and the compilation of the present proceedings. These include the members of the organizing committee and the scientific committee as well as the authors. Special thanks to the project partners who enriched the event with their insights and provided valuable support.

Valenzano (Bari), 8th November 2021
Roberto Capone
Principal Administrator - CIHEAM Bari

Presentation

This issue of Options Méditerranéennes contains the proceedings of a two-day e-workshop *Pastoralism and Sustainable Development* that took place online (via the Zoom platform) on July 14-15, 2021. The international e-workshop was organized by CIHEAM Bari in the framework of PACTORES project (Pastoral ACTORs, Ecosystem services and Society as key elements of agro-pastoral systems in the Mediterranean) (http://www.pactores.eu), funded within ERANET-MED program (project code: ERANETMED2-72-303).

This issue consists of a keynotes section and four sections that address: (1) Pastoralism, environment, ecology and ecosystem services; (2) Pastoralism, society and culture; (3) Pastoralism, economy and finance; and (4) Pastoralism, policy, institutions and governance.

Almost 50 contributions were submitted by practitioners and scholars from 10 countries (Algeria, Burkina-Faso, France, Greece, India, Italy, Niger, Spain, Tunisia, Turkey). Of the received contributions, 28 are included in the present Options Méditerranéenne.

Trends and challenges for sustainable development of sheep and goat systems

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Abstract. Sheep and goat farming systems in Europe are essential part of the agricultural industry providing ecosystem services to society. The sector faces many and diverse challenges. The main problem is low income despite heavy reliance on subsidies of Common Agricultural Policy (CAP). The notion is that subsidies under CAP will be directed at public goods (GHG, Biodiversity, animal welfare and rural livelihoods). Poor uptake of innovations and lack of new entrants are also obstacles for progress in the industry. Our objective is to give an overview of present challenges, trends and opportunities of the sheep and goat industry. A new paradigm for the future is proposed based on key findings of the project "Innovation for Sustainable Sheep and Goat Production in Europe; iSAGE". iSAGE, assessed the sustainability of the sector to future challenge such as climate change, food security, resource use efficiency and rural deprivation in marginal regions. The results showed that emphasis should be given to (i) supporting supply chains and increasing consumption of sheep and goat products through novel labelling, packaging and cuts, (ii) address climate change and greenhouse gas emissions using novel methodologies and technologies, and informing relevant policies particularly in pastoral systems, (iii) breeding for enhanced animal resilience, efficiency and adaptability, and promoting region-specific use of local breeds, and (iv) adoption of relevant innovations.
Keywords. Sheep – Goats – Challenges – Trends – Opportunities.

Titre. Tendances et défis pour le développement durable des systèmes ovins et caprins
Résumé. *Les systèmes d'élevage ovin et caprin en Europe sont des éléments essentiels de l'industrie agricole fournissant des services écosystémiques à la société. Le secteur envisage des défis nombreux et variés. Le problème principal est la faiblesse des revenus malgré une forte dépendance sur des subventions de la politique agricole commune (PAC), tandis que les subventions de la PAC seront dirigées vers les biens publics (GES, biodiversité, bien-être animal et développement rurale). La faible adoption des innovations et le manque de nouveaux entrants sont également des obstacles au progrès du secteur. Notre objectif est de donner un aperçu des défis actuels, des tendances et des opportunités des secteurs ovin et caprin. Un nouveau paradigme pour l'avenir est proposé sur la base des principales conclusions du projet « Innovation pour une production ovine et caprine durable en Europe ; iSAGE». iSAGE, a évalué la durabilité du secteur face aux défis futurs tels que le changement climatique, la sécurité alimentaire, l'efficacité de l'utilisation des ressources et le développement rural dans les régions marginales. Les résultats ont montré que l'accent devrait être mis sur (i) le soutien des chaînes d'approvisionnement et l'augmentation de la consommation de produits ovins et caprins grâce à de nouveaux étiquetages, emballages et découpes, (ii) la lutte contre le changement climatique et les émissions de GES en utilisant de nouvelles méthodologies et technologies, et en informant les politiques en particulier dans les systèmes pastoraux, (iii) l'élevage pour améliorer la résilience, l'efficacité et l'adaptabilité des animaux, et la promotion de l'utilisation des races locales, et (iv) l'adoption d'innovations pertinentes.*
Mots-clés. *Ovins – Caprins – Défis – Tendances – Opportunités*

I - Status of the sheep and goat sector

The European Union's (EU including UK before Brexit) sheep and goat population numbers approximately 98 million heads (86 million sheep and 13 million goats). The largest numbers of sheep are found in the United Kingdom (UK), Spain and Greece (27%, 19% and 10% of the EU total population, respectively), while Greece and Spain together hold more than 50% of the EU

total goat population (32% and 22%, respectively, European Parliament, 2017). In these countries, sheep and goats are often reared in marginal and socioeconomically vulnerable areas, where they are an essential part of the agro-ecosystems and have a special role in the provision of ecosystem services to society (Rodriguez-Ortega *et al*., 2014). These can range from the provision of food (meat and cheese) and wool to the 'non-marketed' services such as the regulation of climate systems (e.g. flood prevention, water purification) and the support of local cultural heritage.

Sheep and goats are reared on approximately 850,000 and 450,000 EU farms (including UK before Brexit), respectively. This corresponds to 113 sheep and 26 goats per farm. However, these numbers vary significantly across the EU with UK being first for sheep farms and Greece for goat farms. In terms of density of sheep per square kilometre, the UK ranks first, followed by Greece and Cyprus. Approximately 1.5 million people work in sheep and goat farms (European Parliament, 2017; 2018a).

The main product of the sheep and goat sector is meat. However, milk, cheese, wool and skin products are also of economic importance in many countries. Several such products have quality labels such as Protected Designation of Origin (PDO), which further enhances their economic potential. Amongst EU Member States, sheep meat production is especially important in UK and Ireland, whereas goat meat production in Greece. Sheep and goat milk is mainly produced in Greece, Spain, France, Romania and Italy and is mostly used for cheese-making (European Parliament, 2018a). Specifically, most sheep milk is processed by dairy industries into traditional cheese types some of which are PDO (e.g. Pecorino, Manchego, and Roquefort). Goat milk is often processed on farm into different local dairy products, including yogurt, and is mainly addressed to local or national markets. Nevertheless, there are also PDO goat cheeses produced by dairy industries (e.g. Murcia al Vino) and pasteurized goat milk for direct human consumption (Pulina *et al*., 2018).

However, small ruminants constitute just a small share of the total EU livestock output in terms of production and added value. According to recent statistics (European Parliament 2018a), in 2017, sheep and goat meat production accounted for almost 755,000 tonnes with a value of 5.8 billion euros (2% of total EU production and less than 6% of its value). Likewise, sheep and goat milk accounts for a minor part of the total agricultural output. In France, it ranges from 1% for sheep milk and 2 % for goat milk so, around 3 % for small ruminants. In Italy and Spain it ranges from a minimum of 0.9% to a maximum of 1.8%, while in Greece, sheep and goat milk contributes approximately 9% (Pulina *et al*., 2018). In the recent years, consumption of meat has decreased, whereas consumption of goat milk and cheese has increased significantly in several Member States. Furthermore, the EU is not self-sufficient in terms of sheep and goat meat; the main importing countries are New Zealand (>80% of EU imports) and Australia (11%). Finally, EU's exports are limited consisting mainly of live animals from Romania and Spain (European Parliament, 2018). Moreover, sheep and goat farming in Europe is characterised by great diversity in terms of production aims, farm size, breeds kept, levels of intensification, and socioeconomic and environmental attributes resulting in several different farm types (Girard *et al*., 2001). The H2020 project iSAGE (Innovation for Sustainable Sheep and Goat Production in Europe) developed a new common typology for sheep and goat production systems in Europe, which can serve as a useful tool to propose better targeted policy measures and strategies (Theodoridis *et al*., 2019). Specifically, through a meta-analysis of a literature review of the typological surveys in Europe and on data collected though an online survey of the iSAGE industry partners, an initial tentative 'broad typology' with 13 sheep farm types and 5 goat farm types was developed.

o Description of sheep production systems

(i) Farms with sheep keep confined and great dependence on purchased feed

(ii) Farms with confined kept sheep and provision of home-grown feed

(iii) Semi-extensive dairy farms

(iv) Dual purpose farms

(v) Traditionally managed farms

(vi) Low input meat farms

(vii) Medium input meat farms

(viii) High input meat farms

(ix) Cheese producing farms

(x) Pluriactive farms

(xi) PDO/PGI specialist farms

(xii) Organic/eco farms

(xiii) Intensive organic/eco farms

o Description of goat production systems

(i) Traditional meat production farms

(ii) Pastoral dual-purpose farms

(iii) Pastoral dairy farms

(iv) Confined dairy farms

(v) Cheese making farms

o Final typology of sheep and goat systems

The above farm types are not discrete and mutually exclusive to all countries. Therefore, this 'Broad' typology was further elaborated with the participation of research and industry organizations from several countries resulting in a final typology which best describes the current multiple sheep and goat systems in Europe**.** This typology consists of nine farm types in total (five for sheep farms and four for goat farms):

(i) Intensive dairy sheep and goat farms (e.g. high input of purchased feedstuffs)

(ii) Semi-intensive or semi-extensive dairy sheep and goat farms (e.g. normally pasture fed animals)

(iii) Intensive meat sheep farms (e.g. high input of purchased feedstuffs)

(iv) Semi-intensive or semi-extensive meat sheep and goat farms (e.g. normally pasture fed animals)

(v) Dual-purpose sheep and goat farms (farms where the farmer sees value in two or more different products such as meat and wool or meat and dairy).

II - Challenges of the sheep and goat sector

The European sheep and goat industry faces great challenges, which must be properly addressed to avoid further marginalization of the sector in the European Agrifood economy (Bernués *et al*., 2011; Dubeuf and Sayadi, 2014). Before finding strategies to counteract these challenges, their diversity needs to be characterised to understand which are the most relevant ones and easy to change. Additionally, the stakeholders responsible for driving this change also

need to be identified to develop robust strategies to reverse the effects of the most important challenges. The iSAGE project contributed to making the European sheep and goat sectors more sustainable, competitive and resilient. Part of the project activities was to identify and quantify the importance of the current and future challenges that may compromise the sustainability of the sheep and goat industry in Europe. To identify and quantify these challenges, iSAGE used a participative multi-stakeholder approach with industry and research institutions working together. Extended literature reviews, descriptions of the sheep and goat sector in each involved country and semi-structured interviews with farmers revealed plenty of technical/social, market, policy/financial and environmental challenges.

2.1 Technical/social challenges

One of the most important issues faced by the sheep and goat industry is the lack of professionalization of farmers and limited management training especially in meat sheep and goats in extensive and semi-extensive systems. Most sheep and goat farmers do not follow an established methodology regarding the management of their enterprises. The latter frequently leads to farms, which operate inefficiently and with reduced productivity and profitability. Sustainability assessments at a Global, Mediterranean and Northern European level have clearly shown that such farms rely on public subsidies to remain economically sustainable (Dýrmundsson *et al*., 2006; Bateman and Balmford, 2018; Guth *et al*. 2020).

The ageing farming labour force, together with the lack of intergenerational transfer of farms, is another problem facing the sheep and goat sector in Europe. Sheep and goat farmers are older than farmers in other sectors, sometime reluctant to make changes, and young people are not interested in the business. There are many reasons that could explain the decision to accept or not the intergenerational transfer in sheep or goat farms, amongst those young farm family members' social profiles and discourses. Moreover, rural populations are declining whilst farms are expanding. Therefore, labour is getting harder to find. At the same time, sheep and goat farming is very labour-intensive and requires specific skills. The sector is being hampered by a lack of technical services and training, which results in varied levels of productivity.

At the same time, the sector is characterised by a low level of innovation and limited investments in technology (Dubeuf *et al*., 2014). The improvement of farm technology, as well as boosting innovations in farm practices, process and products is considered one of the main strategic priorities for the sheep and goat sector, particularly at the farm level. Relative to other agricultural sectors, technology and innovation in sheep and goats has remained relatively stagnant and neglected by both the supply chain actors and mainstream research (Martin-Collado *et al*., 2017). This is especially true for the goat sector. Goat production systems range from traditional systems, with flocks of meat or dual-purpose (meat and milk) animals, to more specialised systems in dairy production. Family businesses are the norm and hired labour is rare.

This may explain why livestock newly developed technology is still not being adopted in the goat sector. Moreover, in terms of farm management, there is notable shortage of suitable tools that would facilitate sheep and goat farmers to make management planning decisions based on the analysis of relevant data and information and to apply well proven methods for production optimization and profits maximisation (Häni *et al*., 2003; The Cool Farm Tool, 2015, Meul *et al*., 2008; Gerrard *et al*., 2012; Villalba *et al*., 2019).

The sheep and goat sector is very fragmented and the main characteristics vary by EU Member State, or even production area; species (sheep, goat, combined), type of farming (milk, meat), systems (suckler or suckler-fattener / intensive or extensive), types of products (heavy lambs, light lambs), structures (small or large), importance of the activity within the area (from very important to marginal) (Ares(2011)1350301 - 13/12/2011). Moreover, production models in Mediterranean countries are highly more fragmented than those in Central Europe. The iSAGE

surveys indicated that this fragmentation may be more of a threat for the dairy sector, probably in relation to the complexity of the market, as compared to the meat sector.

Finally, the lack of integration/cooperation, farmers' gender imbalance, and societal awareness of farmers' role, the low competitiveness of the sector and the fact that researchers do not address relevant issues pose additional challenges of the sector.

2.2 Market challenges

A major challenge is the fact that incomes for sheep and goat farmers are among the lowest in the agricultural industry, with inadequate farm-gate prices and poor monetisation of by-products, and depend heavily on public support over a long period (Dýrmundsson *et al*., 2006; Dubeuf *et al.*, 2014; European Parliament, 2018; Bateman and Balmford, 2018; Guth *et al*. 2020). This lower income is the reason that sheep and goat farmers were among the first to receive direct subsidies from the Common Agricultural Policy (CAP) to compensate for financial falls (Milàn *et al*., 2003). Direct subsidies often represent most of the net farm income of sheep and goat farms, and this is particularly true for those farms located in less favoured areas (Dýrmundsson, 2006; Guth *et al*. 2020). Moreover, production costs are continuously increasing; primarily for feedstuffs; secondarily for fuel, labour and animal health (European Parliament, 2008). At the same time, electronic identification constitutes an additional cost, which is perceived to be too high in the current situation. By comparing the break-even points and sheep milk prices previously reported, it seems that most dairy sheep farms in France and Greece are working under the profitability threshold, whereas in Italy price is aligned with the cost, on average, but with large fluctuations among years and high variability among farms (Pulina *et al*., 2018). Moreover, sustainability assessments within the iSAGE project showed that extensive sheep farms generally achieve lower values within an approximate net profit calculation than intensive farms and as expected organic farms are more reliant on subsidies than low input farms.

Moreover, the sector is characterised by low consumer demand. Specifically, the consumption of lamb in Europe, particularly in northern Europe, is beset by a poor public image, low value for money and poor consumer knowledge and education on consuming local products. The relatively high fat content and the time required to cook are also reported to hamper market penetration. Moreover, sheep meat has a taste that is not to everyone's liking (Mandolesi *et al*., 2020). In particular, the consumption of lamb by young consumers is decreasing. Products such as leg of lamb or stewing lamb have no appeal to single people or young couples, as they are often family- sized portions and cuts that are complicated to prepare or need to be cooked for a long time. It is interesting to note that when new products are introduced to the market that are specially aimed at young consumers, such as minced lamb meat in the United Kingdom or émincé of lamb in Ireland, sales increase rapidly. This suggests that low consumer demand can be addressed by offering new products. Although in a lesser extent, barriers also exist for the market penetration of sheep and goat cheese. Specifically, surveys showed that the high price of sheep and goat cheese (higher than bovine) as well as the poor knowledge and awareness of consumers on the production system (how sheep and goats are raised for the production of milk) and what type of milk (sheep, goat or cow) is used for cheese-making limit their demand. Moreover, the fact that many consumers are prejudiced against the taste of sheep and goat cheese and that they consider it as fatty are also limiting factors.

Finally, the EU sheep and goat sector also faces a volatility of commodity (milk and meat) prices and an increased import from non-EU countries. Such difficulties as well as the unfair trade and the market's control by few companies have contributed to a decrease in livestock numbers in the last decade and to many farmers becoming discouraged and leaving the sector. For example, Italy is losing market share of Pecorino Romano cheese because of politics and the fact that it has only one main importer (the United States) with consequent problems related to low milk prices and competitiveness of sheep farms (Pulina *et al*., 2018).

2.3 Policy/financial challenges

Sheep and goat farmers depend heavily on subsidies to remain financially sustainable. Subsidies, provided by the European CAP, have decreased both production in economically less viable areas and the competitiveness of the sector (ANT International, 2011; Guth *et al*. 2020). A considerable number of sheep and goat farms, taking advantage of previous per-head sheep and goat subsidy schemes, have been modelled to aggressively maximize flock size without accounting for the negative consequences in business and ecological sustainability (overgrazing, land erosion, financial inability to sustain the flock on purchased feedstuffs, environmental footprint etc.). However, in France, the PDO rules (limitation of purchased feed) have limited efforts to improve the flock size. Such schemes have already been phased out and replaced by grants paid to farmers who own land rights, while soon environmental performance will also be taken into account (European Parliament 2019). The above operational model, although viable in the past, cannot guarantee any longer the survival of the sheep and goat sector. Finally, issues relating to recognition and valuation of public services and EU policy measures forced with no scientific evidence further tackle the sustainability of the small ruminant sector. The role of research is important to produce rational arguments on which the choice of orientations and strategies can be based.

2.4 Environmental challenges

The climate in Europe is changing, with higher temperatures, and more variable volume and annual distribution of precipitation (Kovats *et al.*, 2014). These changes are influencing, sometimes dramatically, other abiotic variables including higher likelihood and intensity of fires and floods and changes in nutrient cycles and wind speeds. Such changes inevitably impact on small ruminant farming – both on animal performance directly and the production system more widely. As with all agriculture, small ruminants are affected by the wider environment, whether through direct effects of climate on animals, or indirect effects via pasture, forage, feed crops or parasites and pathogens. Impacts will be very unequal amongst different bio-climatic regions, countries and small ruminants' production systems; Southern European countries are expected to suffer the most from these changes in climate both for pastures productivity and grass quality (Dellar *et al*., 2018) and, at the animal level. At the same time, the sheep and goat sector, as it has been done for other ruminant systems (e.g. cattle), has been implicated for contributing to climate change mainly through their large share of global methane emissions. Both of these aspects represent a challenge for the future of the sector; it should be noted however, that the large potential of their soils to act as carbon stores though pasture management and the important functions of the sheep and goat farming systems is neglected when comparing emissions of GHG among different livestock systems.

The low rate of adaptation of high productive breeds to new environments combined with the lack of well-established breeding programmes for local breeds in most areas is also a major problem. Local breeds are usually small in population size. More numerous breeds have a greater opportunity to increase selection response, because a larger number of individuals allows for greater selection differential, especially when artificial insemination and other reproductive biotechnologies are used to increase the number of offspring per individual. Breeding companies also have more interest in larger imported breeds because the potential market is greater and because the truly superior animals are more extreme and thus more valuable (Biscarini *et al*., 2015).

Moreover, the increasing number of attacks on sheep flocks and goat herds by predators (wolves, bears and lynxes) poses a further challenge for the sector; conflicts with wildlife are becoming costly for small ruminant farmers. Such incidents have been attributed to the proliferation of these animals as a result of the protection measures enshrined in the directive on the conservation of natural habitats and of wild fauna and flora.

Other environmental challenges involve limited land access, lack of integration of agriculture with livestock and the possibility of future environmental policies limiting intensification and reducing grazing levels to a point where sheep farming becomes impractical and habitat degeneration occurs, risking environmentally damaging wildfires in periods of dry weather.

2.5 Relevance of challenges and easiness to address – which are the top priorities?

The high heterogeneity in the small ruminant production systems across Europe results in a variability to the perception of relevance of the challenges faced by the sector. Based on the expert group's surveys in the iSAGE project, geographical region (e.g. Southern vs Central Europe) is one of the main drivers that determine the relevance and difficulties to address the main challenges of the small ruminant sector. In southern countries, technical/social and environmental challenges are more relevant than those from central countries, except for increasing sanitary issues, youth involvement and wildlife conflicts. The type of product (meat vs dairy) and level of intensification can also modulate the relevance of these challenges. In general, the extensive farming systems are perceived as more vulnerable to several challenges such as low competitiveness, low female involvement, increasing sanitary issues, low consumer demand, lack of traceability, climate change threats, wildlife conflicts or limited access to land. Moreover, the relevance of these challenges progressively decreases for semi-extensive and intensive systems suggesting that the intensification can help to tackle some of the abovementioned challenges. On the other hand, the type of livestock species (sheep vs goats) is much less relevant.

However, using the priority index as an indicator of the relevance and easiness to address, the 10 most important challenges to face in all cases are:

(i) Low consumer education in product – external threat

(ii) Low promotion of local breeds – internal weakness

(iii) Low consumer knowledge about farming – external threat

(iv) Poor business management training – internal weakness

(v) Researchers do not address real problems – external threat

(vi) Unfair trade, lack of traceability – external threat

(vii) Low professionalization – internal weakness

(viii) Slow adoption of innovation – internal weakness

(ix) Low adaptability of high producing breeds – internal weakness

(x) Poor recognition of public services – external threat

Amongst these challenges, half of them are internal weakness, meaning that they need more action from the sector itself (farmers and associations), while external threats require a strong involvement of Governments in order to be properly addressed.

Based on the above and with the help of iSAGE partners, the top priorities for dealing with the above challenges were identified for Finland, France, Greece, Italy, Spain, Turkey and the UK (Table 1). All countries identify better market access (such as export opportunities, understanding of public preferences and how to increase consumer awareness, development of niche markets, localised production and local supply chains) and efficient breeding programmes focused on functional traits, genomic selection and local breeds as strategic priorities for the development of the sector. Meanwhile, innovative production practices and improved human

capital in rural areas were reported as priorities by six countries. Mentioned only twice were the priorities concerning environmental sustainability and improvement of the structural characteristics of the sector.

Table 1. Strategic priorities per country

Development axes	Finland	France	Greece	Italy	Spain	Turkey	UK	Total
Innovation in farming practices - Productivity		X	X	X	X	X	X	6
Improvement of human and social capital		X	X	X	X	X	X	6
Environmental sustainability					X		X	2
Market access and economic performance	X	X	X	X	X	X	X	7
Product quality, hygiene and food safety		X	X	X	X	X		5
Genetic improvement	X	X	X	X	X	X	X	7
System structure and exogenous factors			X	X				2
Total	2	5	6	6	6	5	5	35

III - Trends and opportunities

In the light of the challenges faced by the sector, the prevailing view is that only farms which take up innovative solutions to modernise and rationalise their modus operandi with an emphasis on flock size, management of feeding and grazing residues as well as marketing strategies are likely to remain in business (Bernués *et al*., 2011; Paraskevopoulou *et al*., 2020). In this regard, current technological trends such as digital technologies, Internet of Things, decision support tools, and machine learning are opportunities that could be used to re-design the sheep and goat sector towards remaining sustainable.

Furthermore, the severe decrease in consumption of sheep and goat meat within the EU the last 15 years has led the European Commission, following the recommendations of the Sheep meat Forum, to support promotion initiatives in the EU and third countries co-financed by the EU. Specifically, EU funding is directed to campaigns focused on increasing sheep and goat meat consumption with emphasis on traditional products, but also towards introducing newer cuts with respect to consumer choices. Moreover, opportunities arise with current trends in the supply of dairy products and in kid meat exports to third countries. Given these opportunities a greater effort should be paid for competing with the main exporting countries. Moreover, New Zealand's transition from frozen exported meat to fresh or chilled meat must be taken into account in future negotiations for a free-trade agreement (European Parliament, 2018a; 2018b). The latter remains unclear considering the impact of Brexit and its negotiations on the import/export of lamb meat with the UK (and the impact that this could have on NZ qiuotas).

At the same time, promising trends are also identified for the dairy sheep and goat industry across Europe. Specifically, in Italy, the dairy sheep and goat sectors are pushed by processing industries towards increasing the amount of milk destined for the international market. In Spain, the level of dairy specialization and the size of sheep and goat farms have increased with the increase in milk yield per animal and total milk production of the intensive farms, pushed by favourable milk prices. Finally, France is improving the efficiency of dairy sheep and goat farms by increasing milk yield per animal, thus maintaining the share of French cheese in the international market (Pulina *et al*., 2018).

Although local breeds have been less frequently used in intensive systems and preserved in situ in marginal territories, the situation is changing in the last decades in Europe, as some local

traditional breeds have developed breeding programs to increase their productivity, and in some areas 'compete' with high-yielding dairy breeds (e.g., the Saanen and Toggenburg) and perform better than local stocks that are often crossed (Biscarini *et al*., 2015). Some local breeds already have sufficiently high production to achieve profitability, but low performance regarding functional traits. Other breeds may obtain greater benefits by improving output while maintaining their characteristic secondary traits, such as adaptation to the environment.

Promising for the future of the sheep and goat sector is also the fact that emphasis is being given in supporting young farmers through an increase in direct payment schemes. Moreover, sheep farming still provides an achievable access to farming for young people that may not own land or have high levels of capital (European Parliament, 2018b). On the other hand, trends relating to climate change raise concern and should be considered. Specifically, a detailed review and meta- analysis undertaken within the iSAGE project reveals that across the whole of Europe, rainfall is becoming more sporadic and heavy rain events may increase substantially in most areas and seasons (Jacob *et al*., 2014; Kovats *et al*., 2014; Madsen *et al*., 2014). Dry spells will also become longer (although less frequent) in Central regions and especially in Southern Europe, where more frequent and longer droughts are additionally expected (Forzieri *et al*., 2013; Jacob *et al*., 2014). Temperature is also expected to increase. Warming is expected to be greatest in the Northern and Alpine regions by 2.0–4.2°C and 1.9–3.4°C respectively but will likely reach a minimum of 1.4°C everywhere (Jacob *et al*., 2014). Temperature increases may drive an increased incidence of heat stress in sheep and goats (Al-Dawood, 2017). Heat stress has numerous consequences for animals, such as impaired productivity (Lu, 1989; Marai *et al*., 2007; Al-Dawood, 2017, and references therein) and reproductive performance (Sawyer, 1979) and increased disease risk. In general, goats tend to tolerate heat better than sheep, and are less susceptible to environmental stress than other domesticated ruminant species. However, iSAGE results indicate opportunities for selectively breeding for enhanced adaptability to climate change and efficiency. Moreover, the modelling approaches used within iSAGE suggest that most regions, except for Southern Europe, are likely to see grassland yields either increase or stay the same, which is either good or neutral for grazing livestock.

Finally, it should be noted that the European Commission is working towards tackling climate change and environmental-related challenges. Additionally, to existing environmental policies, new medium and long-term (e.g. for 2050) policies and strategies are currently being discussed as part of countries commitments to the Climate Change Paris Agreement (Forsel *et al*., 2016)**.** The notion is to achieve the long-term goal of holding the increase in average global temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. These targets have been included in the new European Green Deal Communication (European Commission, 2019a). Given that food systems are currently considered responsible for almost one third of GHG, with the European Green Deal, all actors across the food chain will need to adjust to new EU standards under the "Farm to Fork" strategy. Special emphasis is given to European farmers with the Commission's proposals for the common agricultural policy for 2021 to 2027 stipulating that at least 40% of the CAP's overall budget would contribute to climate action. Farmers will be rewarded for improved environmental and climate performance such as improved nutrient management to improve water quality and reduce emissions. Moreover, strategic plans involve organic farming, agro-ecology, responsible medicine use, benchmarking and understanding productivity gains and stricter animal welfare standards (European Commission, 2019b). However, such measures require profound transformations on how farms are currently being managed and raise an issue of possible unfair competition and negotiating trade agreements with third countries.

IV - A new paradigm of the sheep and goat industry

The iSAGE project aims at helping the European sheep and goat industry to become more sustainable, competitive and resilient. Based on the major challenges identified, the top priorities and the current trends, using a multi-stakeholder approach, iSAGE provides best practices and recommendations for facing these challenges and sets a new paradigm for the future of the sheep and goat industry.

4.1 Supporting products and supply chains

Detailed interviews with consumers and retailers revealed that organic labels, national origin and PDO drive consumer willingness to pay more for sheep and goat products. Specifically, the main attributes consumers ask about when buying lamb meat are fat content, preparation, provenance, traceability and quality control, which tend to be associated with health and food safety. Therefore, possible ways to boost purchases of sheep and goat meat in the future include (i) increased provenance labelling and assurance schemes, (ii) providing easy to cook and novel lamb meat cuts, (iii) 'tell the whole story' from the breed, and (iv) the availability of novel recipes (Mandolesi et al., 2020). Regarding dairy products, special emphasis should be given on cheese for which the main strengths identified are the perceived health benefits, the wide assortment and the fact that it is considered by consumers as something novel. The main recommendations for cheese include (i) branded products such as PDO Protected Geographical Indication (PGI) plus renowned brand name, (ii) convenient formats such as single-portion and fixed-weight product packaging, (iii) organic plus fair trade, which targets a specific consumer segment, and is somewhat novel for dairy products, and (iv) clear label cues or claims such as a national flag on the packaging, 'easy to digest' claim, punchy and targeted messages to describe different cheese characteristics.

However, in order to support and boost the performance of the whole sheep and goat supply chain a more holistic approach is required. Specifically, for the **meat supply chain** the following recommendations are drawn:

- A mixed approach based on selling through different routes and product innovation is recommended in order to handle carcass imbalance and improve supply chain resilience in a volatile market context for lamb meat.
- Local firms can establish dedicated lamb meat supplies where supply chain alignment is possible (only) to some extent through the adoption of some practices of the lean and agile philosophies.
- Product innovation, flexibility and real-time adjustments can contribute to a better lamb meat supply chain alignment.
- Working relationships between downstream and upstream supply chain members are recommended to identify quality specification of lamb, to develop and market a range of products (including new meat cuts) that optimise the use of that specification and reduce waste.
- Less specialised lamb meat supply chains which engage in valorisation of by-products and waste or breeding dual purpose sheep (meat and wool) can secure sustainable returns in contexts where the added value is distributed along the supply chain.

Moreover, for the **dairy supply chain** the following recommendations are drawn:

- Setting trading conditions relating to milk price, volumes and quality requirements before the milking season, is necessary to guarantee sustainability of the production

base and innovation potential for the sector. Collective negotiations and written contracts are to be preferred.

- Competitiveness through cost leadership must be pursued by improving efficiency at supply chain level rather than cutting milk farm-gate price.
- Logistics efficiency is strategic in cost leadership and can be improved by planning the collection and delivery of milk with suppliers and by exploiting economies of scale, such as absorbing milk supply from additional farmers and managing collection costs.
- Less specialised goat supply chains, such as dual-purpose breeds producing milk and meat (in countries where this is not problematical) can secure sustainable returns.
- Product and market innovation have to be strategically implemented with the involvement of all supply chain members, including producers for the milk quality requirements and retailers to gain premium shelf space.

4.2 Coping with climate change and reducing GHG emissions

Climate change adaptation and mitigation measures need to be tailored to specific conditions (e.g. climatic area, production system, etc.). Feed management is a general area where climate strategies apply to the wide diversity of systems and contexts. For example, the use of alternative feeds is especially relevant in a global future scenario of insufficient and highly variable forage and cereals availability. Given that sheep and goats can transform nutrients from poor quality feed resources into high quality milk and meat, by-products from the agro-industry such as tomatoes and olive- by products could be an option. Such a strategy would improve resource use efficiency of the systems involved, promote a circular economy and decrease competition for human-edible feed resources (Eisler *et al*., 2014). Moreover, increasing mixed, and multi species grass leys pastures is a good measure in order to adapt to potential shortages of global protein sources in Europe, or to face the expected decrease of protein content and digestibility of C3 grasses in non-leguminous plants under climate change conditions (Soussana *et al*., 1995; Dumont *et al*. 2015). Also, growing legumes can cut emissions by up to 20% at farm level due to less need for synthetic fertilisers. Additionally, using forage mixtures farmers can optimise the balance between forage utilisation for animal performance and sustainability in terms of environmental impact and biodiversity.

Regarding extensive small ruminant systems, in rainy areas, manipulating forage quality and quantity through grazing management, fertilization and use of seeded forages is recommended. On the other hand, in drier areas, manipulation of the animal's physiological state and different mobility patterns will be more appropriate. However, it should be noted that reducing grazing from marginal land does not necessarily improve farm-GHG and N losses, or resilience (D3.1). Long-term adaptations can be developed through improved plant breeding. New forage resources are required that are adapted to high temperatures, drought, and increased CO_2. This might be achieved through exploitation of traits for dehydration tolerance and summer dormancy, either in novel species or for introducing traits into existing widely used grasses and legumes (Volaire *et al*., 2009; Dumont *et al*. 2015). In terms of coping with animal heat stress, breeding for higher resistance to heat stress and general management strategies such as ventilation, adequate stocking density, shearing and optimal nutritional management are recommended.

Finally, climate policies directly affecting small ruminant production systems should use the most updated methodologies and emission factors, include different metrics and estimates of potential soil organic matter sequestration from grassland-based systems. In the last years, most GHG emissions calculations were based on methodologies of IPCC dating back to 2006 (IPCC, 2006). Calculations made in iSAGE using the updated IPCC report (IPCC, 2019) revealed that previous GHG emission estimates from small ruminant production systems have so far been overestimated (by 18% and 28% for sheep and goats in Europe, respectively).

Additionally, iSAGE calculations using the new GWP* metrics also revealed that the small ruminant production systems in Europe have not caused additional warming to the atmosphere in the last decades. Such findings should be considered by relevant environmental policies. Moreover, any climate strategy involving small ruminant livestock systems should consider separating methane (i.e. short-lived GHG) from long-lived GHG emissions such as CO_2 and N_2O.

4.3 Breeding for resilience and sustainability

Phenotypic, genetic and genomic analyses conducted within iSAGE revealed that animal traits associated with adaptation to climate, plasticity across environments, and sustainability and resilience to harsh environments are partially under genetic and genomic control and, thereby, amenable to improvement with selective breeding. Specifically, the proposed traits suitable for inclusion in breeding programmes are:

5 Climate adaptation: Rate of change in animal performance to changes in thermal load under heat or cold stress.

6 Sustainability traits: Health related indicators (faecal egg count, immune status), welfare (female longevity and progeny survival), feed intake, growth and meat quality and functional milk production (udder health, persistency of lactation).

7 Resilience to harsh environments: Body condition score and biomarkers of body reserve mobilization.

A set of genomic markers and candidate genes were identified, which could serve as a starting point to enhance the efficiency of genomic selection for adaptation to climate phenotypes, manifested by changes in milk, protein and fat yield, faecal egg count, growth, and immunological profile in response to weather volatility. iSAGE results revealed that local sheep and goat breeds are more suitable for the environment where they have evolved in comparison to newly introduced ones, although some of the latter seem to be better adapted to farming in specific geographical areas and climatic conditions. This calls for both locally contextualized analysis of the individual breeds and deeper study of the animal resilience traits for potential use in selective breeding programmes. However, based on the above and the different perception between different regions in Europe on the challenge of maximising the use of local breeds, it is recommended that any relevant upcoming policies are more contextualized for different regions than they have been before. Any effort to add value to local breeds is important, especially as a contribution to the prospects of their conservation through sustainable use.

4.4 Adopting innovations

Above all, the future of the sheep and goat sector lies on the adoption of new technologies and innovations as they can increase its competitiveness, resilience and sustainability and decrease reliance on public support.

- ***Technical and computational innovations for overall sustainability***

Currently, there are plenty of available technical and IT innovations that can deliver win-win effects on the overall sustainability of the small ruminant production systems. Examples of such innovations include:

1. iSAGE Public Good tool (PG tool)

The iSAGE Public Good tool (PG tool) highlights sustainability scores in sheep and goat farms. Specifically, it provides a picture of how the farm performs with respect to a selection of 13 spurs (areas) that collectively make up the sustainability equation; soil management, agri-

environmental management, landscape and heritage, water management, fertilizer management and nutrients, energy and carbon, food security, agricultural systems diversity, social capital, farm business resilience, animal health management, animal welfare management and governance. The results are presented in a non-confrontational manner, depicted in a radar diagram that is simple to interpret and provides a perfect catalyst for discussion (Figure 1). In this regard, the PG tool can motivate farmers to review their farming activity considering other perspectives than purely economic ones (e.g. environmental impacts). The PG Tool assessment can be repeated; for example, to look at how a change impacts on the other areas of sustainability. Finally, an online toolbox, based on the indicators included in the PG tool is also available for farmers to easily assess the sustainability of their farms.

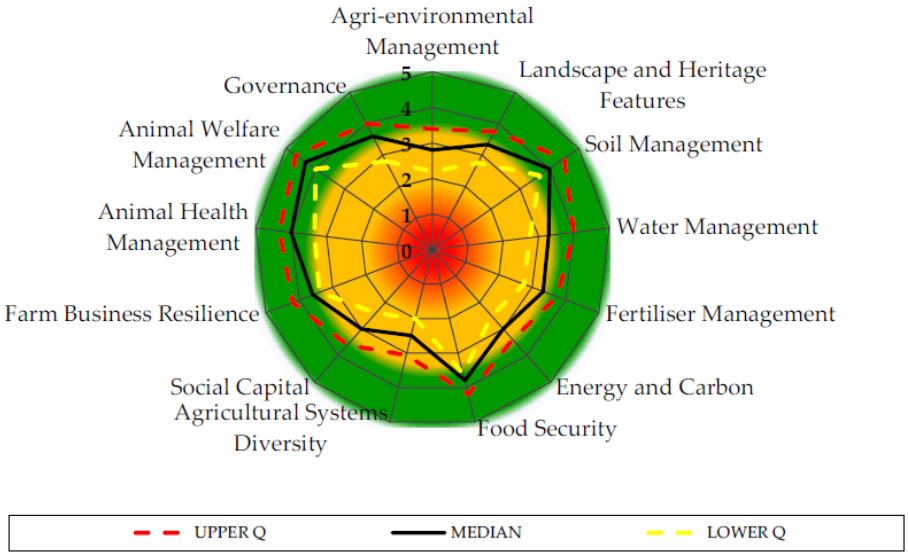

Figure 1. Results in a form of a radar diagram from the PG tool sustainability assessment. Upper, median and lower quartile values illustrate the strengths and weakness of the farm.

2. iSAGEDSS

The iSAGEDSS is a web-based, model-driven, decision support system for the efficient management of meat and dairy small ruminant farms (Vouraki *et al*., 2020). This system allows sheep and goat farmers to make annual management planning decisions by testing future what-if scenarios. The users input data regarding all important farm parameters (flock size, production, feeding, grazing, income from subsidies and farm prices) and with the use of an energy and protein based algorithm they are provided with reports that are focused on profitability and productivity; the impact of management decisions is explicit. Farm income, variable costs and gross margin are estimated taking into account production estimates such as live weight and carcass weight of finishing lambs and milk production of lactating animals (according to the production system) based on their nutritional management. Moreover, the iSAGEDSS provides comprehensible charts of income and cost analyses as well as bar plots of feed costs and variable costs per animal category. This way, farmers may understand their cost structures in depth, identify which factors affect profitability and be incentivized to utilize additional sources of income. At the same time, pasture availability at the end of the year and stocking rate are estimated which help farmers towards testing more environmentally sustainable solutions. Overall, farmers benefit through tighter control over revenues and

expenses and ability to plan for increased productivity and profitability with similar or lower costs, elimination of dependence on public subsidies and ecological awareness.

3. Eskardillo

Eskardillo, a platform-based individual data collection tool, is successfully used in intensive dairy goat farms in Spain to help farmers make breeding, replacement, or culling decisions (Belanche *et al*., 2019). Specifically, Eskardillo is an Android smartphone-based terminal which incorporates various elements: (i) an electronic chip reader to identify animals *in situ*, (ii) a barcode reader to identify tubes with biological samples (milk, blood) or drugs used, (iii) a digital camera to take pictures of post-mortem certificates, (iv) a keyboard for data input, (v) a Wi-Fi connection for data transfer, (vi) a mobile-phone SIM card to store data, (vii) a touchscreen to navigate through the different pages, and (viii) software for data interpretation. However, Eskardillo tool relies on three principles: (i) systematic on-farm individual data recording together with remote data acquisition as a result of the milk control, morphologic evaluation and genetic selection programme, (ii) data storage, processing and interpretation by a supercomputer placed at Cabrandalucía headquarters (Granada, Spain), and (iii) interactive feedback of processed data to the farmer to optimize farm management. The data-driven management decisions can be performed using either a laptop-based software or the Eskardillo smart-phone terminal.

4. Mobile Flock Management Software

The Mobile Flock Management Software is aimed at sheep farmers who need an easy to use 'point and click' solution to keep legislative records and build flock performance data. Metadata used in the software include ewe reproductive performance, overall productivity, lamb growing rate, survival rate of new-borns, and flock health status. The system detects alerts occurring in the farm and suggests for troubleshooting. This innovation combines cloud, IT technologies and farming practices, and explores technological opportunities to improve production efficiency in livestock farming. Therefore, it can be considered as an invaluable support for purchase, cull or breed decisions based on targets of flock performance.

- ***Breeding and genetics innovations***

Recent advances in animal breeding, molecular genetics and DNA analysis have boosted the development of new tools in breeding programmes. Among these tools is the inclusion of new functional traits in the breeding scheme (e.g. longevity, disease resistance, etc.), which until recently have focused only on production traits. The inclusion of longevity in sheep breeding goals was demonstrated within the iSAGE project using the example of Lleyn sheep in the UK. This new breeding goal will enable farmers to more readily identify the genetic potential of livestock for living longer in the flock and therefore, reduce the 'wastage' of animals through involuntary culling (e.g. culling due to disease or poor fertility). The new breeding goal will also improve economic sustainability and efficiency by avoiding the inadvertent use of animals from families with low life expectancy and reduced lifetime performance. Breeding for enhanced longevity has been considered successful so far, and will likely be extended to other sheep breeds, such as Dorset and Texel.

Despite the tested efficiency of breeding indexes in increasing sheep productivity and profitability as the New Zealand and Australia sheep industry experience shows, the use of indexes in many European countries is very limited. There is a huge space of improvement in this area which should be fostered by public institutions given the lack of interest showed by the industry.

Moreover, assessing parasitic resistance of UK local and newly introduced sheep breeds in organic/low input and conventional farms showed that saliva samples are easier to collect compared to faecal samples. It is hoped that, in the future, saliva sampling alone will be

adequate to select sheep for increased parasitic resistance provided that salivary IgA (a parasite-specific immunoglobulin) seems to be a good indicator of a parasite infection.

At the same time, the development of molecular genetic techniques has allowed the identification of major genes, which could have a large effect on the traits of interest and, therefore, their management could generate important benefits for the farmer community. For example, within iSAGE, the ROA allele was used as an innovation case study for improving prolificacy in Rasa Aragonesa breed in Spain. The presence of the ROA allele in the mother increases by 0.31 the average of lambs per birth. Moreover, the iSAGE modelling approaches revealed that this innovation results in large benefits at the economic level (mainly due to a positive balance between an increase in total feed costs and more lambs being raised for the same amount of ewes), but also at the environmental level (reduction over 10% of GHG emissions). Therefore, the search for these types of genes and subsequent integration in selective breeding should be supported by farmers, farmers' institutions and public agencies.

Finally, there is genomic breeding, which uses direct genomic information as additional information in breeding schemes. The use of genomic information would allow for a more efficient selection of breeding animals, among other things, by reducing the generation interval and by allowing the estimation of genetic merit with high precision. Until now, only France, Spain and the UK have included genomic information in breeding schemes.

- ***Reproduction technologies***

Reproduction technologies have evolved extensively in the last decades and multiple methodologies and innovations, such as artificial insemination (AI) and embryo transfer have been developed and are available for farmers to apply. Proper use of most of these technologies is important to maximize animal performance and farm profitability. Although there is still space for the development of reproductive technologies, the main issue in the sheep and goat sector is the uneven use of these technologies across farming systems, breeds, regions and countries. Therefore, although some of these technologies, for example AI and oestrus synchronization are routinely used in some breeds, they are an innovation in some other breeds or countries.

One of the most important reproduction technologies is AI because it maximizes the spread of genetic improvement to the whole population, but also because it allows for the progeny test, which can help to identify males with high genetic breeding values. The main problem of this technology in sheep and goats is that it leads to low fertility rates (30% to 60%) due to different causes such as the anatomical characteristics of the reproductive tract of these species. Moreover, the AI technique itself and the tools used in AI implementation at farm level may be another cause of its inefficiency. Therefore, all efforts to improve AI success may contribute to the sustainability and efficiency of the small ruminant production systems. In this regard, in iSAGE, a new speculum for AI in sheep and goats was tested to see whether it performs better than the classical duckbill and tubular AI instruments, in terms of increasing the fertility rate, but also in terms of labour ease or number of AI personnel needed. The main advantage of the new speculum was found in dairy breeds by allowing inseminations to be performed in the milking parlour without lifting ewes. This also led to the consequently reduction of ewe stress, ease of the labour burden, and the reduction of the number of personnel needed in the process. Meat breeds do not seem to benefit from this innovation, due to technical aspects that should be improved by adapting the instrument to the specific anatomical characteristics for each of them.

- ***Product and market innovations***

There is a great need to implement and support innovation at the product and market level. New packaging and cuts, development of quality labels or other certification and traceability systems and new marketing campaigns to make society aware of the environmental and social services of sheep and goat farming systems, are key strategies to produce significant benefits for the small ruminant sector in EU. Useful examples of innovations that were tested within the iSAGE

project include: (i) a Participatory Guarantee System for Brogna sheep Association in Lessinia, (ii) the food production from goat milk and lamb meat enriched in conjugated linoleic acid by feeding, and (iii) marketing innovations for transhumance dairy products.

5. Participatory Guarantee System (PGS) for Brogna sheep Association in Lessinia

The Participatory Guarantee System (PGS) for Brogna sheep Association in Lessinia, Italy is an alternative to the official PDO/PGI quality assurance system. While PDO/PGIs are more aimed to certify the origin of products, PGSs are more flexible and allow communicating the environmental and social benefits of extensive small ruminant farming systems. PGSs imply lower bureaucratic burdens and lower cost than PDO/PGI certification and are particularly suited to small farmers located in highlands and hinterlands. Although the short time since the establishment of PGSs is not enough to analyse the impact of such an innovation in the mid and long term, there are some initial signs that indicate a promising potential to improve marketing and, therefore, the demand of products associated to it. Regional authorities are showing a strong interest in the initiative, confirming public support through a measure for animal biodiversity direct support included in the Regional Rural Development Plan, which is paid to farmers rearing the Brogna breed, and also through other support measures in the short term, possibly including the Brogna PGS.

6. Production of goat milk and lamb meat enriched in conjugated linoleic acid

The production of goat milk and lamb meat enriched in conjugated linoleic acid (CLA) by feeding focuses on the development of new products with augmented health properties oriented to those consumers who are seeking healthy diets; CLA is a fatty acid that occurs naturally in many foods and it has proven to have positive effects on human health (Chinnadurai and Tyagi, 2011). Results of the iSAGE case studies in Turkey showed that both lamb meat and goat milk CLA content can be enriched with simple feeding regimes (e.g. soybean oil supplemented diets) by keeping additional costs acceptable. Manipulation of the animal's diet resulted in 8 to 10-fold increase in the concentration of CLA in milk. Since consumption of CLA enriched milk could provide considerable benefits for human health, strategies to produce milk with higher CLA content provide new marketing opportunities.

7. Marketing innovations for transhumance dairy products

A label for 'transhumance-origin' dairy products could be a marketing opportunity for dairies. Considering that these products are of higher quality and have been found to have high CLA concentrations (Ioannidou *et al*., 2019), they are expected to be welcomed by consumers who seek healthy diets and lifestyles. In addition, these products are linked to a farming system which provides significant ecosystem services and affects a large part of society interested in environmental quality, tradition and vivid rural areas. In this context, these products could become a relevant marketing asset for small local dairies focusing on the production of specific, local, high-quality, characteristic products, by providing them a significant identity, but also to larger firms that wish to boost their profiles.

- ***Innovations for participatory farmer-group training programmes***

Innovations for participatory farmer-group training programmes is a strategy with high potential to develop a more knowledgeable and competent farming workforce by fostering communication and knowledge exchange in three directions, technicians-farmers, farmers to technicians and farmers to farmers. Flock Health Clubs and Next Generation Ambassador Programmes are examples of such innovations, which have been successfully implemented in UK within the iSAGE project.

8. Flock Health Clubs

Flock Health Clubs aim to improve communication between farmers and veterinarians by encouraging farmers to regularly access cost-effective veterinary advice and vets to enhance

their knowledge, but also between farmers. Specifically, a relevant case study within iSAGE revealed that such clubs improved the relationship between vets and member clients. Farmers trusted and were more willing to contact a knowledgeable vet who was willing to invest time in their flocks. Moreover, these clubs increase farmers' knowledge and encourage them to be proactive about animal health often resulting in productivity benefits. Finally, participating farmers highlight the opportunity to develop and exchange knowledge with other likeminded farmers. One of the most important attributes of this innovation is that it can be extended to any country or farming system. According to the UK experience, such clubs should consist of no more than 25 congenial forward- thinking people, host a minimum of four meetings a year on a range of topics reflecting the season, the issues farmers are facing or factors of importance to the sustainability of the industry and should be rather informal with plenty of time for discussion. However, the main issue here is that disease surveillance across Europe is extremely poor. This means that initiatives cannot rely on good information on disease risks. The notion is that government policies should increase surveillance support.

9. Next Generation Ambassador Programmes

Next Generation Ambassador Programmes focus on developing competent young farmers who stay in the industry and who then become ambassadors for the sector as well as active members of their regional committee. Specifically, each year, a group of 12 successful applicant young farmers receive free, comprehensive training in all aspects of running a healthy flock in a healthy business as well as creating networks of farmers and other industry partners. The iSAGE case studies showed that Next Generation Ambassador Programmes are highly successful at creating supportive networks since members use each other for support and advice suggesting an increase in social sustainability at a regional farm level.

- ***Other innovations***

Innovations relating to any other aspect or problem faced by the sheep and goat industry as a whole or in individual countries/regions are also expected to help towards a more sustainable future. For example, in the iSAGE project the following innovations were also identified and tested:

- **Controlled weaning in organic goat rearing,** as an alternative to standard artificial weaning and with respect to EU organic regulation. This method was tested in a dairy goat farm in Italy and in a dairy sheep farm in Greece. According to the case study results, the controlled weaning method has the potential to produce well developed lambs with non-significant differences in final carcass weight, compared to lambs that are kept constantly with their mothers.
- **Portable milking machine in different farming systems in Turkey.** The results showed that machine milking increases daily milk production of both goat and sheep and reduces the labour force needed but does not have any effect on other milk composition traits. Despite its good performance, the main constrains to the uptake of this technology by farmers in the area is the deficient electricity supply. This is an extreme example of how the socioeconomic conditions of an area, and not the lack of innovation development, are mayor constrains for innovation in sheep and goat farming systems in less favoured areas of Europe.
- **Managing *Haemonchus* burden in lambs using a copper oxide bolus.** This innovation was tested in the UK, with an on-farm trial. The trial was highly innovative for this farm in UK where the presence of *Haemonchus* spp was first identified the previous year when 30 lambs died within 48 hours. The lambs receiving copper supplementation had higher growth rates and this was significant in the first month compared to untreated lambs.

4.5 Strategies for the efficient implementation of innovations

For the adoption and successful implementation of innovations, specific measures and strategies should be developed. Overall, the main challenge of the sheep and goat sector in Europe regarding the implementation of innovations and adoption of best practices, is not the creation of new knowledge, tools, methods and/or techniques, which generally are well-developed and ready available to be implemented, but the socioeconomic and structural constrains that prevent farmer acceptance and uptake of innovations at farm level. Therefore, any research/extension service programme or action aiming at overcoming these constrains will most likely have greater impact on innovation uptake (and therefore in its capacity to adapt to future challenges) than investing in the development of new practices and innovations. Moreover, according to iSAGE innovation case studies, extensive and semi-extensive farming systems appear to face these constrains more than intensive systems. This imbalance is also present among countries and regions. Therefore, innovation strategies should be adjusted to specific features and priorities in individual countries, regions and farming systems.

Strong and well-organized, long-term, farmer collaboration is required for most innovations to be successfully implemented. This is especially true for genetic and breeding innovations and IT technologies on farms sustainability. If farmer collaboration is lacking or is deficient attempts to implement such innovations will most likely be inefficient. The role of farmers' institutions and collective structures (e.g. farmers levy organizations, breeders' associations, cooperatives, etc.) is decisive in regulating and managing such collaboration. Specifically, the efficient implementation of successful breeding techniques and programmes requires a well-organized participation structure characterized by (i) strong and long-term collaboration, (ii) the existence of accurate livestock performance and pedigree recording schemes, (iii) a team of specialized experts in genetics to generate the appropriate tools for the identification and selection of the best breeding animals, (iv) a well-organized structure to spread use of selected animals (live or by AI) across the farmer community, and (v) a common breeding goal set by the farmers participating in the scheme in collaboration with the expert specialists. Likewise, the existence of efficient farmer organizational structures and data recoding schemes along with the support and advice from experienced independent husbandry consultants are needed for the efficient implementation of IT technologies.

A strong vertical sheep and goat value chain integration in inter-branch organizations or any other organizational structure will facilitate the adoption of innovative practices in product development and marketing. Performing an accurate survey of the niche segments of the market that may be interested and estimating the willingness to pay for such products that encompass ethical, environmental and social values is also needed. Moreover, the implementation of participatory farmer-group training programmes requires a national organisation with regional branches, a strong national network of farms, businesses, organisations and key industry people and, moreover, a reliable funding source. This may not be possible in countries where the industry partners and farmers do not have a high degree of organization or where sheep and goats are only reared in specific regions or where small ruminant sector constitutes a minor economic activity.

Finally, iSAGE case studies showed that innovation led by farmers and farmer organizations mainly focus on improving farm and animal performance. Therefore, for farmers to uptake innovations aiming to reduce the environmental impact of their farms, relevant policy signals and intervention of governmental institutions are required. An effective approach would also be for extension programs to emphasize farm innovation that increase farm efficiency (increasing farm profit) and reduce at the same time the farm environmental impact (e.g. PG tool, iSAGEDSS). Moreover, farmer well-being, place of the farmers in the society, quality of products and knowledge of the specificity of small ruminants should be also considered.

IV - Conclusions

The European sheep and goat sector face many technical/social, market, environmental and policy/financial challenges. Outcomes of the iSAGE project produced strategic information for tackling such challenges towards a more sustainable and competitive small ruminant industry. Key findings and recommendations include:

(i) Novel packaging and labelling, new cuts, national origin and PDO products in order to increase consumption of meat and dairy products.

(ii) Enhancing alternative forages (e.g. by-products from agri-food industry) in order to decrease the risks associated with climate change.

(iii) Environmental policies and strategies should consider separating methane from long-lived GHG emissions and using the most updated methodologies and emission factors; small ruminant systems have not caused additional warming to the atmosphere in the last decades.

(iv) Breeding for enhanced animal resilience and adaptability, and region-specific efforts for maximising the use of local breeds.

(v) Industry inspired innovations at all levels to increase the resilience and sustainability of the sheep and goat sector and decrease dependence on public subsidies.

(vi) Adoption and efficient implementation of innovations lies on overcoming the socioeconomic and structural constrains of the sector. Above all, long-term farmer collaboration is crucial for the successful implementation of innovations.

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Mediterranean agro-pastoral systems and agro-ecology: A cross-analysis of two situations in Corsica and in the argane tree area in Morocco

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Abstract. Agro-ecology is the way of designing agricultural production systems by relying on the functionalities offered by ecosystems. Today, it stands out as the direction to take to meet the challenges of preserving natural resources and combating or adapting to climate changes. Our objective is to explore to what extent agro-pastoral systems in the Mediterranean could be involved into this agro-ecological approach.
After presenting the general principles of agro - ecology in its different environmental as well as social, economic and societal dimensions, we analyze and compare two examples of Mediterranean agro-pastoralism. The first case is Corsica, a French island located in the North-Western part of the Mediterranean, the second one is in the South- West of Morocco in the argane tree biosphere reserve.
From this comparative analysis, a holistic diagnosis of the strengths of pastoral systems but also of their challenges is proposed. Some prospective scenarios are then discussed on the possible futures of these systems and the dynamics to impulse.

Keywords: Agro-ecology, sustainable development, agro pastoralism, Corsica, Morocco, Argane tree area

L'agro –écologie et les systèmes agro – pastoraux méditerranéens : une analyse croisée de deux situations en Corse et au Maroc dans l'arganeraie

Résumé. *L'agroécologie désigne la manière de concevoir les systèmes de production en s'appuyant sur les fonctionnalités offertes par les écosystèmes. Elle émerge aujourd'hui comme la direction à prendre pour relever les défis de préservation des ressources naturelles, d'adaptation au changement climatique ou pour combattre ses effets. Notre objectif est d'explorer dans dans quelles mesures les systèmes agro – pastoraux de Méditerrannée peuvent être impliqués dans cette approche agro – écologique.*
Après avoir présenté les principes généraux de l'agro – écologie dans ses dimensions à la fois environnementales, sociales, économiques et sociétales, nous analysons et comparons deux exemples d'agro – pastoralisme méditerranéen. Le premier concerne la Corse, une île française située au nord – ouest du Bassin, le second est localisée au sud – ouest du Maroc, l'arganeraie, labellisée comme réserve de biosphère.
A partir de cette analyse comparative, un diagnostic holistique des forces du pastoralisme mais aussi des défis qu'il doit relever est proposé. Quelques scénarios prospectifs sont ensuite discutés sur les futurs possibles de ces systèmes et sur les dynamiques à impulser

Mot clés *– Agroécologie, développement durable, agropastoralisme, Corse, Maroc, arganeraie*

I - Introduction, objectives and methodology

For centuries, in a large part of the Mediterranean hinterlands and mountainous areas, pastoralism and agro – pastoralism have been the main form of animal production and the source of unique practices to use specific harsh environments and manage herds on the rangelands. Today, since the middle of the 20th centuries, these traditional systems have faced rural exodus, development of urban littoral and the competition of more productive intensified animal production systems considered as more efficient and more modern. In spite of this realty, pastoral systems are still present in many Mediterranean areas but deeply modified.

While, the awareness of the need to face climate changing and the preservation of bio diversity, and natural resource leads to think about alternative models following agro ecological models, the aim of this study is to explore if the present trends of the Mediterranean pastoralism could answer agro – ecological specifications and under what conditions.

After having reminded the characteristics of pastoralism and its diversity, the several dimensions of agro – ecology are introduced. Then, two Mediterranean situations will be presented and analyzed as emblematic examples to illustrate opportunities for pastoralism to be part of the agro – ecological movement but also their weaknesses and threats. The first one is in the Northern European part of the Mediterranean, the Corsican island, the second one is the Argane tree Area in South Western Morocco. These analyses are based on researches and surveys implemented in each of these situations

II - The principles and definitions of pastoralism and agro-ecology

Pastoralism is a form of animal production based exclusively or partly on the grazing of the spontaneous resources of natural spaces including scrubs, rangelands, etc. but its definition could be diverse according to the local situations and regions. Pastoralism involves all domesticated ruminants (cattle, sheep, goats but also camels and in some regions pigs) and according to FAO (2001), 90% of the dry matter consumed by livestock comes from pasture and pastoral animal production systems. When the production systems combine grazing and crops for feeding the animals, we speak of agro – pastoralism; for instance, agro – pastoral systems are the most common in Europe and Northern Africa where specific characteristics are for instance the practice of limited transhumance on fixed pastures and the use of local breeds. Many Sahel or Central Asia populations are nomadic pastoral shepherds. Pastoralism is considered well adapted to extreme climatic situations and fragile environments whose quality, quantity and accessibility to resources are very uncertain. Although pastoralism is often named as extensive, it is also intensive in skilled labor (Linck, 2013), which is often neglected and the shepherds have generally a low social and marginal status.

The development of animal production like all agricultural activities has been dominated by one main model based on the improvement of technical performances of the production factors. Most of innovations have led to a more intensive use of external inputs (Stassart et al., 2012) with a significant and permanent growth of production units. Their negative effects are visible on bio – diversity, eco – systems and climate change but also on working conditions, human welfare, the resilience and structural weaknesses of many farms and the cause of many disparities (Mazoyer and Roudard, 1997). Once, based mainly on the use of natural resources provided by rangelands, the pastoral production systems and particularly, the sheep and goats Mediterranean ones have been more and more artificialized with an increasing use of feed stuffs, more and more intensive grasslands, and the use of specialized breeds for milk or meat (Dubeuf et al., 2016). The awareness of these negative effects have emerged in the 80's and several concepts and frameworks have addressed the sustainability of Agriculture (agro – ecology, organic agriculture, integrated production, sustainable intensification, conservation agriculture, etc.). The application of these concepts and specially agro – ecology for animal production, has been more recent and proposed new ways of producing in favors of the integration of animals in one's agro – ecosystems (Gliessmann, 2006, Tichit and Dumont, 2016). But this integration of agro – ecology has been nearly absent for pastoral systems (Bellon and al., 2016).

A Russian agronomist, Bensin, (1928) has used the word agro – ecology for the first time in 1930. But, Altieri (1983) and other authors have conceptualised it more recently as the science to define principles, to study, design and manage productive, efficient to use natural resources, socially just and economically viable sustainable agro –ecosystems with a special emphasis on bio – diversity and to develop agricultural practices based on ecological principles.

To face the challenges of climate change and the preservation of biodiversity, agriculture needs a real alternative to so-called conventional or intensive production systems that consume pesticides and emit high GHG emissions. Agroecology offers agricultural production systems based on a logic of "management of cultivated ecosystems" (Dupraz, 2005). Agro- ecology includes several techniques such as organic agriculture but cannot been reduced to one of them..

Agro - ecology in animal production is involved in 2 types of processes:

- Ecological intensification for a reduction of the uses of not renewable resources, of GHG, pollution impacts and waste recovery optimization. A first vision of agro ecology introduces a first paradigm shift in the organization of productions systems, it advocates an "ecological intensification" (EI) and an increasing resource use efficiency, replacing chemical inputs by organic ones, developing precision agriculture technologies or even using Genetically Modified Organisms (Godfray et al., 2011). Focused on minimizing the negative impact of agriculture on the environment, the main objectives of EI are to keep on raising incrementally the limits of yields and encouraging the still dominant pathways of specialization and modernization (Duru et al., 2014). Pastoralism would be little involved in EI.

.- Agro - ecologically intensive animal production is based on the potentialities of agro systems on regulations and complementarities. Regarding pastoral systems, it involves understanding the integration of the animal in its agro – eco system to get levers and conciliate sustainably not only environmental but also economic, social and societal concerns (Gliesmann, 2006). Biodiversity based animal production could be a framework for proposing new ways of producing to meet the growing demand for food by linking food to productive practices and the production environment. This new type of agriculture and animal production must also have the status of activity of general interest. This approach would be very relevant for Mediterranean rural areas where until more recently village communities have remained perennial with locally anchored niche products and where the dialogue between society and animal production could be re - opened (Sorba et al., 2017). The challenge of agro – ecology for pastoralism would be to produce more with less input.

Requiring generally low inputs, pastoralism would have real advantages to be agro – ecologic with real adaptation and resilience capacities but it does not mean that pastoralism and its recent trends make it agro – ecological by nature. One objective of this article is to explore these trends for the Mediterranean Pastoralism to go in this direction and if it could give it perspectives for the future.

III - Main issues of pastoralism regarding agro – ecology in Corsica

Corsica is a mountainous island located in the Central Western part of the Mediterranean basin. Today, only 3% of Corsica are cultivated (including vineyards and orchards) ; 32% of the island are considered as permanent very diverse herbaceous and ligneous rangelands and scrubs than meadows.44% of the island are composed by forests and a part of them could be grazed by animals. 2500 km^2 are mountain pastures above 1000 m where the herds used to transhumant. For millennia, pastoral activities associated to subsistence crop production have influenced the organization of the social life and pastoral culture keeps still in the minds and mental models of a large part of the Society. Pastoral production in Corsica was not specialized but dairy production and cheeses were an important part of these activities. A high percentage of lands cannot be mechanized but grain was produced until high altitudes (Ravis – Giordani, 2001; Mercury, 2013). The progressive extinction of subsistence agriculture during the 20^{th} century has contracted the space used by animals with a growing and general re-in forestation. One answer for animal production has been to settle in the few lowlands areas what has also reduced the use of rangelands. The number of breeders using high summer pastures has also

decreased of the number of breeders and their practices to manage herds on lower rangelands are degraded with a loss of food autonomy (an average of less than 30%). A high percentage of feedstuffs and hay are bought in huge quantities in the south of mainland France.The high production costs in feeding are compensated for cheeses and pig meat by the high prices of the local market for traditional Corsican products and public subsidies. In Corsica, animal systems involve sheep, goats, cattle and pigs and all have pastoral components:
Dairy sheep: The 570 sheep flocks produce milk sold to dairy industry (65%) or processed in farms to make typical Corsican cheeses (35%). Most of the flocks have ewes of the local Corsican breed. The dairy sheep systems have less pastoral components than other ones but more farmers use again rangelands and transhumance for dry ewes during summer; the average performance of the dairy sheep farms is considered low with a very low food autonomy.
Goat systems: Most of the 380 herds of goats are on scrubs and rangelands. The main breed is the Corsican breed with crossed animals. Most of the farms have no crops and do not produce dry forage. Consequently, the food autonomy is very low (<25%).as the dairy yields (<200 l/doe/lactation). Most of the goat farmers are farm made cheeses. The technical assistance for goat farmers are little developed except for cheese making.
Cattle systems: Around 1100 animal farms out off a total of 1600, have cattle. A large part of them are owned to get CAP subsidies and are left free on not controlled rangelands; some cattle owners have developed a highquality production but their number is very low and most of the herds are not professionally managed.

Pig systems: Most of the pigs are said “running pigs”, the sows using rangelands with their piglets and the pigs being fattened under the oaks and chestnut trees. But these traditional practices have decreased due to the high level of demand and the pigs are more and more fed at the trough. In spite of the DOP, imposing the use of the local breed and a minimum purchase of local acorns and chestnuts many farmers do not apply the specification and import not local pigs.

Principle of the methodology to determine the agro – ecological orientations of pastoral farms

A survey has been carried out by a group of technicians, teachers and scientists to identify the agro – ecological orientations of the farms. The method used was based on indicators and criteria chosen by a multi – variables analysis (Principal Component Analysis) tested previously in a large number of situations including Sardinia (Ruiz et al., in press) and Andalusia (Mena et al., 2012, Ruiz et al., 2016) to identify the diversity of agro - ecological profiles. Regarding the choice of indicators and the discussion of criteria, we adopted a more participative framework following here the participatory approach proposed by Duru et al. (2015)

We considered that an agro – ecological orientation is based on the balance between 10 indicators:
1. Animal nutrition (*grazing; production of conserved forage and grains; part of the feedstuffs produced on farm; quantity of concentrates distributed…*)
2. Sustainable pasture management (*part of the rangelands in the total dry matter distributed; adequate stocking rate, potentialities of rangelands, mechanical interventions on rangelands…*)
3. Crops and forage practices (*soil contamination, using of organic fertilization, absence of herbicides, use of shrubs, practice and duration of transhumance...*)
4. Disease prevention (*body conditions of the herds, practice of quarantine for introduced animals, natural treatments, controls of water quality, livestock and watering facilities, closing of rangelands*) …
5. Breeds and reproduction *(autochthonous breeds, no hormones to manage reproduction, birth seasons organized to limit the dependence on purchased feed…)*
6. Animal welfare (*natural lactation of young animals, permanent access to open spaces and rangelands, conditions of slaughtering…*)

7. Food safety and hygiene (*absence of pathogen and free of controlled diseases, storage of effluents not rto contaminate the environment…*)
8. Marketing and management (*local marketing, farm processing, direct marketing…*)
9. Conditions of social and economic sustainability (*age of the farmer, positive perception of the farmer's income and standards of living, social integration, other incomes in the farmer's family*)
10. Environmental sustainability and societal contribution (*environmental integration of housing facilities, practice of transhumance, participation in actions in favour of bio-diversity*)

For each indicator, several agro – ecological criteria were discussed and chosen (table 1a and table 1b). If the criteria is applied the note is 1, if not, it is 0. The sum of the notes give the weight of each indicator. Each note is positioned on a radar to give the agro – ecological profile of the farms. The several criteria are presented on table 1a and 1b.

Table 1a - Criteria discussed during a focus group regarding pastoral systems in Corsica [indicators 1 to 4] *(adapted from Mena et al., 2012).*

If the criterion is considered as applied, the score is one; if not, it is zero. For each indicator, the score is the addition of the score of all criteria

1. Animal nutrition

1.1. Animals graze daily for at least 6 h.
1.2. At least 50% of daily ration (for milked females) and 60% (for other animals) is common forage and/or grass (fibres).
1.3. The farm has lands to produce forage.
1.4. The farm produces grain for goats
1.5. 80 % of the feed for animals have been produced on the farm or near the farm (in the island)
1.6. The farm uses only forage produced regionally (in the island for the Corsican case)
1 7. The goats receive less than 500 g/head/day concentrate

2. Sustainable pasture management

2.1 Rangelands provide more than 60% of the dry matter of the diet (Rangelands being defined as spontaneous grass or forest lands grazed freely by the herds including transhumance.
2.2. Rotational grazing is practiced on cultivated pastures (with at least 5 cm of grass before reintroducing the herds)
2.3. Stocking rate is between 4 and 5 goats per ha. (Average optimal stocking rate to valorize the potential of rangelands in the local conditions)
2.4. Stocking rate is adequate (No need for more land according to the farmer's declaration).
2.5. The farmer cultivates leguminous crops in isolation or associated with grains.
2.6. There is a mechanical intervention of the farmer on rangelands to improve them
2.7 The potentialities of rangelands are adapted for goats (more than 400 kg DM/ha with an opened environment and an high of scrubs between 60 cm and 2 meters).
2.8 The breeder practices transhumance during at least two months

3. Crops and forage practices

3.1. The farmer uses mineral or organic fertilizers <100 U nitrogen / ha) on the cultivated areas
3.2. The farmer makes and applies compost, or manure and the lands are always covered in summer (no bare grounds).
3.3. The farmer has already carried out soil profiles and analysis.
3.4. There is no proved risk of contamination soil or water reserves by white waters and manure.
3.5. The farmer uses tines and disc tools for tillage or direct seeding by over seeding or he ploughs less than 20 cm deep.
3.6 .The farmer practices rotations of different crops (including green manure)
3.7 No herbicides on forage areas (Direct seeding without herbicides)
3.8. The farmer uses woody resources as forage

4. Disease prevention

4.1. The body condition of the herd is satisfactory
4.2. The introduced animals are quarantined (a sufficiently long time).
4.3. The farmer carries out natural treatments mainly with natural products (herbalism or homeopathy)
4.4. The farmer treats parasites only when necessary and never more than twice per year (no systematic treatment, after a faeces analysis, or with natural treatments).
4.5. The farmer controls regularly water quality.
4.6. Livestock facilities are generally clean
4.7. Hygienic-sanitary control of all aspects of milking is adequate.
4.8. The watering facilities are correct (no direct access to streams, no watering in ponds, etc ...).
4.9. Sick animals are isolated and crawl spaces are provided in accordance with the regulations
4.10. The rangelands are closed (to avoid contacts with wildlife, wandering of animals and ease the rangelands managemen

Table 1b - Criteria discussed during a focus group regarding pastoral systems in Corsica [indicators 5 to 10] *(adapted from Mena et al., 2012)*

If the criterion is considered as applied, the score is one; if not, it is zero. For each indicator, the score is the addition of the score of all criteria

5. Breeds and reproduction

5.1. 75% or more of the animals are autochthonous and/or adapted to the region.
5.2. Animal reproduction is natural: no hormones are administered to synchronize heat, induce birth, etc.
5.3. Births are distributed in order to minimize dependence on purchased feed.

6. Animal welfare

6.1. The farmer uses natural lactation until 30 -35 days
6.2. Lactation period is at least 40 days (the lambs are not killed at birth).
6.3. Covered area is at least 1.5m^2 per adult sheep or goat and 0,35 m^2 per kid or lamb
6.4. Outside space is at least 2.5m^2 per adult animal (0,5m^2 per kid or lamb)
6.5. Livestock have permanent access to open spaces, preferably to grasslands.
6.6. The farmer does not systematically tie up or isolate animals and limit their stress by his practices (no electric sting, water spray in summer, soft dehorning,...).
6.7. The area for housing offspring is sufficient, protected from inclement weather and clean and well ventilated.
6.8. Adult animals have sufficient access to water, food, ventilation, light and adequate temperature and humidity.
6.9. The conditions of transport before slaughtering are satisfactory

7. Food safety and hygiene

7.1. The farm can prove the absence of pathogens and is free of governmentally controlled diseases (principally brucellosis and tuberculosis).
7.2. The farm complies with the regulatory criteria of sanitary quality and good practices.
7.3 The farmer makes tests for chronic mastitis
7.4 Analyses of milk during the past year indicate an absence of bacterial growth inhibitors.
7.5 The farmer follows waiting periods for treatments and had no inhibitors
7.6 The effluents are stored in such a way that they not contaminate the environment
7.7 The farmer disinfects the litters

8. Marketing and management

8.1. The farmer adequately records information (of vet .treatments feed management, purchases and sales)
8.2 All the products are sold locally to industry, cooperatives or regional shops
8.3 The farm closes the productive cycle (farm processing).
8.4 The farmer sells his products to local consumers directly at the farm or through local shops or markets
8.5. The milk is processed in units where local material is used and accepted.

9. Conditions of social and economic sustainability

9.1. The farmer thinks he has good standards of living and good working conditions
9.2. The farmer is less than 55 years or his succession is planned..
9.3 The farmer thinks he has a correct income
9.4. Without public subsidies (Pillar II of the European CAP), the farm could continue his activity?
9.5. The farmer has other agricultural, livestock not agricultural activities
9.6. The farmer is an active member of professional Associations or Unions
9.7. Collective works with other farms are usual (formally or not)
9.8 The farmer thinks he is well integrated socially
9.9 There are other sources of income within family?

10. Environmental sustainability and societal contribution

10. 1.The farm is well integrated in one's environment, looks clean and without visual pollution
10.2. The farmer is involved in the restoration of his heritage (old buildings, terraces, threshing areas...)
10.3. The farmer is aware of his animal (local breeds, wild species...) or vegetal (protected natural plan reserves) heritage and assumes it (for instance by participating to collective actions in favour of bio - diversity
10.4. The farmer practices transhumance regularly and follows his herd at least one a week
10.5. The location of the farm is a real contribution for maintaining local traditional landscapes
10.6. The farm is not located in natural hazard zone or the farmer tries to limit it (cleaning of rive banks against floods, firewalls area...)

To be agro – ecological production systems should meet ecological but also economic, technical, social and even societal components of sustainability. The diagnosis realized in some characteristic production systems described above give a good vision of the agro –ecological situation of these systems. Although pastoral farms have rather an environmental friendly image, the realty is more nuanced. At the opposite of the green natural image of pastoralism, many indicators show that the pastoral systems are often far from agro – ecological conditions:

- The contribution of rangelands to animal feeding is very low and most of the feed are imported from the continent with an important negative environmental effect of transportation, with a rather important use of hay and grain not compensated by the exclusive use of good quality rangelands.
- Some animal health control problems (10% loss of grazing animals, pathologies, loss of productivity, % of infertility...) are seen as a fatality by the farmers but it shows rather a lack of control of his management practices
- Another interesting point is the criterion on stocking – rate. The pastoral farm having a very low stocking rate (0,3 goats/ha), the practices of the farmer could not be adapted to control the vegetation of his rangelands with such a low stocking rate.
- The control of the productive process and the management of the farms are often very weak
- The social conditions of living in the hinterlands are often hard (lack of public services, desertification of villages, isolation)

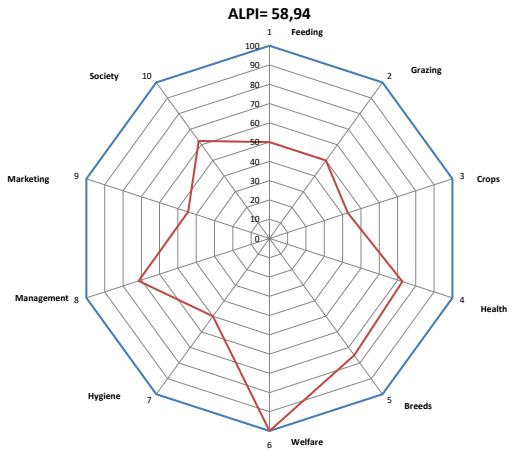
But at reverse, pastoral systems in Corsica have generally good indicators:

- on animal health with few and natural treatments,
- on the type of animals used (use of local breeds) but with few genetic improvements,
- on animal welfare (the herds have spaces and good conditions of living),
- on marketing (short value chains are well developed, farm processing)

In many cases, compromises have to be found between pastoral practices and the sustainable development of the farms.

Table 2 – An example of agro – ecological profile for a Corsican Pastoral farms

Score (%)	Indicator
50	Feeding
50	Grazing
42,86	Crops
72,73	Health
75	Breeds
100	Welfare
50	Hygiene
71,43	Marketing
44,44	Management
62,5	Society



We consider this situation is not specific to Corsica and characteristic of what happened in many Mediterranean regions where traditional pastoral systems have been marginalized, seen as archaic and doomed to disappear. Simultaneously, we observe in these areas, an important loss of bio – diversity, a degradation of pastoral landscapes with erosion and closed scrubs and an increasing risk of forest fires in less and less controlled territories. We observe both a global under grazing and local areas of overgrazing. Meanwhile, everywhere, pastoral practices and know -how, appreciated typical products as cheeses fascinate more and more both citizens, local stake – holders and the development experts are inspired to manage territorial resources and to redesign technical systems to answer agro – ecological transition issues (Dubeuf et al., 2016).
In Corsica, the regional authorities have decided to make pastoralism one of the priorities for the development of the island to face the new challenges of global changing and because more lands could be available in pastoral areas (Collectivité territorial de Corse, 2015). With a rather fantasy but not documented perception, they considered also that pastoralism would have high potentials; and they took several initiatives to define an operational pastoral strategy (Dubeuf, et al., 2018)

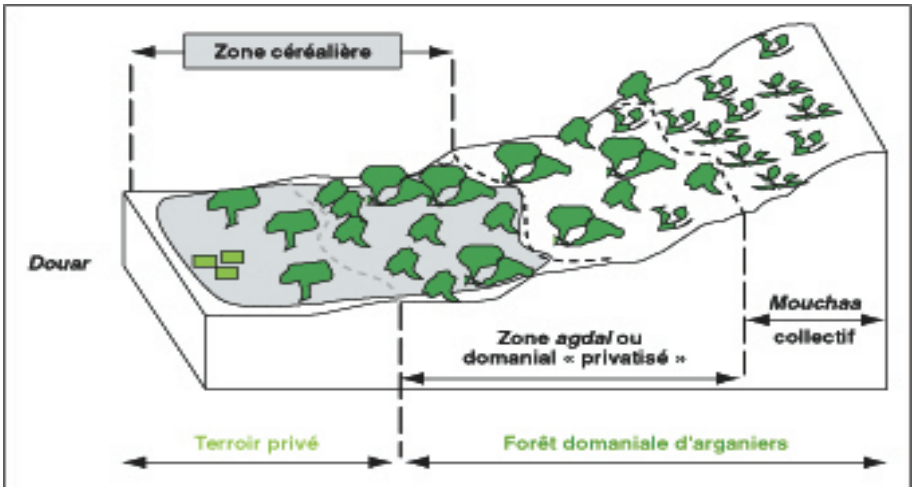
IV- Situation and changes in the Argane tree area in Morocco

Presentation of the Argane tree area.

The argan forest is a unique and endemic plant formation and is characteristic of Southwestern Morocco (see map n ° 1). The argane forest itself covers approximately 800,000 ha around Taroudant, Agadir, Essaouira, and Tiznit where are living around 1.3 million people. It is traditionally a cultivated forest for several uses: Collecting and processing argane nuts for the production of oil (food and cosmetics), goat breeding, cereal crops. Woods of the trees are also collected for heating and branches for the constitution of hedges. It is useful to remind here that, since centuries, to ensure the preservation of resources, the system of exploitation of the argane forest, a complex one, was based on a collective and structured traditional management of the territory and a sharing of the lands by right holders [*mouchaa, melk*] and an important part of the lands being *agdal* lands. Bourbouze and El Aïch (2005) described precisely the organization of the system (see figure 1). Under this organization, the argane forest was and is still administratively a national forest, the land being owned by the state and managed by the Water and Forests Department. It confers rights of use both to the municipalities (*douars*) and to a part of the population within the framework of a complex local institution, the *jmaa,* which managed the access rights. Although for private use by the rights holders, one function of the j*maa is to* decide each year the period of defense during which goats could not graze on *agdal* lands.

Map 1 – The argane tree area

Figure 1. The organization model of the argane tree area (Bourbouze and El Aïch, 2005)



But today, the *jmaa* organization has often disappeared and the argane tree area has faced important degradations due to important changes of its production systems aggravated by climate change and repeated periods of drought. The total area of the forest has decreased significantly, at a not well-known extent, but which could threaten its preservation in the medium term. From 1989, Moroccan and European scientific works launched the reputation of the oil and prompted UNESCO to classify it as a World Biosphere Reserve (WBR) in order to promote its preservation while stimulating the economic and social development of the region. The Arganeraie WBR covers 2500 000 ha and this label has impulse many initiatives with a multitude of projects involving many NGOs. From this period, the factors of degradation, and the options of ecological governance are at the heart of the discussions on the development of the Argane tree area. Simultaneously, the demand of for argane oil on the national and world market has boomed after its dietary characteristics (high in unsaturated fatty acids) of argane oil and its cosmetic properties have been highlighted. The national production of marketed oil would have practically tripled between 2006 and 2009 to reach 4000 t / year mainly towards export markets (Auclair, 2007) and the artisanal local sector, once preponderant is now only anecdotal. Once neglected and considered uninteresting, the argan forest is now the object of much attention and is becoming at the center of very important economic, social and environmental issues.

Goat farming in the Argane tree area

Goat farming, always occupied a large place in the balance of the local ecosystem and is still particularly present in the South of the Essaouira Province, in the mountainous Haha region where are 80% of the goat livestock of the Province. The traditional production system is clearly pastoral and 75% to 80% of feeding comes from pasture under the argane trees. Goats intake both herbaceous plants (rich in aromatic plants) and scrubs but also the leaves and nuts of the argane trees. The aptitude of goats to climb the trees to feed is than one of touristic attractions of the region. Once the nut is ingested, its pulp is eaten and the goats are able to regurgitate the fruits when they come back the farms where the argane nuts are collected by the farmers to make oil. This practice gives the meat a special taste with specific dietary qualities.
Goat farming in Morocco has always been marginalized. Until recently, goats had a bad image and were seen often as a relic of the past and good only for poor people. Since at least a

decade, we observe nevertheless a growing demand for the meat of the goat kids from urban consumers attracted by its lower fat content. The specific dietary and taste quality of the kids produced in the argane tree area caught the attention of public authorities who have initiated a process to certify the kid of the argane tree area. With the support of the Green Morocco Plan (Moroccan Ministry of Agriculture and Fisheries, 2009), the administration has thus formalized a project to promote and certify the kid in order to organize production and producers and increase also the income of poor rural populations which represents local social issues. Sheep and goats are present in most of the Argane tree area with about 1,2 million goat heads, mainly in the Essaouira and Taroudant Province (See table 3).

Table 3 – Animal livestock in the several provinces of the Argane tree area.

Province	Agadir	Essaouira	Guelmim	Taroudant	Tiznit	**Argane tree area**
Cattle	73 000	60 900	3 000	93 100	43 000	273 300
Sheep	194 800	510 900	67 700	528 800	157 500	1 459 700
Goats	162 500	379 100	58 700	450 300	143 600	1 194 200

Source*:* Moroccan Ministry of Agriculture and Fisheries, 2009

Several projects to promote kid meat have been implemented. For example, around Smimou in the Haha traditional area, 17 million dirhams (2,5 million €) were dedicated to the 23 000 small farms of this rural community by the regional services of Agriculture to increase the production of kids, to improve slaughtering conditions and marketing and for labelling the local kid. Extension services have been developed to improve the technical capacities of the goat keepers (sanitary and health control, reproduction and selection, nutrition).

We observe that by promoting the development of goat farming for kid meat, the balance of the complex system of the argane tree area, tends to be modified. Although goats were a part of the balance of the system by providing manure, by disseminating seeds, by eliminating weeds, the forest services still consider them as the enemies of the trees by over grazing and a cause of the degradation of the traditional agdal system. Besides, to answer the demand of the cosmetic industry, the argane nuts ingested by goats cannot be used anymore for making oil and the goats farms become more and more specialized. Enclosures for goats are built where argane cake (*alig*), a subproduct of oil making, dry figs (*Afiyach*) or barley are distributed to the goats.

Consequences of these changes on the agro – ecological properties of the production systems in the argane tree area

All the communication of the argane tree area and argane oil is based on the image of a “natural” tree and bio – tope where human intervention would be very limited which is not the truth. According to Simenel et al. (2009), recent orientations (promoted by the forest services) have favored the naturalization of the argane tree area. This term here designates the processes which have led to consider the argan tree area only as a natural space and the tree as a gift from God, relying on religious references to construct this representation, which is far from being true. Insofar, it has always undergone human intervention and goat farming contributes to the overall balance. The representation is that of a natural forest that should be preserved from any degradation by limiting human action to the strict minimum (harvesting to which regeneration plantations would be added). The argane forest would then be gradually transformed into a sort of orchard in which only the best-located plots could be cultivated, which has already been observed in completely privatized plots. Small breeders would be accepted as a trace of a tradition but without launching development projects involving innovations in breeding. The assertion of the negative effect of goats is not based on any legitimate scientific result, most of the bibliographical references highlighting the contrary This naturalistic approach

has ignored completely that the present situation is the result of centuries-old interactions between man and his environment. The representation described above therefore widely shared and tends to exclude any idea of development and certification of goat farming in the argane tree area because, according to these actors, this would cause uncontrollable windfall effects with accentuation of overgrazing aggravated by climate change and more and more repeated droughts that it causes. Conversely, the windfall effect on oil and the overexploitation of trees are hardly mentioned, except for the communication campaigns to limit the galling of fruit which damages trees. The pressure from these actors to the public authorities has largely contributed to postpone the certification of the kid with agro – ecological specifications.

Michon et al (2012) were the first to introduce the notion of dissociation within the argan tree area. They demonstrated that the process of qualification and traceability for industrial purposes has helped to simplify the heritage identity of argan oil within its territory. This patrimonial identity was thus dissociated it from local customs and often complex social and cultural operations, with a risk in the law of this dissociation. The present dynamics described above show that this dissociative logic which does not meet the objectives of agro – ecology and could contribute to weaken the system. Interviews with stakeholders also provided additional information that sheds light on the representations. At the climatic level, all the stakeholders met, including the breeders, underline the intensification of the frequency of periods of drought. The public authorities organize the distribution of subsidized food (barley) but the farmers specify also that these droughts generally lead to overgrazing of goats but also to decapitalizing the herd. Such an adaptation practice, which is usual in a pastoral system, does not promote selection practices and the constitution of genetic lines, as good reproducers can be eliminated. All interviews emphasize also the negative effect of transhumant herds. These large herds of goats and camels from the Southern provinces would be brought in the dry season, often by truck on more favorable routes but without control or grazing rights, which generates conflicts between the owners and the local actors. Although there is no direct relationship between these herds and the issue of local goat farms which also undergo these transhumances, their impact is often highlighted and it is exploited against goat farming in general.

At the opposite, at a social and economic level, pluri – activity could give more resilience to the farmers and made them less dependent of oil industry. Most of them are small farmers (76% have less than 5ha, they own less than 100 trees, and less than 40 goats). But the development of a goat sector as for oil industry is seen as an opportunity to professionalize an activity, to be more competitive. For the local Haha association, according to the interviews carried out during the study, the stake would be primarily to legitimize the goat in the argane tree area by considering the ecological stake including for the small herds and in taking into account the multifunctionality of activities and mobilizing customary mechanisms of territorial and eco-systemic governance.

V- Discussion and conclusions: Strengths, challenges and prospects for pastoralism and agro – ecology in the Mediterranean

These two examples have shown that pastoralism and agro – ecology in the Mediterranean are not synonymous and that the future of pastoralism has to build its own agro – ecological strategy. The Mediterranean area has to face important challenges at a short term dead line related to climate changing, water and food shortages and the future of animal production or the management and development of hinterlands are ones of these challenges. We have shown here that the case of Corsica is very relevant to identify and face these issues and the methodology developed in the island could be used in other situation like in Morocco. In spite of nostalgic visions, the rural societies will not be anymore what they were and the return to the

past is neither possible nor desirable. For example, no young farmer would accept to give all his time to build stone walls and terraces. It is necessary to imagine new technologies, new know how mobilizing for instance digital ones, new knowledge to answer the present environmental and ecological challenges.

We have shown also the prevalence of the dominant paradigm of progress calling for more specialization, simplification, and intensification while emphasizing the protection of the environment. These two examples illustrate the agro – ecological challenge and the complexity to promote a real agro – ecological transition. On one hand, it is important to favor innovation by promoting research and training and we need new references and formalized models and improving capacities to manage the resources. Enhancing labor and human skills is another challenge to manage natural pastoral resources. On the other hand, the local knowledge and know – how often half forgotten, have a coherence which could be mobilized for more resilient and sustainable activities which would answer the present challenges. The mobilization of both hybrid local secular and scientific knowledge and scientific ones could improve the competitiveness and agro ecological dimension of pastoral systems. Favoring pluri activity and the co – existence of several systems could be another way to consider the agro – ecological transition. To be operational, ecologically intensive pastoralism seen as a bio – diversity based agriculture requires a changing regime to reorganize this transition, change the way to face problems and find solutions.

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Session I

Linear body measurements as a management tool for Tunisian local goat population raised in arid conditions

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Abstract. The study aims to describe the linear body measurements and their factors of variation, and to establish their possible relationship. The morphostructural parameters for 92 local kids,including the body length, the wither height, the paunch girth, the heart girth and the rump length,were collected from birth to 150 days of age. The mean body length of male was 39.80cm, while that of the female was 38.27cm. Similarly, the heart girth as well as the wither height was also higher ($p<0.05$) in male than those in female. This trend confirms sexual dimorphism in local kids. The type of birth has non-significant effect on paunch girth. A high correlation ($r=0.90$) was recorded between the paunch girth and the heart girth.This is the same for the correlation between the height at the withers and the body length. Both, the body length ($r=0.97$) and the wither height ($r=0.95$) presented the highest correlations with live body weight. It could be concluded that the weight of local kids can be predicted with accuracy from some body measurements such as the heart girth which can be exploited by goat producers for management, selection and genetic improvement programs in local goat population.

Keywords. *Morphostructural parameters, Live body weight, Selection.*

Titre : Mesures de la croissance linéaire comme un outil de gestion chez la population caprine locale élevée dans des conditions arides

Résumé.*L'étude vise à décrire les mensurations linéaires, leurs facteurs de variation et à établir leur éventuelle relation. Les paramètres morphostructuraux de 92 chevreaux locaux comprenaient la longueur du corps, la hauteur au garrot, la circonférence de la panse, la circonférence du cœur et la longueur de la croupe ont été recueillis de la naissance jusqu'à 150 jours d'âge. La longueur moyenne du corps du mâle était de 39,80cm, tandis que celle de la femelle était de 38,27cm. De même, la circonférence du cœur ainsi que la hauteur au garrot étaient également plus élevées ($p<0,05$) chez les mâles que chez les femelles. Cette tendance confirme le dimorphisme sexuel chez les chevreaux locaux. Le mode de naissance a un effet non significatif sur la taille de la panse. Une forte corrélation ($r=0,90$) a été présentée entre le tour de poitrine et le tour de cœur. Il est de même pour la corrélation entre la hauteur au garrot et la longueur du corps. La longueur du corps ($r=0,97$) et la hauteur au garrot ($r=0,95$) présentent les corrélations les plus élevées avec le poids vif. On pourrait conclure que le poids des chevreaux locaux peut être prédit avec précision à partir de certaines mesures corporelles telles que la circonférence du cœur qui peut être exploiter par les producteurs de chèvres pour la gestion, la sélection et les programmes d'amélioration génétique dans la population caprine locale.*

Mots-clés. *Paramètres morphostructuraux, Poids,Sélection.*

I – Introduction

Goat meat production is a widely extended activity in the arid areas of Tunisia. In southern Tunisia, kids' meat represents about 75% of the local meat production (Najari, 2005). Further, the demand for meat from kids is increasing because of its nutritional quality. Among others, to improve meat

production of the local goat population breeding objectives need particular attention to linear body measurement for their economic objectives.
As known for animal quantitative traits, variation in body size is one of the criteria largely used for classifying and characterizing caprine breeds (Nsoso *et al.,* 2003).
Live weight plays an important role in determining several characteristics of the farm animals especially the ones having economic importance. Birth weight, early growth, feed conversion ratio as well as feeding requirements could be predicted by knowing the live weights of several stages of the lambs (Eker and Yavuz, 1960). Estimating the live weight using body measurements is practical, faster, easier, and cheaper in the rural areas where the sources are insufficient for the breeder (Nsoso *et al.,*2003). Very few studies have been carried out on the linear body measurements of Tunisian local goat and their possible use for estimating animal growth traits. Where genetic evaluation has still limited use in developing countries, identification of some linear traits may be useful and farmers' tools for selecting kids with desirable characters.
The study aims to describe the linear body measurements and their factors of variation, and to establish their possible relationship with the live weight of local goat population.

II – Material and methods

2.1 Animals and management

All studied animals belong to the goat experimental herd "ElGORDHAB" which is located in the South-East of Tunisia with an arid continental Mediterranean climate, with irregular and sporadic rainfalls. The season of kidding begins in November and continues until March, with a concentration during November and December. Throughout the study, replacement animals were selected based on weaning weight and physical conformation. Animals grazed on natural pastures during the day. In general, pasture grasses production covered about 70% of breeding animals feed requirements. The remaining 30% was covered by a supplementation of barley provided during the mating (600 g/day), the last month of pregnancy and the beginning of lactation (750 g/day). Goats received about 1 kg per day of concentrate mixture during lactation. All animals were provided with water allowed twice a day, before and after grazing.

2.2 Data recording and studied traits

The data used in present study were collected from a total of 92 kids (40 males and 52 females), the progeny of 3 sires and 70 dams. Since the start of the kidding period and till 150 days of age, kids were weighed once every two or three weeks. In addition, five body linear parameters measured included Body length from the tip of the scapula close to the neck region to the pin bone of the tail region; Heart girth : circumference of the chest; Punch girth: circumference of the body measured immediately after the abdomen just before the hind legs; Withers height : the highest point on the dorsum of the animal to the platform at the level of the forelegs while the animal was standing; Rump length : measured with a tape measure, from the rump to the depression of the first join.

2.3 Statistical analysis

The GLM Procedure (SPSS, 20) was carried out for determining the effects of the sex, the birth type and the month of birth of local kids on the studied traits. The general model can be represented as follows:

$$Y_{ijk} = \mu + MN_i + S_j + MO_k + e_{ijk}$$

Where:
Y_{ijk}: performance to be analyzed (live weight andbody linear parameters); μ: general mean, MN_i: effect of type of birth (i = single, double), S_j: effect of sex (j = male, female),MO_k: effect of month of birth (k= November, December, January, February, March) and e_{ijk}: residual error.

After variance analysis, a means comparison test (SNK, α=0.05) was applied to identify homogenous class of studied factors for each variable. The Pearson correlation matrix was calculated to establish the qualitative relationships between the different variables.

III – Results and discussion

3.1 Body weight and linear body measurements

The descriptive statistics for average weight and linear body parameters are presented in table 1. The overall average weight was 9.20kg. Local kids were characterized by low weights. Similar results have been reported in most breeds and local populations raised under arid environments (Al-Shorepy *et al.,* 2002). Such a low weight of local kids corresponds to low energetic needs, which can be considered as a strategy of adaptation toward the difficult environmental conditions.

Kids of this local breed were characterized by low weights. Similar results have been reported in most breeds and local populations raised under arid environments Atoui et *al.,* (2020). Such a low weight of local kids corresponds to low energetic needs, which could be considered as epigenetic strategy of adaptation to the difficult environmental conditions. In this regard, low weights can be regarded are indeed specific mechanisms of adaptation to the restrictive and irregular environment as shown by Al-Shorepy *et al.,* (2002). The adaptation mechanism could be either genetic or epigenetic as these harsh and limiting environments may result in epigenetic marks oriented to limit the size of animals to endure starvation and heat-stress, as it has been observed in some African human population (Al-Shorepy *et al.,* (2002)

The local goat was characterized by small body size with an average wither height of 44.10cm and an average body length of 44.10cm. Small adult size is a characteristic of most breeds raised under arid conditions (Najari,2005).Our values were lower than that reported by Moaeen *et al,.*(2006) who reported 64.97cm body length, 70.23cm height at wither, and 61.29cm heart girth for crossbred goats raised under arid conditions. The variation in various body measurements in different studies on the same breed may be due to the difference in the environment and climate, the size of data set and the management practices adopted.

Table1. The characteristics of the data structure for body weight and linear body measurements of Tunisian local kid at 150 days of age .

Variable	Min.	Max.	Mean	SD	CV%
Live body weight(kg)	7.88	11.20	9.20	4.45	48.37
Body length(cm)	34.22	46.45	40.00	7.45	18.63
Heart girth(cm)	38.22	53.22	46.80	9.70	20.73
Punch girth(cm)	41.40	61.02	50.31	11.30	22.46
Withers height(cm)	36.89	51.12	44.10	7.20	16.33
Rump length(cm)	9.77	13.25	11.01	2.13	19.35

SD: std. deviation; CV: coefficient of variation

3.2 Estimates of environmental effect on studied traits

Table 2 shows the results of the ANOVA analyses to test the significance of the sex and type of birth effect on body weight and linear growth of local kid population. The results show that all studied linear body measurements were significantly affected ($p<0.05$) by sex of kids. The type of birth presents a highly significant ($p<0.01$) on body measurement but no significant effect on paunch girth. The body weight (LBW) was also affected ($p<0.01$) by sex and type of birth. The estimated coefficient of determination (R^2) ranges between 0.62 and 0.83.A relatively high R^2attests the importance of the fixed effects included in the model.

Table 2. Test of significance from ANOVA analyses and coefficient of determination (R^2) of a model including non-genetic factors on studied traits.

Sources of variation	DF	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
Sex of kids	1	HS	HS	HS	HS	HS	HS
Type of birth	1	HS	HS	HS	NS	S	S
R^2	----	0.80	0.71	0.83	0.72	0.77	0.62

DF: degrees of freedom; NS: non-significant; S, HS: significant ($p<0.05$; $p<0.01$, respectively).

3.3 Kid's sex effects upon body weight and linear body measurements

The sex of kids shows a significant effect in all studied traits. The average LBW over the studied period was 9.80±4.50kg for males and 8.32 ±4.02kg for females, respectively (Table 3). Such results are within the range of estimated weights in other local breeds in hot and arid conditions (Al-Shorepy *et al.,*2002).The higher values reported for the morphometric traits of males compared to females seem in accordance with earlier reports on goats (Vargas *etal.,*2007). This difference has been attributed to hormonal differences between sexes and their resultant effects on growth. Najari (2005) reports that female kids can reach the maturity state rapidly and they can begin their reproductive process since the first year of age. This can be considered as an adaptation criteria of local goat population under arid condition (Atoui *et al.,* 2020).

Table 3. Effects of sex upon body weight and linear Body measurements.

	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
Male	9.80^{a} ±4.50	39.80^{a}± 7.50	52.52^{a}±10.80	47.82^{a}± 10.12	45.02^{a}± 7.13	11.20^{a} ± 2.20
Female	8.32^{b} ± 4.02	38.27^{b}±6.60	49.01^{b}±9.80	45.45^{b}± 8.88	43.50^{b}±6.22	10.84^{b}±2.04

^{a,b}Means with different superscripts within a column are significant ($p<0.05$, $p<0.01$).

3.4 Kid's type of birth effects upon body weight and linear body measurements

The effect of type of birth is considered classic for almost livestock species (Ouni*etal.,*2007). Since fœtal life, single kids have normally better conditions to realize lower weight and larger body linear parameters than twins, and this continues during all animal life (Najari, 2005).The average LBW was10.13 ± 4.65 kg for single and 7.82 ± 3.70kgfor double respectively (Table 4). Similar results were obtained by Wenzhong *et al.,*(2005).The higher values reported for the

body length of single compared to twins seem in accordance with earlier reports on kids in the same conditions (Moaeen *et al.,* 2006).

Table 4. Effects of type of birth upon body weight and linear body measurements.

	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
Single	10.13^{a} ±4.65	40.23^{a} ± 7.43	48.41^{a}± 9.50	47.20^{a}±11.01	45.33^{a}± 7.17	11.40^{a}± 2.20
Double	7.82^{b}± 3.70	36.86^{b}±6.71	44.60^{b}±9.23	47.90^{a}± 11.50	42.42^{b}±6.80	10.50^{b} ±1.90

^{a,b}Means with different superscripts within a column are significant (p<0.05, p<0.01).

3.5 Kid's month of birth effects upon body weight and linear body measurements

The results of the comparison of means of the studied traits according to the month of birth-are presented in Table 5. The month of birth presents a highly significant effect on body weight and all body linear measurement, except the Rump length parameter. The best values were obtained with kids born during the period November to December. The effect of month of birth on studied traits is explained by the variation in pastoral resources from one season to another, especially in arid regions with irregular conditions (Najari, 2005). This variation affects the milk production of dams and forage production of the rangelands and therefore on the development of kids (Atoui*et al.,* 2020). Al-Shorepy*et al. (*2002) indicated that kids born in hot, dry season are heavier (p <0.05) than those born duringhumid season.

Table 5. Effects of month of birth upon body weight and linear body measurements.

	Live body weight	Body length	Heart girth	Punch girth	Withers height	Rump length
November	9.81^{a} ±4.51	39.81^{a}± 7.51	52.52^{a}±11.81	47.82^{a} ± 11.12	45.12^{a} ± 7.13	11.21^{a} ± 2.21
December	8.32^{b} ± 4.12	38.27^{b}±6.61	49.11^{b}±9.81	45.45^{b} ± 8.88	43.51^{b}±6.22	11.84^{a}±2.14
January	7.32^{b} ± 4.12	37.27^{b}±6.51	49.11^{b}±9.61	45.45^{b} ± 7.57	43.51^{b}±6.42	11.74^{a}±2.04
February	7.32^{b} ± 3.12	37.27^{b}±6.61	39.11^{b}±9.71	35.35^{b} ± 7.77	33.51^{b}±6.22	11.73^{a}±2.13
March	8.32^{b} ± 4.02	36.27^{b}±6.60	49.01^{b}±9.60	45.45^{b} ± 6.66	43.50^{b}±6.22	10.64^{a}±2.04

^{a,b}Means with different superscripts within a column are significant (p<0.05, p<0.01).

3.6 Bivariate correlations between body weight and linear body measurements

The correlation coefficient between live weight and body linear measurement of kids are shown in table 6. The correlations between the morphometric variables and the live weight are all significant (Table 6). The correlations varied from 0.60 and 0.99. A higher correlation (r=0.99) is observedbetween the LBW and the Heart girth parameter. The lowest correlation(r=0.70) is recorded between the body length and rump length .

The highest correlations are recorded between the height at the withersand the body length are in agreement with those obtained by Rashidi et *al.* (2008) in Markhoz goats and by Schoeman et *al.* (1997) in Boer goats. Due to the existence of high correlations coefficients between live

body weight and linear body measurements, these parameters, could provide a good estimate for predicting live weight in local kid population and it may be used as selection criteria in genetic improvement program.

It seems that the weight of the kid varies essentially with the measurements which represent the stature of the animal than those relating to the shape of the animal. The higher correlation coefficient of body weight with a given body dimension demonstrate that on the basis of the dimensions of various measurements, the body weight could be predicted more accurately. Nsoso et *al.*(2003) found a higher correlation coefficients between body weight and measurements for males indicated the fact that body weight could be predicted more accurately in males as compared to female goats.

The heart girth is the best parameter used for live weight estimation at farm conditions especially under smallholder farmers.

Table 6. Estimates of bivariate correlations among linear morphological traits and live weight.

	Live body weight	**Body length**	**Heart girth**	**Punch girth**	**Withers height**	**Rump length**
Live body weight	1	0.97**	0.99**	0.70*	0.95**	0.77**
Body length		1	0.80**	0.72*	0.90**	0.70*
Heart girth			1	0.90**	0.88**	0.60*
Punch girth				1	0.80*	0.61*
Withers height					1	0.63*
Rump length						1

*significant correlation.

IV - Conclusions

Kid body weight can be predicted from body measurements with high accuracy to support breed improvement and husbandry practices of local goat population. Variation in kid body weight was explained to a large extent by heart girth. It recommended to develop a simple chart that indicates heart girth and corresponding weights to be used by farmers and development agents to support genetic improvement, marketing, feeding and veterinary services.

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Croissance pondérale des chevreaux de la population caprine locale et sources de variation dans les régions arides tunisiennes

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Résumé. La présente étude contribue à la caractérisation de la population caprine locale et sa production de la viande qui représente le produit principal de son élevage. Le but est l'établissement des facteurs de variation de la croissance du chevreau ainsi que les relations entre les différentes variables corporelles en évolution dès la naissance jusqu'à 150 jours d'âge. Les données analysées sont issues des suivis des performances individuelles des chevreaux du troupeau caprin expérimental de la station expérimentale d'ElGORDHAB-TATAOUINE. Un total de 92 chevreaux issus de 70 chèvres et 2 boucs ont été étudiés par l'analyse des performances de croissance dès la naissance jusqu'à l'âge du 5 mois. Les poids moyens du chevreau de la population locale sont estimés à 2,55 ; 3,40 ; 4,91 ; 7,41 ; 9,82 ; 12,31 et 12,93 kg respectivement à la naissance, 10, 30, 60, 90, 120 et 150 jours. Le gain moyen quotidien diminue avec l'âge. En général, le chevreau local est de petite taille et d'un poids léger à la naissance qui varie selon les facteurs de variation comme le sexe, le type pigmentaire, le mode de naissance et surtout le mois de mise bas. Les performances enregistrées confirment les potentialités modérées de croissance des chevreaux de la population locale, et aussi, l'importance des impacts des facteurs de l'environnement aride sur les phénotypes productifs. Outre leur inclusion impérative dans les modèles mixtes, les sources de variation des milieux arides, ainsi que leurs interactions, nécessitent d'être considérées au niveau de leurs natures aléatoires. Les corrélations entre les différents caractères de croissance sont comprises entre 0,15 et 0,94. Elles sont plus élevées entre les poids adjacents et entre les poids et les gains correspondants. Les résultats apportent un complément aux caractéristiques phénotypiques et génétiques de la population caprine. Les paramètres établis aideront à optimiser la gestion des performances de la population caprine locale adaptée aux conditions arides.

Mots clés. Chevreau local, milieu aride, performances de croissance, corrélation, gain moyen quotidien, amélioration génétique.

Abstract. *Goat meat production, a widely extended activity in the more arid areas of Tunisia, relies on local breeds. These breeds are well adapted to produce under harsh conditions but have a very small size and low productivity. The aim of this study was to establish the factors of variation of kids' growth as well as the relations between weights at typical ages from birth up to 150 days of age. A total of 92 kids in the caprine herd at the ElGORDHAB-TATAOUINE experimental station, were used. The average weights of local kids were 2.55; 3.40; 4.91; 7.41; 9.82; 12.31 and 12.93 kg respectively at birth, 10, 30, 60, 90, 120 and 150 days. The average daily gain decreases with age. Results indicate that Tunisian local kids were characterised by a reduced weight at birth, which varies with sex, pigment type, mode of birth and especially the month of birth. Such performances confirm the moderate growth potential of local kids and also, the importance of the impacts of environmental factors on the productive phenotypes. Besides their imperative inclusion in mixed models, the sources of variation of arid environment, as well as their interactions, need to be considered at the level of their random nature. The correlations between the different growth traits are between 0.15 and 0.94. The correlations were higher between adjacent weights and between the corresponding weights and gains. The establishment of the kid's weight parameters under arid regions helps to develop accurate selection indices and to optimally a breeding programs and performance recording systems for maximum economic gain or profit from growth traits.*

Keywords: *local kid, arid environment, growth performance, correlation, average daily gain, selection.*

I- Introduction

Dans les régions arides tunisiennes, le cheptel caprin représente plus que 60% de l'effectif national (Najari, 2005, Atoui et al., 2019). La concentration des troupeaux de chèvres dans les zones arides montagneuses et marginales est en étanche relation avec les capacités d'adaptation de l'espèce caprine en Tunisie, on assiste actuellement à un regain d'intérêt pour l'espèce caprine qui s'est illustré par des programmes de recherche et de développement de l'élevage des chèvres. Tout projet de développement d'une production de la chèvre locale doit reposer sur une logique d'ensemble comprenant, en premier lieu, la caractérisation de la population locale existante, d'un point de vue zootechnique, morphologique, productive, génétique et moléculaire (El Ouni et al., 2007). La connaissance de ses aptitudes biologiques et de la variabilité génétique de la population aiderait à élaborer les programmes de sélection pour les différents systèmes de productions en cohérence avec les ressources animales et environnementales. C'est dans ce contexte que se justifie le présent travail dont l'objectif est de produire des connaissances et des indicateurs scientifiques sur les aptitudes et les caractéristiques de la chèvre locale et ses performances de production de la viande

II- Matériels et méthodes

1.1 Présentation de la zone d'étude

L'étude a été réalisée dans le sud-est tunisien dans le gouvernorat de Tataouine. Dans cette zone, la moyenne annuelle des précipitations est de l'ordre de 100mm (données climatiques ; Station météorologique de Tataouine, 2020). La pluviométrie est caractérisée par son irrégularité intra et interannuelle, la région est marquée par une longue saison sèche (6 à 9 mois) et la dominance des vents « Sirocco » desséchants ce qui augmente considérablement l'évapotranspiration potentielle et par conséquent accentuant le déficit hydrique. L'été est chaud et sec, de durée de 4 à 5 mois et l'hiver est tempéré à doux et irrégulièrement pluvieux, l'automne et le printemps présentent des conditions climatiques très variables.

1.2 Troupeau expérimental

Les essais et les observations ont été effectués sur des chevreaux du troupeau caprin expérimental de la station expérimentale d'ElGORDHAB-TATAOUINE. La population caprine locale est un groupe animal très hétérogène sur le plan génétique et morphologique. Elle est connue par sa petite taille ; la hauteur moyenne au garro est de l'ordre de 73cm chez les boucs et seulement 60 cm pour les femelles ;quant au poids adulte moyen, il est de 35 kg pour les mâles et de 24 kg chez les femelles (Najari, 2005). Le noir constitue la couleur dominante chez la chèvre locale avec une fréquence supérieure à 60% ; tandis que la fréquence des robes pie est d'environ 20% (Najari et al., 2007). Le même auteur a signalé la présence d'autres couleurs comme le rougeâtre ou le blanchâtre. Toutefois, une variabilité plus marquée a été observée au niveau de la couleur de la tête, avec des patrons incluant le noir, le blanc et le rouge (Najari, 2005).Généralement, les animaux sont conduits selon un système semi intensif.
Le troupeau caprin pâture quotidiennement. En plus de pâturage, les chèvres ont reçu pendant la lutte une supplémentation de l'orge (400 à 600g/jour). Tous les animaux reçoivent de l'eau deux fois par jour ; avant et après le pâturage. Les animaux sont abrités dans une chèvrerie devisée en compartiments qui servent pour manipuler les animaux et pour réaliser les opérations d'alimentation, mensuration, contrôle de croissance, et traite.

1.3 Protocole de la caractérisation pondérale des chevreaux locaux

Les données utilisées dans le présent travail proviennent des suivis périodiques de la croissance pondérale des chevreaux depuis la naissance (tableau 1.) En total, et après éliminations, les données de 92 chevreaux locaux ont été retenues. Les distributions des chevreaux contrôlés par sexe et par mode de naissance figurent dans le tableau 1.

Tableau 1. Description des données étudiées par sexe et mode de naissance.

Paramètres	Nombre d'observations
Nombre des boucs connus	2
Nombre des chèvres	70
Effectifs total des chevreaux	92
Mâle	40
Femelle	52
Nés simple	36
Nés multiple	56

Les naissances sont enregistrées sur des registres de mise bas. Les chevreaux sont pesés à la naissance et identifiés par des marques plastiques tip tag. Le sevrage n'est effectué qu'avec la séparation des chevreaux en juin.

Les pesées des chevreaux sont faites tous les 15 jours et les différents contrôles sont enregistrés sur le registre du contrôle de croissance. Les chevreaux qui meurent à des âges précoces sont éliminés. Le poids à la naissance figure dans le fichier de base, les poids à différents âges types sont estimés soit par interpolation ou extrapolation. L'estimation des poids aux âges types est obtenue par interpolation lorsque deux pesées, le poids de naissance non compté, encadrent l'âge type voulu, en appliquant la formule suivante (Atoui, 2019) :

$$PAT_i = \frac{Pn + (An - i) \times (Pn+1 - Pn)}{(Dn+1 - Dn)}$$

Où : i est l'âge-type du chevreau, égal à 10, 30, 60, 90, 120 et 150 jours ; P_n, P_{n+1}, D_n et D_{n+1} représentent respectivement les poids et les dates de contrôle de croissance n et n+1 ; et A_n est l'âge à la pesée n (avec $A_n < i < A_{n+1}$). Dans les cas où il ne peut y avoir interpolation, le calcul peut être réalisé par extrapolation inférieure (où $i < A_n < A_{n+1}$) ou extrapolation supérieure (où $A_n < A_{n+1} < i$). Les gains moyens quotidiens (GMQ) en g/jours sont calculés à partir des poids aux âges types. .

1.4 Analyses statistiques

Outre les paramètres descriptifs des caractéristiques pondérales, et qui sont élaborés lors de la première étape de dépouillement, des analyses statistiques ont été appliquées pour décomposer la variabilité totale observée de ces variables phénotypiques. L'étude des sources de variation des caractères étudiés nécessite l'application d'une décomposition de la variance (GLM : Modèle linéaire généralisé) du logiciel statistique SPSS.20 pour illustrer la nature statistique de l'action des différents facteurs et sources de variation. La décomposition de la variance a été suivie par une comparaison des moyennes de Student Newman et Keuls (S.N.K, α=0,05), afin de comparer les moyennes des modalités de chaque facteur de variation qui illustre un effet au moins significatif ($p<0,05$ ou $p<0,01$).

III - Résultats et discussions

3.1 Performances de croissance des chevreaux locaux

A. *Nature de la dispersion et distribution des performances individuelles de la croissance*

La visualisation de la dispersion des performances brutes peut mettre en valeur certains aspects relatifs à l'évolution globale des performances du troupeau et aussi, de la nature de la distribution de l'information observée (Najari, 2005, Atoui, 2019). La figure 1 illustre l'évolution des poids des chevreaux de la population caprine locale en fonction de l'âge. Cette simple présentation des pesées des chevreaux témoigne d'une variation considérable au niveau des potentialités individuelles. La dispersion des poids observés représente une expression collective des génotypes des chevreaux sous les conditions observées durant cette campagne de suivi. La marge de variation des poids individuels aux contrôles se voient importante et croissante avec l'âge du chevreau. Le problème ne réside pas dans la variabilité importante qui peut être exploitée par sélection mais plutôt dans sa nature qui rend difficile la modélisation des performances et risque d'augmenter les résiduels inexplicables. Ce type de dispersion est considéré typique aux performances des animaux réalisées sous les conditions difficiles et variables (Najari et al., 2002). Au niveau de la dispersion, la variabilité la plus importante est observée pour les valeurs élevées, le poids les plus légers sont plus homogènes. Quant aux faibles performances, il s'agit d'un comportement général chez la population rustique. L'amplitude de la dispersion augmente avec l'âge, dès l'âge de 3 mois, la marge de variation des poids devienne considérable et la différence entre le maxima et minima dépasse le 15 k.

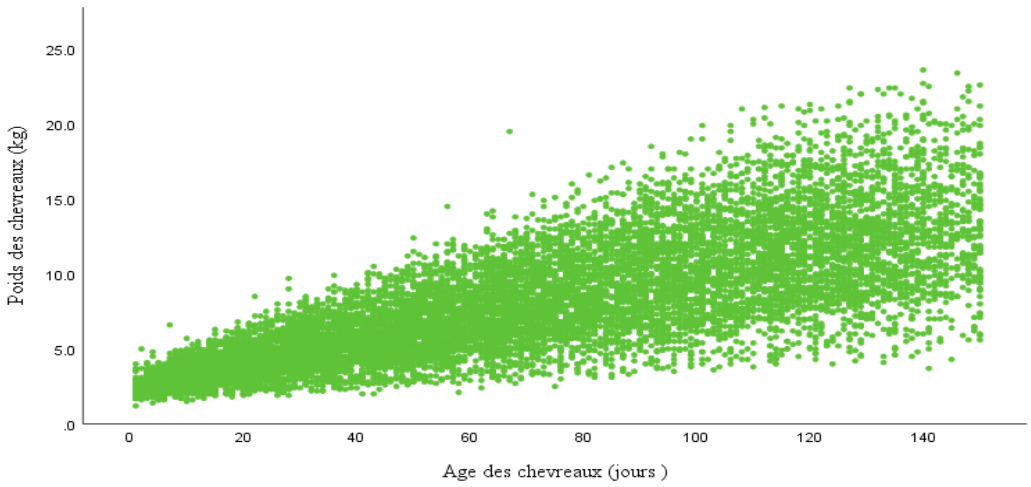

Fig. 1 : Distribution des poids estimés des chevreaux locaux en fonction des âges.

B. *Paramètres statistiques des performances individuelles de la croissance*

Le tableau 2 regroupe les principaux paramètres des poids aux âges types des chevreaux locaux estimés à partir des performances enregistrées au niveau du troupeau de chèvres locales installé dans le centre expérimental d'ElGordhab

Poids aux âges types (kg)

	1j	10 j	30 j	60 j	90 j	120 j	150 j
Moyenne	2,55	3,40	4,91	7,41	9,82	12,31	12,93
Ecart type	0,43	0,75	1,18	2,02	2,97	3,56	3,68
Minimum	1,50	1,37	2,15	3,33	4,47	6,03	6,50
Maximum	3,95	5,59	7,61	8,65	13,25	14,10	19,36
Coefficient de variation (%)							
Test de normalité «Shapiro-Wilk»	Rejeté	Accepté	Accepté	Rejeté	Rejeté	Rejeté	Accepté

Les poids moyens du chevreau de la population locale sont estimés à 2,55 ; 3,40 ; 4,91 ; 7,41 ; 9,82 ; 12,31 et 12,93 kg respectivement à la naissance, 10 jours, 30 jours, 60 jours, 90 jours, 120 jours et 150 jours. Ces performances de croissance peuvent être jugées relativement faibles, mais elles illustrent les aptitudes réelles de production de la population locale (Tableau 2). En effet, la plupart des races et des populations caprines des zones chaudes et désertiques présentent des poids légers. Des poids similaires des caprins, en croissance ou adultes, ont été indiqués dans des élevages de races indigènes des milieux difficiles (Okello, 1993 ; Sharma et al., 1998).

Les écarts types restent élevés, ce qui explique la variabilité non négligeable au niveau des caractères de croissance de la population caprine locale. En effet, le poids maximum enregistré (Tableau 2) dénote l'existence des certains animaux performants.

Le chevreau naisse avec un poids moyen de 2,55kg ; ce poids moyen parait assez lourd en comparaison avec celui observé chez d'autres races et populations caprines (Alexandre et al., 1997b ; Awemu et al., 1999 : Ahuya et al., 2000). La valeur moyenne du poids corporel à 120 jours d'âge est presque cinq fois plus lourde que celle du poids à la naissance (Tableau 2). Selon ElOuni et al., (2007b), les chevreaux de la population locale réalisent environ 83% la stature de l'animale adulte à l'âge de 5 mois. Au fur à mesure que le chevreau avance en âge, son gain moyen quotidien diminue. Ces résultats traduisent, outre le potentiel génétique relatif à la cinétique de la croissance, l'effet favorable de l'environnent que procure la mère à son produit pendant le premier mois d'allaitement et qui lui permet une croissance correcte durant son premier mois d'âge (GMQ (1-30) = 84,61 g/j). Une fois le chevreau est confronté aux conditions alimentaires des parcours, sa croissance diminue même en année favorable (GMQ (90-120) = 50,11 g/j).

3.2 Sources de variation des performances de la croissance des chevreaux locaux

L'analyse de la variance a permis d'identifier, statistiquement, les principales sources de variation de ces performances durant certains âges prédéfinis. Les résultats des procédures GLM figurent sur le Tableau (3).

Tableau 3. Analyse de la variance des poids aux âges types et de la croissance journalière des chevreaux locaux.

Facteurs de variation	**Ddl**	**Poids aux âges types (kg)**						
		1j	**10 j**	**30 j**	**60 j**	**90 j**	**120 j**	**150 j**
Mois de naissance	5	HS	S	S	HS	HS	HS	S
Age de la mère	8	NS	NS	HS	S	S	S	NS
Sexe	1	HS	HS	HS	HS	NS	HS	HS
Mode de naissance	1	HS	HS	HS	HS	HS	HS	HS
Type pigmentaire		HS	NS	S	HS	HS	HS	S
Sexe×mode de naissance		HS	HS	HS	HS	HS	HS	HS
Age× mois de naissance		S	S	S	NS	S	NS	NS
R^2		0,71	0,57	0,63	0,68	0,73	0,78	0,80

HS: Hautement Significatif (p<0,01) ; S : Significatif (p<0,05) ; NS : Non Significatif (p>0,05);

R^2:Coefficient de détermination

Le coefficient de détermination (R^2) varie de 0,57 à 0,80 pour les poids aux âges types; et ce coefficient évolue sensiblement avec l'âge de chevreau. Un tel coefficient de détermination atteste l'importance des effets fixes inclus dans le modèle de décomposition de la variance adoptée.

La décomposition de variance a montré que, malgré que les performances sont enregistrées durant une seule campagne et au niveau d'un seul troupeau, ces phénotypes estimés chez les chevreaux locaux sont hautement tributaires des conditions de milieu (surtout le facteur mois de mise bas).

Ces résultats reflètent bien l'importance des changements climatiques surtout à un âge avancé de chevreau (entre 60 et 90 jours) quand l'alimentation est prélevée sur le parcours.

Le sexe et le mode de naissance affectent significativement la plupart des poids aux âges types alors que l'âge de la mère a un effet non significatif pour le poids à la naissance et les poids estimés aux âges 10 et 150 jours.

Le mois de naissance a montré un effet hautement significatif (p<0,01) sur les poids pour tous les âges-types, sauf à l'âge de 10 jours.

Les intéractions entre les facteurs non génétiques : sexe×mode de naissance et âge de la mère×mois de naissance, sont relevées comme les principaux sources de variation qui affectent la croissance des chevreaux de la naissance jusqu'au sevrage. Ces résultats sont en accord avec les travaux de (Gebrelul et al.,1994 ;Gbangboche et al., 2006) qui soulignent l'importance de l'action de l'environnement de production sur les performances de la croissance des caprins à jeune age. Djemali et al., (1994) ont mentionné que les effets du sexe, mode de naissance et l'âge de la mère sont des sources importantes de variation des caractères de croissance des petits ruminants et ce dès la naissance et jusqu'à 3 mois d'âge.

3.3 Corrélations entre les performances de croissance chez les chevreaux locaux

Le tableau 4 illustre les corrélations calculées entre les performances de croissance des chevreaux de la population caprine locale.

Tableau 4. Matrice de corrélation de Pearson entre les poids des chevreaux de la population caprine locale

	PN	**P10**	**P30**	**P60**	**P90**	**P120**	**P150**	**GMQ (0-30)**	**GMQ (60-90)**	**GMQ (90-120)**
PN	1	0,764	0,647	0,557	0,619	0,611	0,570	0,501	0,424	0,324
P10		1	0,74	0,58	0,54	0,48	0,44	0,22	0,24	0,32
P30			1	0,91	0,82	0,75	0,66	0,80	0,30	0,25
P60				1	0,93	0,86	0,65	0,77	0,67	0,12
P90					1	0,94	0,72	0,70	0,75	0,70
P120						1	0,94	0,61	0,80	0,42
P150							1	0,75	0,44	0,16
GMQ(0-30)								1	0,24	-0,40
GMQ(60-90)									1	0,15
GMQ(90-120)										1

Les corrélations entre les différents caractères de croissance sont comprises entre 0,15 et 0,94. Elles sont plus élevées entre les poids adjacents et entre les poids et les gains correspondants. Ces résultats sont similaires à ceux de Portoland et al., (2002) et Al-Shorepy et al., (2002).

Les valeurs de corrélation sont toutes positives et moyennes à élevées entre les différents poids aux âges types. La corrélation entre P30 et GMQ (0-30) est la plus élevée (0,80) et celle entre le P150 et GMQ (90-120) est la plus faible (0,15).Par ailleurs, la corrélation négative entre GMQ (90-120), qui donne une idée sur la précocité du chevreau, et GMQ (0-30), utilisé comme critère d'appréciation de la valeur laitière de la chèvre, montre que l'amélioration de l'un des deux caractères sans détériorer l'autre nécessite la sélection des chevreaux sur la base d'un index de sélection combinant les deux caractères à la fois.

IV - Conclusion

Le chevreau local est de petite taille et d'un poids léger qui varie sous les effets de certains facteurs comme le sexe, le mode de naissance, l'âge de la mère et surtout le mois de naissance. Ces performances pondérales sont similaires à celles connues des races locales caprines élevées dans les régions chaudes à ressources restreintes et irrégulières. Le poids léger et le petit format confèrent des besoins alimentaires réduits ce qui favorise l'achèvement de la maturité et l'entrée en reproduction dés jeune âge en dépit des conditions difficiles. Il s'agit donc d'une stratégie d'adaptation de la population caprine locale vis-à-vis des conditions

de l'environnement. La rusticité s'exprime par la capacité de survie et la possibilité de renouvellement du groupe animal pour garantir sa continuité génétique, ce qui ne peut être favorisé que par des animaux de petite taille et des besoins réduits. Certes, un léger effort d'amélioration des conditions d'élevage, associé à un programme de sélection approprié à cette ressource génétique adaptée et à son -milieu aride, permettront d'extérioriser des niveaux de productions et de reproductions sensiblement plus élevés.

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Impact of Long-term fencing on vegetation structure and carbon sequestration in arid areas: case study of Sidi Toui National Park, southern Tunisia

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Abstract The degradation of arid rangelands is mainly caused by overgrazing. Fencing is considered as a key management aspect to restore these ecosystems leading to changes in vegetation and soil structure. However, it depends on intensity and duration of protection. The aim of this study was to evaluate the impact of long-term fencing (more than 25 years) on the soil surface state and vegetation structure. Aboveground biomass and carbon contents were also assessed. Measurements were made using the quadrat point method and phytomass sampling in two defined plant communities: (i) G1 dominated by *Anthyllis henoniana* (Coss.) Maire and *Gymnocarpos decander* Forssk. and (ii) G2 dominated by *Rhanterium suaveolens Desf.* and *Stipa lagascae R. et Sch*, inside and outside Sidi Toui National park, during spring 2019. One-way analysis of variance (ANOVA) was performed using SPSS software. The main results indicated that under long-term grazing exclosure the perennials density, total vegetation cover and litter increased significantly in G1 and G2. Likewise, a significant increase in total aerial phytomass and aerial carbon content was observed inside the fenced area for both studied communities. However, a negative effect was stated on the annuals density. These results suggest that long-term grazing exclosure appears to be beneficial in aboveground phytomass expansion of arid rangelands and enhancing their contribution to carbon sequestration.

Keywords: arid rangelands, grazing exclosure, protected areas, phytomass, carbon content.

Résumé La dégradation des parcours arides est principalement causée par le surpâturage et se manifestent sous forme des changements dans la structure de la végétation et le sol. La mise en défens est considérée comme un aspect clé de la gestion pour restaurer ces écosystèmes. Néanmoins, cela dépend de l'intensité et de la durée de la clôture. Par cette étude on a visé à évaluer l'impact d'une mise en défens à long terme (plus de 25 ans) sur l'état de surface du sol et la structure de la végétation. La biomasse aérienne et les teneurs en carbone ont également été évalués. Les mesures ont été effectuées au printemps 2019, en utilisant la méthode du point quadrat et l'échantillonnage de la phytomasse dans deux groupements végétaux définis : (i) G1 dominé par *Anthyllis henoniana* (Coss.) Maire et *Gymnocarpos decander* Forssk. et (ii) G2 dominé par *Rhanterium suaveolens* Desf. et *Stipa lagascae* R. et Sch, à l'intérieur et à l'extérieur du parc national de Sidi Toui. Une analyse de la variance à un facteur (ANOVA) a été réalisée à l'aide du logiciel SPSS. Les principaux résultats obtenus ont indiqué que sous l'exclusion du pâturage à long terme, la densité des espèces pérennes, la couverture végétale totale et la litière ont augmenté de manière significative au niveau des groupements étudiés, G1 et G2. De même, une augmentation significative de la phytomasse aérienne totale et de la teneur en carbone aérien ont été observées à l'intérieur de la zone protégée pour les deux groupements. Cependant, un effet négatif a été constaté pour la densité des annuelles. Ces résultats suggèrent que l'exclusion du pâturage à long terme semble être bénéfique dans l'expansion de la phytomasse aérienne des parcours arides et l'amélioration de leur contribution à la séquestration du carbone.

Mots-clés : parcours arides, clôture, parc national, phytomasse, teneur en carbone.

I- Introduction

Rangeland ecosystems are not only a valuable base for livestock production but also perform significant ecological service to tens of millions of people in large urban areas located within or among rangelands (Havstad et al., 2007). These ecosystem services are involved in different environmental sectors, livestock production, water quality and quantity, biodiversity conservation and carbon sequestration (Briske, 2017). Globally, rangelands (including grasslands, savannas, shrub lands, deserts, tundra's, marshes, and meadows) comprise the largest land use, are estimated to cover about 25% of earth's land surface (Liebig et al., 2006). Land degradation, in the form of desertification, woody species encroachment, non-native species invasion and loss of range biodiversity, appears to be the major challenge in the rangelands worldwide (Palmer et al., 1997). Over the past years, excluding livestock in the rangelands by establishing fences has become a common management tool for conserving and restoring native vegetation (Spooner et al., 2002). Some researchers have proven that lightly and moderately degraded rangelands can be restored to their initial state within ten to twenty years by reducing the grazing intensity and establishing fencing. However, for heavily and extremely degraded rangeland, other measures are also necessary (Feng et al., 2010). Grazing exclusion by fencing is an effective ecological management measure that excludes grazing to reverse the negative effects of overgrazing and restore degraded rangeland (Wang et al., 2014) by improving ecosystem functions including vegetation production , species diversity, physical and chemical soil properties and soil fertility (Li et al., 2018). Overgrazing leads to excessive removal of the most palatable species, which are usually perennial grasses (Anderson and Hoffman, 2006). This opens the way for less palatable and faster establishing annual grasses and forbs to take hold. Constant decreasing of the highly palatable species leads to rangeland deterioration (Reda, 2020). However, many authors demonstrated that grazing exclusion have a positive effect on vegetation and soil by enhancing diversity and productivity (Jeddi and chaib, 2010; Moumni et al., 2020), reducing bare soil and increasing plant cover (Yeo, 2005; Mofidi et al., 2013), increasing litter accumulation (Jing et al., 2013) and rising above-ground biomass accumulation (Li et al., 2018; Al-Rowaily et al., 2015).

Rangelands represent a vast store of carbon (C), both in soils and vegetation. Scientists estimated that rangeland and grassland globally contain 306–330 Pg of organic carbon and 470– 550 Pg of inorganic carbon representing 20 to 25 % of the global terrestrial carbon (Havstad et al., 2007), with the potential to store almost 0.3 Gt C/year (Lal, 2004). In Africa, 59% of total carbon storage was estimated in arid areas (Campbell et al. 2008; UNEP 2008). In these regions, where pastoral activities are dominant, most of the sequestered carbon is stored underground, and is therefore relatively stable (FAO 2002). A significant amount of aboveground carbon is stored in trees, bushes, shrubs and grasses, which are not or lightly grazed (IPCC 2007; Vashum and Jayakumar 2012). Indeed, the reduction of livestock in overgrazed areas significantly increases carbon storage in aboveground biomass, litter mass (Xiong et al., 2016) and even in soil (Su et al., 2005). However, some studies revealed that carbon sequestration rates decreased with vegetation restoration (Speed et al., 2014; Deng et al., (2014).

In Tunisia, rangelands constitute the largest land use by 4.5 million hectares (DGF, 2010). However, the estimation of carbon sequestration in vegetation has been concentrated on forest areas located in the north of the country (Zribi et al., 2016) and until now, the dry lands contribution in carbon sequestration through vegetation and soil is not or partially studied.

The restoration of degraded rangelands is currently one of the major focuses of ecologists and land managers. Thereby, national parks and other protected areas have been established to protect biodiversity and maintain ecological stability through long-term restriction of livestock grazing and other human interventions. These techniques revealed restoration of these rangeland ecosystems in terms of aboveground vegetation, biomass production, species composition and soil quality (Wu et al. 2009).

The investigation of the environmental impacts of long-term grazing exclosure on vegetation and soil can be considered as an important tool for policy-makers to better formulate policies to manage natural rangelands.

In the present study, we investigated the effects of long term grazing exclosure (more than 25 years) on the soil surface state, vegetation structure, aboveground biomass and carbon sequestration in Sidi Toui region, southern Tunisia. Also, we would like to test the hypothesis who says that long-term grazing exclusion enhance biomass and carbon sequestration and make changes in the structure of vegetation communities. For that, we have done a comparison of soil surface state, vegetation structure, phytomass accumulation and aboveground carbon contents, in two defined plant communities; (i) G1 dominated by *Anthyllis henoniana* and *Gymnocarpos decander* and (ii) G2 known by *Rhanterium suaveolens* and *Stipa lagascae,* inside (long term protection) and outside (open grazing) the national park of Sidi Toui.

II- Material and methods

2.1 Study site

The present study was carried out inside (long-term protection) and outside (open grazing) the Sidi Toui National Park. This park, is located in El Ouara natural rangeland at 70 km from the Ben Guardene town in south east of Tunisia, having a surface of 6315 ha and created in 1991 (Figure 1). This protected area includes a low hill, Djebel Sidi Toui (172 m), surrounded by an extensive plain composed of small dunes, sebkhas and dry sandy wadis. The vegetation cover is mainly dominated by shrubby chamaephytes. Principal shrubby species include *Anthyllis henoniana* Coss. Ex Batt.*, Gymnocarpos decander* Forssk.*, Rhanterium suaveolens* Desf.*, Haloxylon schimittianum* Pomel. and *Haloxylon scoparium* Pomel. This area is mainly grazed by small ruminants and camels.

Ben Guardene climate is classified as type BWh, according to Köppen-Geiger classification (data for the period 199-2019, available at https:/fr.climate-data.org, accessed on 11 September 2021). The mean annual precipitation is around 195 mm and characterized by low quantity and rainstorm. The average temperature is 20.6 °C. The mean precipitation recorded in the meteorological station of the Sidi Toui National Park during the three last year's previous experimentation (2017-2019) was relatively low (121mm) compared to the mean annual rainfall of the region (Fig 1).

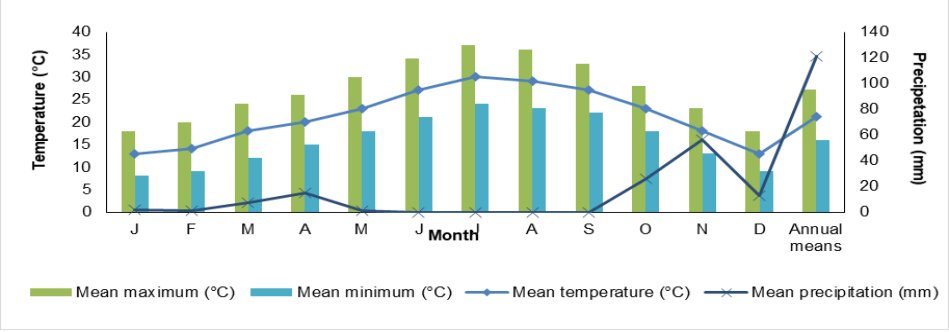

Figure 1. Climate data for the Sidi Toui National Park 2017–2019 (local meteorological station).

2.2 Vegetation sampling and data collection

Vegetation was monitored during spring 2019. Within each experimental plot, five random transects of 50 m long each were established in two plant communities (i) G1: dominated by *Anthyllis henoniana* and *Gymnocarpos decander* and (ii) G2: dominated by *Rhanterium*

suaveolens and *Stipa lagascae* of the studied rangeland site and used to determine vegetation structure, according to the quadrat-points method described by Daget and Poissonet (1971). This design permitted the assessment of the regeneration capacity and the persistence of plant species by monitoring the evolution of several descriptors (global plant cover, specific frequencies, flora richness and plant density). The state of the soil surface (wind veil, crust, stones and litter) was also studied to monitor and assess changes of soil surface structure. In each sampling plot, annual plants densities were measured by counting species individuals inside five randomly established quadrats of 1 m² each. However, the perennial density was measured by counting the tufts of each species within five quadrats of 20 m², each. Species richness was determined by counting all perennial and annual species within the experimental plots. In both, the protected and open grazing (control) areas, biomass production was determined. The aerial phytomass was obtained by clipping all the aerial parts of five measured plots (8 m^2) of both studied vegetation communities (G1 and G2).

2.3 Vegetation biomass and organic carbon content measurement

In each measured plot, the fresh material was weighed and dried at 105 °C for 24h, to obtain the aerial dry biomass (DM). The carbon content was measured by the loss on ignition method (ash method) (Chavan and Rasal, 2011). Samples from each clipped plot were weighed (fresh matter: M1) then burned in an oven for about 4 hours at 550°C. The obtained ash was weighed (dry matter: M2) after cooling in a desiccator.
The proportion of organic carbon (OC) content for each biomass was calculated using ash weight (M2), primary weight (M1), and the proportion of organic matter (OM), by the following formulas (Allen et al., 1986):

$$OM\ (\%) = (M1 - M2) / M1 * 100 \qquad [1]$$

$$OC\ (\%) = OM\ (\%) * 0.58 \qquad [2]$$

2.4. Statistical analysis

One-way analysis of variance (ANOVA) was performed using SPSS software 20.0 to test the effect of long term grazing enclosure on (1) the soil surface state, (2) vegetation structure and (3) aboveground biomass and carbon content.

III - Results and discussion

3.1 Soil surface state

The results of soil surface conditions in the studied rangeland sites subjected to two different management regimes (fenced versus open-grazed) for two plant communities ((i) G1 dominated by Anthyllis henoniana and Gymnocarpos decander and (ii) G2 dominated by Rhanterium suaveolens and Stipa lagascae) are presented in Figure 1.

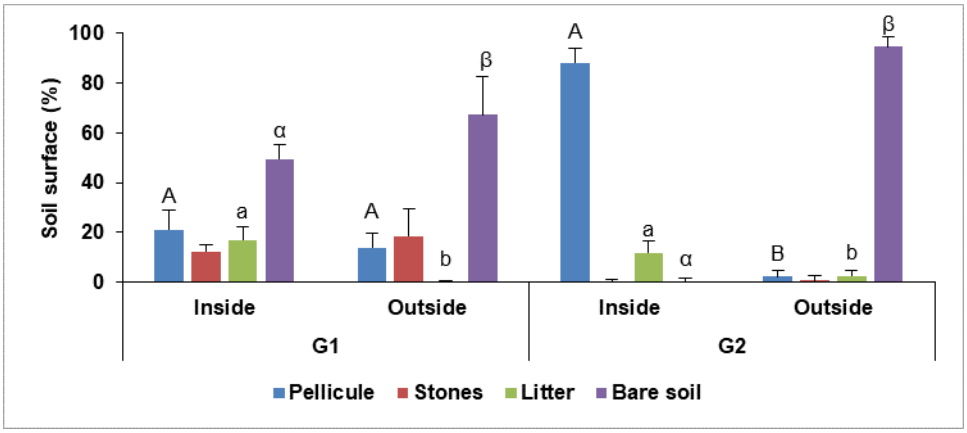

Figure 2. Variation of soil surface states for two plant communities (G1 and G2) inside and outside the Sidi Toui National Park. A/B, a/b and α/β indicated the differences between sites inside and outside park for Pellicule, litter and bare soil, respectively. No difference observed for stones for the two communities. Values are means ± SD (n = 5)

For the G1, the effect of protection was significant on the bare soil percentage ($p=0.039$), highly significant ($p<0.001$) on the litter percentage and non-significant on the pellicle and stones. The bare soil was higher in the open-grazed site with 67.4% then the protected site with 49.6%. The site inside the park had the highest litter value (17%) while it was very low outside, in order of 0.2%.

In G2, the highest percentage of bare soil was showed in the open-grazing site (94.6%) and lowest was in the protected site (0%). In contrast, the pellicle percentage was very higher inside the park (88.2%) than outside (2.2%). The litter percent too was significantly lower in the grazed area (11.8%) than the fenced area (2.4%).

The long term grazing exclusion reduces significantly the bare ground cover and by evidence the reduction of soil erosion and the sensitivity of the site to desertification (Ouled Belgacem et al., 2019). These results corroborate with those found by Yeo (2005) in east central Idaho in America and by Mofidi et al. (2013) in an Iranian rangelands.

Heavy grazing results in a reduction of plant residues in soil (Litter). Qiu et al. (2013) reported that the accumulation of litter materials on the ground could contribute to the increase of carbon and nitrogen input into soil.

Jing et al. (2013) concluded that excess litter accumulation in long-term fenced sites can inhibit species renewal. This build-up of fresh litter and organic material may also prevent the infiltration of rainfall into the soil. Which accelerates the decomposition of organic matter and renders the rainfall unavailable for infiltration, plant growth and cycling of C and N in semiarid and arid regions (Qiu et al., 2013).

3.2 Vegetation Cover

Plant cover percentages in the studied plant communities subjected to two different management regimes (open grazed and protected) are presented in figure 3.

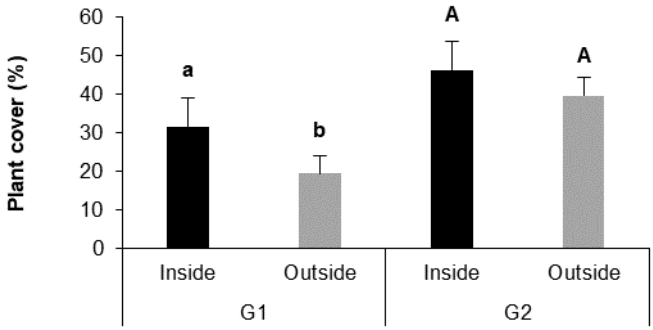

Figure 3. Plant cover variation on two plant communities (G1 and G2) inside and outside Sidi Toui National Park. Letters above (a,b and A) indicated the differences between sites inside and outside park for G1 and G2, respectively. Values are means ± SD (n = 5).

The mean values were 31.6% and 46.4% inside and 19.4% and 36.9% outside for G1 and G2, respectively. For the G1 community, plant cover percentage increased significantly inside the protected area. Whereas, no difference was detected between the protected and grazed rangelands for the G2 community.

The increase of the total plant cover inside the protected areas can be explained by the improvement of soil conditions (temperature, moisture, nutrient cycling) inside the protected sites promoting the regeneration and the development of plants. Our statements are in accordance with those reported by (Jeddi and Chaib, 2010) and (Ludwig and Tongway, 1997), which they reported that bigger patch size with more litter content provided specific microclimate, prevented resource loss, and improved structural and functional characteristics of the protected sites.

These results confirm those found by many authors (Yeo (2005); Mofidi et al. (2013); Zhang et al., 2017). However, the findings stated by Song et al. (2020) on the effect of long term grazing exclusion on plant traits in China, oppose our results and conclude that long-term grazing exclusion significantly reduce the total plant coverage.

3.3 Plant density

The annuals and perennials densities for the two vegetation groups were presented in table1. As shown in this table, the perennials density was higher in the protected area for the two studied plant communities. These increases were significate and in order to 22% for G1 but non-significate for G2. The highest perennials density was measured inside the park for the G2. Our results corroborate the results stated by Tang et al. (2016), Li et al. (2018), China and Jeddi et al. (2010) and Moumni et al. (2020), in Southern Tunisia. These authors reported that grazing exclusion increases the number of species in sandy lands. In addition, Ouled Belgacem et al. (2019) concluded that some perennial dynamics are supported by protection.

Table 1. Annuals and perennials densities for the two vegetation communities (G1 and G2) inside and outside Sidi Toui National Park. Values are means ± SD (A/B and a/b indicated the differences between sites inside and outside park for annuals and perennials, respectively).

Individuals plants m^{-2}	***Group 1 (G1)***		***Group 2 (G2)***	
	Inside	**Outside**	**Inside**	**Outside**
Annuals (n=10)	4.5 ± 3.6 (A)	16.5 ± 9.7 (B)	9 ± 2.5 (A)	25.2 ± 7.8 (B)
Perennials (n=5)	2.24 ± 0.1 (a)	1.75 ± 0.1(b)	3.16 ± 0.7 (a)	2.58 ± 0.6 (a)

The highest value of annuals densities (25.2 plts m^{-2}) was recorded in G2, in the open grazing site. However, this density was 9 plants m^{-2} for the same community subjected to the protection regime. Similar results were observed for the G1, where the annuals density was significantly higher in the grazed site (16.5 plants m^{-2}).

The annuals densities are generally depending on soil conditions, disturbance stage and rainfall consistency (Ouled Belgacem et al., 2019). Our results showed that annuals were increased by grazing pressure. These results corroborate the findings of Tai et al. (2021) and Diaz et al. (2007) considering that grazing exclusion decreased annuals density and species diversity. Su et al. (2005) found that in grazed communities, the proportion of annuals density reached 70%, which was coupled with lower productivity. The abundance of these species in the grazed area is probably explained by germination capacity that stimulated by grazing and rainfall. In the fenced area, the large coverage of the studied communities and the accumulation of litter can reduce the access to light for seedlings of other species (Ungar, 1998).

3.4 Species richness

Species richness variations across rangeland management of sampled sites are illustrated in table 2. For the two plant communities, there are more perennials species (three additional species) in the protected area than the open grazing zone. However, no effect of the protection was observed on the annual richness. These results demonstrated that no significant effect of long term grazing exclusion on the species richness.

Table 2. Perennials and annuals species richness for the two vegetation communities (G1 and G2) inside and outside Sidi Toui National Park.

	G1		G2	
	Inside	**Outside**	**Inside**	**Outside**
Annuals	9	9	9	8
Perennials	8	5	10	7

Wu et al. (2009) reported that long-term fencing decreased species diversity. Jing et al. (2013) suggested that species diversity and biomass reached a peak values in the 20th year then decreased with time of restoration due to the litter accumulation. The same for Deng et al. (2014) who reported that peak species richness appeared under moderate and light grazing but not long-term fenced. This occurrence can be explained by plant competition and reproduction, the large coverage and the accumulation of litter caused by long term grazing exclusion (Schultz et al., 2011).

Tang et al. (2016) and Moumni et al. (2020) reported that grazing exclusion increased the number of species, as well as Li et al. (2018) who mentioned that the total number of species exhibited a hump-shaped pattern in response to the length of the grazing exclusion, with a threshold of 6 years. Yet, Schultz et al. (2011) reported that the species richness decline in fenced area by phytomass accumulation. These authors mentioned that Species richness decreased in the absence of grazing only at the high productivity sites (i.e. when phytomass accumulation was > 500 g m^{-2}).

3.5 Aerial Biomass

The aerial dry biomass (kg ha^{-1}), for G1 and G2 both in the grazed rangeland and inside the park, was presented in figure 4. The analysis of this figure show that the aerial biomass value varies from 1855 kg ha^{-1} to 3537.5 kg ha^{-1} for all plant communities. This biomass was

significantly higher in the protected area for the two studied plant communities. An increase of 44% and 42% were observed in the protected area of G1 and G2, respectively.
Continuous grazing accelerated aboveground biomass loss by herbivore and leads to less phytomass accumulation. This is in agreement with results obtained by Yong-Zhong et al. (2005) in Inner Mongolia (China), Jeddi and Chaib (2010) and Moumni et al. (2020) in southern Tunisia and Mofidi et al. (2013) in Iran. These authors stated that increased vegetation production in the exclusion could be due to soil conditions improvement (temperature, moisture, and nutrient cycling). However, Yet et al. (2018) reported that the remarkable improvement in pasture yield in the fenced plots was mainly related to decrease of herbivore consumption, whereas the improvement in soil properties was beneficial to the restoration of the vegetation.

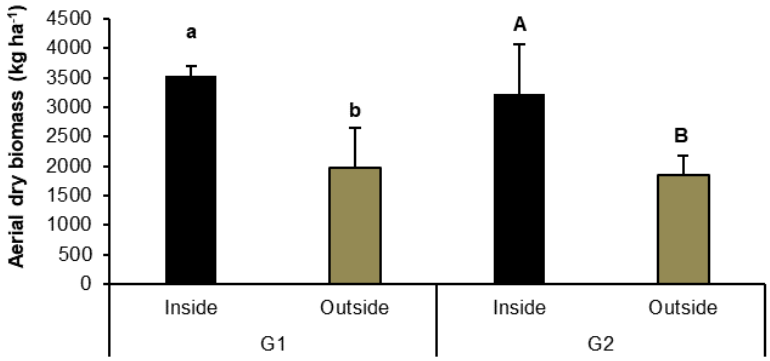

Figure 4. Variation of aerial biomass for the two vegetation communities (G1 and G2) inside and outside Sidi Toui National Park. a/b and A/B indicated the differences between sites inside and outside park for G1 and G2, respectively. Values are means ± SD (n = 5)

3.6 Aerial carbon content

The carbon content in aerial biomass for the two studied communities inside and outside the park was presented in figure 5. The amount of carbon was significantly higher in protected area for the two studied communities. There were 1918 kg ha^{-1} and 1355 kg ha^{-1} in protected and grazed area, respectively, for the G1 community. In the second studied community (G2), there were 1727 kg ha^{-1} in protected area and 846 kg ha^{-1} in open grazing area.

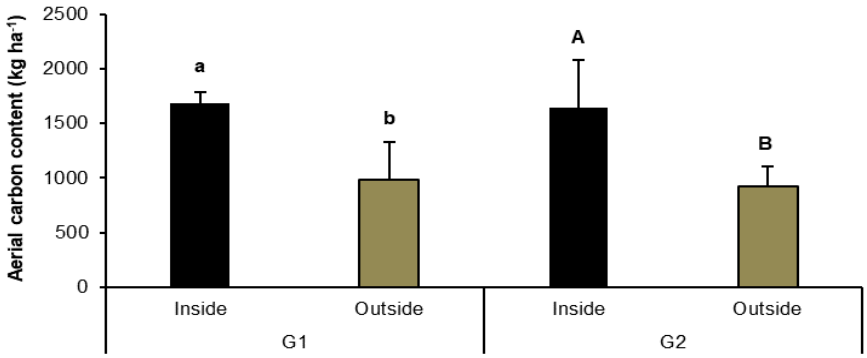

Figure 5. Variation of areal carbon content for the two plant communities (G1 and G2) inside and outside Sidi Toui National Park. a/b and A/B indicated the differences between sites inside and outside park for G1 and G2, respectively. Values are means ± SD (n = 5)

Our results showed that grazing exclosure had a significant effect in the phytomass carbon content. Continuous grazing can decrease the level of vegetation cover, resulting in the loss of aboveground biomass and carbon content and even the loss of SOC (Su et al., 2005). Reda (2020) suggest that grazing exclusion has the potential to enhance carbon store (on average 192.70%) in aboveground biomass in different grazing ecosystems. Deng et al., (2014) explain the increase of carbon stock in grazing exclusion by the fact that it reduces output of carbon from the ecosystem to livestock and increase productivity. In addition, Xiong et al. (2016) stated that grazing exclusion significantly increased carbon storage in aboveground biomass (84.7%) and litter mass (111.6%). A study in the alpine ecosystem in China revealed that aboveground carbon stocks are higher in long-term absence of grazers than in continual grazing due to the reduction of herbivores populations. Deng et al. (2014) confirmed that aboveground carbon stock of the grazed grassland was lower than that of the restored grassland, while carbon sequestration rates decreased with vegetation restoration.

However, Nosetto et al. (2006) disagree with the above conclusions and checked that there was no significant difference in carbon store between exclosure and adjacent free grazing areas in a study in north western Patagonia. Likewise, Chibani et al. (2021) reported that the Comparison of the aerial biomass and carbon content of some key woody species inside and outside the Sidi Toui National Park indicated a non-significant effect of long-term protection on shrub biomass production and carbon content, except for the big canopies of the low range value chenopods (i.e. *Haloxylon schmittianum* and *Haloxylon scoparium*).

Tanentzap and Coomes (2012) considered that Plants which are adapted to high-intensity grazing regimes may be more capable to recover rapidly from herbivory (can re-grow to an equal or greater biomass (overcompensation) than their pre-defoliation levels). They explained this by the fact that grazing can be associated by increases in soil nitrogen availability, which promote growth, herbivore consumption of litter fall that shades young plants and/or reductions in the competitive ability of neighbors. They concluded that carbon stocks increased in many circumstances because of the influence of herbivores on litter decomposition and nitrogen mineralization.

Generally, continuous grazing is very disastrous to carbon sequestration in vegetation and soil. Then, appropriate grazing intensity will stimulate vegetation and soil carbon sequestration and subsequent carbon storage considering precipitation gradient and vegetation type.

IV - Conclusion

Grazing exclusion has been reported as one of the effective methods to restore the degraded rangelands. The study of the impact of long-term fencing on vegetation and aboveground carbon sequestration amount contribute to the assessment of this management technique. The results of this study showed that grazing exclusion is a beneficial ecosystem restoration approach to reduce significantly the bare ground cover and improve sensitivity of the site to desertification and soil erosion. Moreover, long-term protection contribute to restore overgrazed rangelands and to increase phytomass and carbon sequestration in El Ouara natural rangeland in Southern Tunisia. However, this study did not investigate the effect of fencing on rangeland production and soil nutriment improvement and soil carbon sequestration.

Acknowledgements

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Forage quality of dominant plant species of mountainous grasslands in northern Greece

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Abstract. The objective of this study was to detect differences in floristic composition and diversity indexes between four grasslands grazed by small ruminants in mountainous areas of Northern Greece. Moreover, the study was focused on the chemical composition of the dominant plant species. Vegetation cover was measured in each grassland, while floristic composition, and plant species diversity indexes were estimated. Moreover, plant material of dominant species was analyzed for crude protein (CP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and Acid Detergent Lignin (ADL). The results revealed no significant differences between the vegetation cover of the grasslands, which is relatively high (83% to 98%). According to the results, forbs were the dominant functional group in most grasslands, followed by legumes. There was a high differentiation among species richness, Shannon index, and Morisita similarity index among the studied grasslands. Concerning the chemical composition, the forb and legume species had significantly lower NDF and ADF compared to grasses, while there was no significant difference in CP content of the tested species, except *Anthoxantum odoratum* and *Thymus sibthorpii*. High species diversity and high forage quality were recorded in the studied grasslands.

Keywords. Floristic composition - nutritive value - diversity index – grazing - mountainous grasslands - northern Greece.

Qualité fourragère des espèces végétales dominantes des prairies montagneuses du nord de la Grèce Résumé. *L'objectif de cette étude était de détecter des différences dans la composition floristique et les indices de diversité entre quatre prairies pâturées par de petits ruminants dans les zones montagneuses du nord de la Grèce. De plus, l'étude s'est concentrée sur la composition chimique des espèces végétales dominantes. Le couvert végétal a été mesuré dans chaque prairie, tandis que la composition floristique et les indices de diversité des espèces végétales ont été estimés. En supplément, le matériel végétal des espèces dominantes a été analysé pour la protéine brute (CP), la fibre détergente neutre (NDF), la fibre détergente acide (ADF) et la lignine détergente acide (ADL). Les résultats n'ont révélé aucune différence significative entre le couvert végétal des prairies, qui est relativement élevé (83 % à 93 %). Selon les résultats, les plantes herbacées étaient le groupe fonctionnel dominant dans la plupart des prairies, suivi des légumineuses. Il y avait une forte différenciation entre la richesse en espèces, l'indice de Shannon et l'indice de similarité Morisita parmi les prairies étudiées. Concernant la composition chimique, les espèces forb et légumineuses avaient des NDF et ADF significativement plus faibles que les graminées, alors qu'il n'y avait pas de différence significative dans la teneur en CP des espèces testées, à l'exception d'Anthoxantum odoratum et Thymus sibthorpii. Une grande diversité d'espèces et une haute qualité de fourrage ont été enregistrées dans les prairies étudiées.*

Mots-clés. *Composition floristique- valeur nutritive- indice de diversité- pâturage- prairies montagneuses- nord de la Grèce.*

I – Introduction

The vegetation in Mediterranean grasslands ecosystems is characterized by a great species

diversity and richness, mainly due to seasonality and high climate variability (Blondel 2006). This high floristic composition in grasslands has been exploited by transhumance, as it is an ancient livelihood strategy of adaptation to spatial and temporal environmental variability (Oteros-Rozas *et al*., 2013; Perez Leon et al. 2020). Floristic composition of grasslands affected by the interaction of environmental factors (Holechek et al. 2010), with management practices (Cop et al. 2009), and grazing intensity (Sasaki et al. 2008; Hilker et al. 2014).

Usually, grazing reduces the abundance of palatable species, which are replaced by less palatable ones (Briske, 2017). The result is low vegetation cover and an increase in non-economically desirable species (Alishtayeh and Salahat 2010) due to the removal of vegetation and consequently soil degradation from animal trampling. Moreover, the dominance of unpalatable species decreases the grazing capacity and affects the quality of animal products as milk or cheese. The objective of this research was the comparable study of the floristic composition and nutritive value of dominant plant species in mountainous grasslands of Northern West Greece grazed by differend animal species. The grasslands in the area are mainly used by transhumance during the summer.

II - Materials and methods

In early July 2019, the study was conducted in three grasslands in Aetia (grassland 1,2,3) and one in Polyneri (grassland 4) villages located in the Regional Unit of Grevena. The elevation of the research areas is around 1100 m, and the climate is characterized as Dfb in the Köppen-Geiger system (www.en.climate-data.org). The mean air temperature was at 9.9°C, and the mean annual rainfall at 779 mm. Transhumant flocks of ruminants (small ruminants about 600 heads in Aetia; small ruminants about 900 head and 80 cattle in Polyneri) grazed in those grasslands from April to October in a continuous grazing system.

In each grassland, vegetation cover was measured with the line and point method (Cook and Stubbendieck, 1986), and floristic composition was calculated and classified into five functional plant groups: (1) grasses, (2) legumes, (3) forbs, (4) woody and (5) graminoids. Moreover, plant diversity indices Species Richness (N), Shannon-Wiener diversity index (H´), Evenness (J), Berger-Parker's index of Dominance (d) and Morisita's Index of Similarity (Cλ) were calculated with Past software (Paleontological Statistics Ver 2.17) (Hammer et al, 2001) for each grassland (Shannon and Weaver, 1949; Morisita, 1959; Pielou, 1966; Henderson, 2003):

At the same time, the above-ground biomass was harvested by three 0.5 m x 0.5 m quadrats, oven-dried at 60°C for 48 hours, ground through a 1 mm screen, and analysed for N using a Kjeldahl procedure (AOAC, 2002). Crude protein (CP) was then calculated by multiplying the N content by 6.25. Additionally, Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and Acid Detergent Lignin (ADL) were determined with the ANKOM fiber analyzer with the addition of sulphite, but not α- amylase to the solution for the NDF determination. All analyzes were carried out on duplicate samples, and results reported on a DM basis.

Statistical analysis of the data was performed using ANOVA with the use of the SPSS® statistical software v. 25.0 (SPSS Inc., Chicago, IL, USA). The Tukey criterion (Steel and Torrie, 1980) at the 0.05 probability level was used to detect the differences among means.

III – Results and discussion

Vegetation cover in the studied grasslands ranged between 83 -98%, and there were no significant differences among them. It seems that the vegetation cover is high, regardless of the continuous grazing in the area from May to October. Similar results have been found for another

mountainous area in Greece with similar edaphoclimatic conditions (Abraham et al., 2009). Forbs were the dominant functional group in the first three grasslands (Aetia village), and there was no significant difference among them (Figure 1). On the contrary, legumes were the dominant functional group in the grassland of Polyneri, and their percentage was significantly higher compared to the other tested grasslands. Regarding the grasses, their participation did not significantly differ among the studied grasslands. Additionally, woody species were recorded in Aetia (grassland 1&3). Species composition results from environmental factors, climate, and management (Cop et al. 2009; Holechek et al. 2010) and enhances the establishment of different species in different habitats (Jafari et al. 2004).

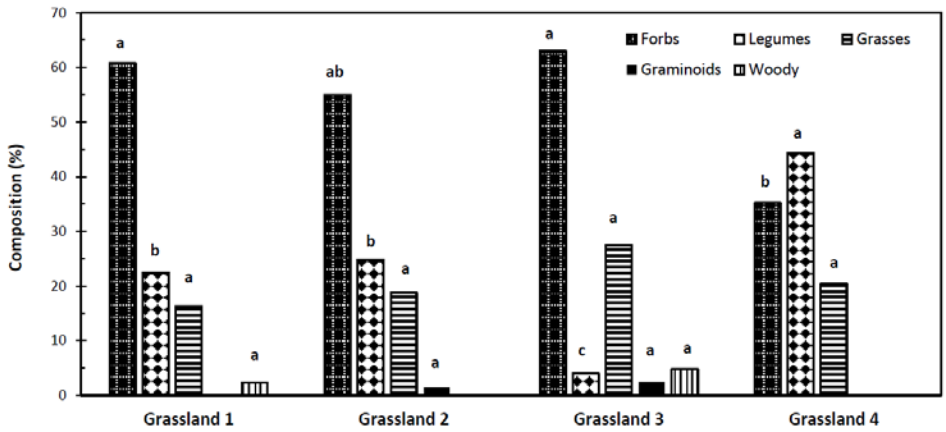

Figure 1. Vegetation composition at the study grasslands. Means for the same parameter followed by the same letter are not significantly different (P ≤ 0.05)

The highest number of species and Shannon's index were recorded at grasslands 2 and 4 (Table 1). These grasslands are characterized by higher elevation slopes compared to the others. This differentiation in slope inclination is likely to affect floristic diversity, as was also reported by Margioula et al. (2016). The opposite trend was noticed for the Berger Parker index of dominance which reached the higher value in grassland 1 and the lower one in grassland 4. According to the results, evenness was more or less the same between the study grasslands, and the differentiation among grasslands was confirmed with the Morisita index.

Table 1. Species diversity indices (N, H´, J, d) of the four grasslands (R1-R4)

	R1	R2	R3	R4
Species richness (N)	27	28	19	45
Shannon's index (H´)	2,802	3,079	2,586	3,439
Evenness (J)	0,6101	0,7759	0,6987	0,6923
Berger-Parker's index (d)	0,2674	0,1099	0,1647	0,09091

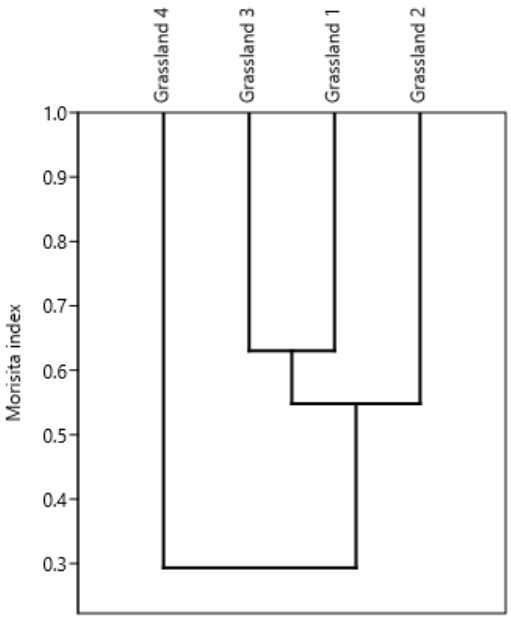

Figure 2. Morisita index for the four study grasslands

There was no significant difference in the CP content of the tested species, which was high, except *Thymus sibthorpii* Benth. and *Anthoxantum odoratum* (Table 2). Similar results have been found for *Hordeum bulbosum* L. f (Shadnoush 2013), *Poa bulbosa* L. (Shahri et al. 2019), for *A.millefolium* (Vondraskova *et al*. 2012). According to the results of CP, the tested species could exceed the demands of small ruminants for maintenance and lactation except for *A.odoratum* and *Th. sibthorpii* that cover only maintenance demands (NRC, 1981, 1985). Nevertheless, these species are less consumable from the animals.

Concerning the NDF content, *A. odoratum* had the significantly higher one, following from the other grass species (Table 2), while forbs and legumes had significantly lower content compared to the other functional groups. Similar results for CP and NDF content have been found for *H, bulbosum* from Shadnoush (2013), for *Poa bulbosa* (Shahri et al. 2019), for *A. millefolium* (Vondraskova et al. 2012). The same trend was recorded for ADF content, with grasses having the higher content followed by forbs and significantly lower legumes. On the contrary, forbs had significantly higher ADL followed by grasses and legumes. As there were structural differences between the tested plant species, the variation among the chemical composition was expected (Shadnoush 2013). Moreover, the establishment of relationships between floristic composition, the nutritive value of plant species, and the quality of animal products as dairy products and meat has an important economic prospect and ought to be investigated (Ioannidou et al. 2019). Additionally, integrated management plans for mountainous rangelands will help the equilibrium between floristic diversity, grazing, and animal products.

Table 2. Chemical composition of the dominant species of the study grasslands

Species	CP	NDF	ADF	ADL
Forbs				
Achillea millefolium	170ab	320e	248e	50b
Thymus sibthorpii	101b	355d	251e	78a
Grasses				
Anthoxanthum odoratum	103b	640a	285c	31d
Poa bulbosa	180a	600b	303b	22e
Poa pratensis	245a	540c	270d	43c
Hordeum bulbosum	168ab	600b	317a	37cd
Legumes				
Medicago sp.	235a	300f	225f	41c
Lotus corniculatus	210a	295g	200g	55b

Means in the same column and for the same parameter followed by the same letter are not significantly different (P ≤ 0.05)

IV - Conclusions

High differentiation in floristic diversity was detected among the studied grasslands grazed by different animal species. Grazing by cattle and sheep enhanced the floristic diversity. Nevertheless, the forage quality of mountainous plant species was high in all cases.

Acknowledgements

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Adequacy of stocking rates applied on protected pastures of Monti Sibillini (Central Apennines)

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Abstract. The management of permanent pastures aims at achieving a balance between stocking rate and their carrying capacity to prevent undesired vegetation dynamics and to maximize the provision of ecosystem services. Among all methods, pastoral value (PV) is considered a valuable option that provides preliminary evaluation of pastures productive potential exploiting data already available (i.e., phytosociological surveys and maps). The current paper aims to compare the actual stocking rate and the potential carrying capacity calculated by applying the PV method in several Natura 2000 sites (1000-2448 m a.s.l.) of Monti Sibillini (Marche region, Italy). Available vegetation data and maps were used to calculate PV of the pastures located in the grazing areas used by the monitored livestock farms. Geographic Information System (GIS) technologies were used to measure the grasslands surface and the site characteristics of the grazing areas to be used in the integrated measurements. PV of the grasslands varying between 1.7 and 28.2 was assessed and used to calculate carrying capacity ranging from 0.06 to 1.62 LU ha^{-1} per 120 grazing days. Actual Stocking Rate in the range of the study areas demonstrated to be in general adequate to the carrying capacity allowed by vegetation types and site characteristics of the grazing areas.

Keywords. Protected grasslands - Natura 2000 - Pastoral value - GIS - Carrying capacity.

Adéquation des charges pastorales appliqués sur les pâturages protégés des Monti Sibillini (Apennins centraux)

***Résumé**. La gestion des pâturages permanents vise à atteindre un équilibre entre la charge pastorale et leur capacité potentielle afin d'éviter des dynamiques de végétation indésirables et de maximiser la fourniture de services écosystémiques. De toutes les méthodes, la valeur pastorale (VP) est considérée comme une option valide qui permet l'évaluation préliminaire du potentiel productif des pâturages en utilisant les données déjà disponibles (c.-à-d. cartes et relevés phytosociologiques). Le présent document vise à comparer la charge pastorale réelle et la capacité de charge potentielle calculée selon la méthode de la VP dans plusieurs sites Natura 2000 (1000-2448 m d'altitude) des Monti Sibillini (région des Marche, Italie). Les relevés et les cartes de végétation disponibles ont été utilisés pour calculer la VP des prairies dans les zones de pâturage utilisées par les fermes étudiées. Les technologies du système d'information géographique (SIG) ont été utilisées pour mesurer la surface des prairies et les caractéristiques du site des zones de pâturage. La VP des prairies varie entre 1,7 et 28,2 a été évalué et utilisé pour calculer la capacité de charge allant de 0,06 à 1,62 UGB ha^{-1} pour 120 jours de pâturage. La charge réelle des zones d'étude s'est avérée en général adéquat à la capacité potentielle des types de végétation et des caractéristiques des zones de pâturage.*

***Mots-clés.** Prairies protégées - Natura 2000 - Valeur pastorale - SIG - Capacité de charge.*

I – Introduction

As in most of the Mediterranean European countries, since the 1950s grazing systems of the Apennines has undergone a collapse (Caballero et *al*., 2009; Lasanta et *al*., 2015), and just in the recent years they are slowly improving thanks to Common Agricultural Policy (Jouven et *al*., 2010). Under these conditions, understocking and land abandonment over time has caused

natural successional dynamics in grasslands to the benefit of forest and shrubland communities in many areas. While on the one hand, these dynamics have positive effects (e.g., increasing CO_2 sequestration, reducing soil erosion) (Lasanta et *al*., 2015), on the other hand, they entail several disadvantages. Among these, reduction of biodiversity, increasing risk of wildfire, loss of agricultural land, a more uniform and trivialized landscape (Caballero et al., 2009) could be mentioned. Moreover, the establishment of invasive plant species with null interest for livestock (e.g., *Brachypodium pinnatum* s.l. or *Juniperus communis*), would results in an impoverishment of the pasture (Jouven et *al*., 2010; Lasanta et *al*., 2015), as extensively reported for several areas in central Apennines (e.g., Allegrezza et *al*., 2014; Tesei et *al*., 2020).

Such dynamics, together with overstocking conditions still locally active in some farming units (Caballero et *al*., 2009), represent an even greater issue for protected pastures, such as those included in Natura 2000 areas. These, along the mountain range of Apennines are grasslands with high naturalistic value and mostly related to habitats: 6170 “Alpine and subalpine calcareous grasslands”; 6210* “Semi‐natural dry grasslands and scrubland *facies* on calcareous substrates (*Festuco‐Brometalia*) (*important orchid sites)”; and 6230* “Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe)”. Among these grasslands, those of secondary origin require the adoption of management practices to promote the conservation of biodiversity and the connected ecosystem services (ES). In the specific case of pasturelands, this implies maximising grassland carrying capacity, avoiding over- or under-stocking, and saving handwork and resources for farmers (Caballero et *al*., 2009; Jouven et *al*., 2010). Grazing systems can provide a very wide range of Ecosystem Services (D’Ottavio et *al*., 2018), defined as the benefits people obtain from ecosystems and classified according to four main categories by Millennium Ecosystem Assessment (Alcamo et *al*., 2003): (i) Supporting: services necessary for the production of all other ES (e.g., soil formation, nutrient cycling); (ii) Provisioning: products obtained from ecosystems, such as food and fresh water; (iii) Regulating: benefits obtained from the regulation of ecosystem processes, such as climate and disease control; and (iv) Cultural: non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences.

According to Millennium Ecosystem Assessment, biodiversity is the necessary condition for the delivery of all ES, in all its scale levels (from single species and communities to landscapes), between the different biospheres (belowground, aboveground, water, air) and among the various organisms (microorganisms, animals, plants). The management practices applied to pastures and able to regulate degradative and dynamic processes in extensive conditions are many and well documented in the literature. These include, among others, grazing management (e.g., grazing method, mixing different livestock species and ages, shepherding), provision of supplementary feeding, watering spots and shelters, control of shrubs and unwanted herbs. Many of these aspects, mainly together with topographical and climatic factors, can significantly affect the stocking rate, which in turn regulates the containment of some invasive species (e.g., Pittarello et *al*., 2020).

In recent decades, many indices have been proposed to classify rangelands based on their forage potential, for example considering the percentage of tree-shrub cover, or their seasonal forage potential (Jouven et *al*., 2010). Among all, pastoral value (PV) is considered a valuable method that provides preliminary evaluation of pastures productive potential exploiting data already available (i.e., phytosociological surveys and maps) (Roggero et *al*., 2002). Compared to other methods (i.e., energy yield- and forage dry matter yield-based) (Peratoner et *al*., 2011), the PV does not require forage sampling and laboratory analysis and takes into account the plant palatability, and is widely utilized in Mediterranean basin (Bagella et *al*., 2013; Fracchiolla et *al*., 2017; Seddaiu et *al*., 2018).

Under a general downward trend of grazing systems in central Apennines, it is conceivable that under-stocking conditions could be active leaving room for potential invasive species encroachment and loss of biodiversity. With the aim to assess the adequacy of management on protected pastures of Monti Sibillini, the paper compares the potential carrying capacity calculated by applying the PV method with the actual stocking rate applied in several Natura 2000 sites (1000-2448 m a.s.l.).

II - Materials and Methods

2.1 Study area

The study area is included in the Monti Sibillini National Park which covers approximately 70,000 ha between Marche and Umbria regions (Figure 1) with its main mountain system whose highest complex is Monte Vettore (2476 m a.s.l.). In the area, forests and permanent grasslands dominate (40 and 32% of the total park surface, respectively) followed by arable lands (10%), shrublands (7%) and other surfaces (i.e., urban areas, bare rocks, water bodies).

Sibillini Mountains are an anticlinal complex essentially consisting of a carbonate sedimentary succession of marine environment dating from the lower Lias (Ballelli et *al.*, 1981). On their top there are older lithotypes, pure and little stratified, mainly Jurassic limestones and sometimes dolomites in neritic and carbonate platform facies. Along the slopes we find an alternation of Jurassic limestone series, marly limestones and marls, marls (cherty) of pelagic facies. While in the valley bottoms accumulate Miocene deposits or more recent formations from turbidite sandstones, clays and evaporites (Ballelli et *al.*, 1981; Centamore and Deiana, 1986).

According to climate station of Montemonaco (Figure 2), the study area presents a temperate oceanic-semi-continental bioclimate, with mean annual precipitation of 1240 mm and highest values occurring from early autumn to late spring and mean annual temperature of 11.2 °C with maximum in July.

The sheep farming has been one of the main economic activities of the territory of Monti Sibillini. The influence of the pastoral activities on the environment results extremely meaningful. To create new pastures, the forests of the mountain plane (1000-1800 m a.s.l.) were eliminated. The grasslands of secondary origin, with those located above the potential timberline have been traditionally grazed by sheep (Caballero et *al.*, 2009).

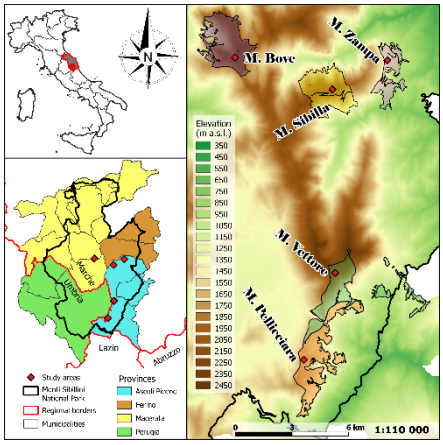

Figure 1. Location of the study area and the grazing areas (EPSG:3004).

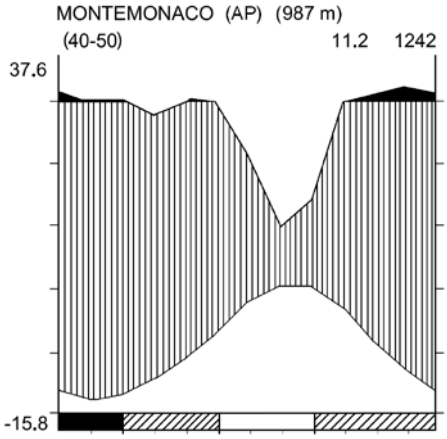

Figure 2. Walter-Lieth climate diagram of Montemonaco (Walter and Lieth, 1960) [1926-1972: data of temperature; 1921-1972 data of precipitation (Ballelli et *al.*, 1981 modif.)].

2.2 Grazing areas: site and management characteristics

In the territory of Monti Sibillini five different grazing areas (Table 1), namely Monte Bove, Monte Sibilla, Monte Zampa, Monte Vettore and Monte Pellicciara, by the name of the main mountains on which they are located, were identified and analysed (Figure 1). Each grazing area falls within Natura 2000 network, one or two Special Areas of Conservation (SAC) and all within the Special Protected Area (SPA) IT5330029 (Dalla Gola del Fiastrone al Monte Vettore).

The grazing areas and the farm characteristics (livestock, grazing period), as standard of the last five-year reference period, were collected by interviewing the farmers. The same information was used to assess the actual stocking rate (ASR), expressed in Standard Livestock Units (LU) ha^{-1}, adopting 0.15 as transformation coefficient for sheep.

Table 1. Site and management characteristics of the grazing areas.

	Altitude (m a.s.l.)	Surface (ha)	Natura 2000 site		Livestock		Grazing period (days)
			SAC	SPA	Number	Species, main breed	
Monte Bove	**(min-max)**	542.7	IT5330004	IT5330029	100	Cattle, Marchigiana	120
Monte Sibilla	1215-2172	504.9	IT5340020 IT5340013	IT5330029	2150	Sheep, Bergamasca	120
Monte Zampa	797-1454	247.0	IT5340020 IT5340013	IT5330029	1450	Sheep, Merinizzata	120
Monte Vettore	939-2471	515.6	IT5340014	IT5330029	2000	Sheep, Bergamasca	120
Monte Pellicciara	1174-1750	583.7	IT5340014	IT5330029	2600	Sheep, Merinizzata	120

2.3 Assessment of Pastoral Value, Potential Carrying Capacity and Actual Stocking Rate

Overlapping the studied grazing areas on available vegetation maps (Regione Marche, 2021), a total of 18 phytosociological associations were identified (Table 2). Reference phytosociological surveys of the 18 vegetation types were collected in the available literature and all taxonomic entities had been updated to the current nomenclature according to Bartolucci et *al.* (2018). The available phytosociological surveys were then elaborated to calculate Potential Pastoral Value (PPV: 0÷100) of the different vegetation types according to Daget and Poissonet (1971), using the specific indexes (SI: 0÷5) reported by Roggero et *al.* (2002), which indicate the forage value of each species contributing to CSP_i (i.e., the percentage contribution of each species to plant cover-abundance):

$$PV = 0.2 \sum_{i=1}^{i=n} CSPi * SIi$$

CSP_i was calculated as the percentage ratio between the species cover-abundance assigned to each species and the sum of the cover-abundance of all species.

A Fragility Coefficient (FC: 0.5-1.0) of the different vegetation types, as proposed by Cemagref (1983), was determined by considering the structural instability of the soil, evidence of erosion, and the gradient of the slope if greater than 26.6° (50%). With this regard, the slope information was extrapolated from the TINItaly 10 m-resolution Digital Elevation Model (Tarquini et *al.*, 2007). The FC was then utilised to obtain a Corrected PV (CPV) to assess the Potential Carrying Capacity (PCC, LU ha^{-1}) of the vegetation types and of the grazing areas weighted according to the grazing period (Roggero et *al.*, 2002) and the surface of vegetation types (D'Ottavio et *al.*, 2005). With this regard, Geographic Information System (QGIS Development Team, 2020) technologies were used to measure the planimetric surface of vegetation types

within each grazing area. The actual surface of the pastures was obtained by increasing the planimetric surface according to the gradient of the slope as electronically calculated.

III – Results and discussion

3.1 Vegetation types

The 18 sintaxa can be grouped in 4 main types (Table 2 and 3): *Sesleria apennina*-dominated grasslands (types 1-4), *Bromopsis erecta*-dominated grasslands (types 5-8), *Sesleria nitida*-dominated grasslands (types 9-10), other grassland types (types 11-13) and Shrublands (types 14-18).

Sesleria apennina-dominated grasslands (types 1-4) are primary, pioneer, xerophyte and basiphilous grasslands of the criotemperate, orotemperate bioclimate belts growing on rocky slopes with shallow soils exposed to winds and cryoturbation (Table 3). These harsh conditions prevent these types from developing in more evolved vegetations. Type 9 usually forms discontinuous strips with a step-shaped conformation due to the compensatory effect against the winds and mobile detritus. Due to the creeping chamaephyte *Dryas octopetala*, vegetation 10 can colonize mobile detritus and lithosoils, creating closed islands of vegetation which promote the settlement of other similar species. Vegetations 7-8 are vicariants of the previous one on the supratemperate bioclimate belt, with a greater xeric character. They are in the chain transition from the high-altitude perennial grasslands to the secondary grasslands dominated by *Bromopsis erecta*. PPV (on average >10) is mainly due to the low SI of the dominant species and to the vegetation cover (on average>85%).

Bromopsis erecta-dominated grasslands (types 5-8) are dense and continuous grasslands of low altitudes where range from xerophytic to mesophilic conditions (Table 3). They have highly specific composition, mainly perennial, hemicryptophytic and camaephytic species. They grow on calcareous and calcareous-marl substrates, stable or slightly mobile detritus, in meso-temperate areas. Vegetation types 5-6 are sub-mesophilic and settle on less acclivity slopes. Vegetation 7 stands out for its distinctly xerophilous character, it is an arid and discontinuous grassland that colonizes underdeveloped soils, on more acclivity and southern exposure. Vegetation 8 grows on warmer exposures and greater acclivity in the *Lathyro veneti-Fagetum* series. The decent SI of the dominant species, together with its high vegetation cover (on average >95%), justify the great PPV (on average >25) of this vegetation compared to the others (Table 1). As secondary grasslands, their maintenance is strictly linked to management practices able to prevent the natural dynamic processes towards more evolved communities and shrublands.

The grasslands dominated by *Sesleria nitida* (types 9-10) are xerophytic and discontinuous in transition towardstypes5-8 (Table 3). They are common on very steep slopes (on average >46%), on calcareous, shallow and rocky soils with accumulation of significant debris. PPV here is low (on average >8) due to low SI of the dominant species and to the low vegetation cover (on average, 76%).

Grasslands 11-13 are acidophile, mesophilic or mesohygrophilous vegetations of *Nardetea* class, and include some associations mainly dominated by *Nardus stricta, Ranunculus pollinensis* and *Plantago atrata* (Table 3). They occupy flat or weakly acclivity morphologies (on average >13°) such as the bottom of dolinas and small glacial valleys between mountain and alpine levels and from supra-temperate to cryo-orotemperate bioclimatic belts. They grow in sites where partial or complete decarbonation of soil occurs with compacted substrates rich in organic matter are well acidified. Here they tend to form closed swards and in particular cases, *Plantago atrata*-dominated (type 13) small-sized and dense carpets together with other slightly mesophilous and hemicryptophyte species. Hence, due to their very low slopes, high vegetation

coverage (on average >93%), they reach a higher PPV compared to *Sesleria* types (on average, 16).

Shrublands (types 14-18) are the pre-forest upper forest limit mantles (Table 3). Depending on the conditions they tend to form dense and closed communities or groups or strips. Generally, they are strongly pioneer formations which tend to occupy steep and rocky slopes or to recover abandoned areas. Vegetation 14 settles on very steep slopes; vegetation 15 instead prefers deeper and decarbonated soils. Shrublands types 16 and 17, are mantles communities with generally high coverage (on average >96%), but sometimes are small nucleuses or linear formations not directly connected to the forest. Type 16 spreads from the hilly to the high-hilly level on sandy-arenaceous substrates. Type 17 is linked to evolved, deep and fresh soils of the mesotemperate plane and tends to form dense and wide shrubberies. In contrast to *E. arborea*, *Spartium junceum* has greatest colonizing abilities on the neighbouring grasslands occupying large areas not being contrasted by grazing. Type 18 is a shrubland of the highest altitudes forming typical circular groups of very prostrate vegetation. Despite their importance to wildlife, their colonization of open grasslands leads to the entry of unwanted and fast encroaching species, responsible of very low PPV (on average >3).

3.2 Grazing areas

Monte Bove has a low Pastoral Value (on average >12.4) (Table 4). Slopes and shallow, unstable, and prone to erosion soils of some of the dominant vegetation types (*S. apennina*- and *S. nitida*-dominated grasslands, respectively), tend to keep their PCC low due to the application of 0.5-0.8 FC. On the other hand, Monte Sibilla on average shows the steepest slopes between the five areas (Table 4). So that, despite the PPV of its vegetations would be higher compared to other grazing areas (on average >15), it is halved when corrected by FC (0.5 for all of its vegetation types), with consequent effect on PCC of the grazing area. Monte Zampa reaches the highest PCC (Table 4). This is due to the large surface occupied by *B. erecta*-grasslands with good PV and moderate slopes (on average >22°). These values agree with Pittarello et *al*. (2020) concerning the direct relationship between PV and flattest and nutrient-rich sites. Monte Vettore and Monte Pellicciara have comparable PV (on average 10.8 and 12.2, respectively) (Table 4). Their low PV is due to a prevalent presence of shrublands and grasslands with very low PV. Nevertheless, the remaining grassland types (types 10-12) have enough large areas, and good PV as well, to rise PCC. In general, the results are consistent with the PCC reported by Ziliotto et *al*. (2004) regarding to *Sesleria* sp.- and *Bromopsis erecta*-dominated grasslands, and higher compared to the values reported for *Nardus stricta*-grasslands probably due to steeper slopes.

3.3 Potential Carrying Capacity and Actual Stocking Rate

Actual Stocking Rate in the range of the study areas seem to be in general adequate to the PCC allowed by vegetation types and site characteristics of the grazing areas (Figure 3). Regarding Monte Bove, ASR and PCC can be considered equivalent given the negligible difference. On Mounts Vettore and Pellicciara, ASR remains slightly below the PCC. Among all of the above-mentioned grazing areas, only in Monte Bove is highlighted consistent encroachment of shrub communities (around 27% of the total grazing area surface), much less in Monte Vettore and in Monte Pellicciara and, due to the higher altitude and the higher stocking rate applied, is absent in Monte Sibilla. This dynamic is also present, but not very consistent (around 1% of the total grazing area) in Monte Zampa where the great difference between PCC and ASR would have suggested more evident and active vegetation dynamics.

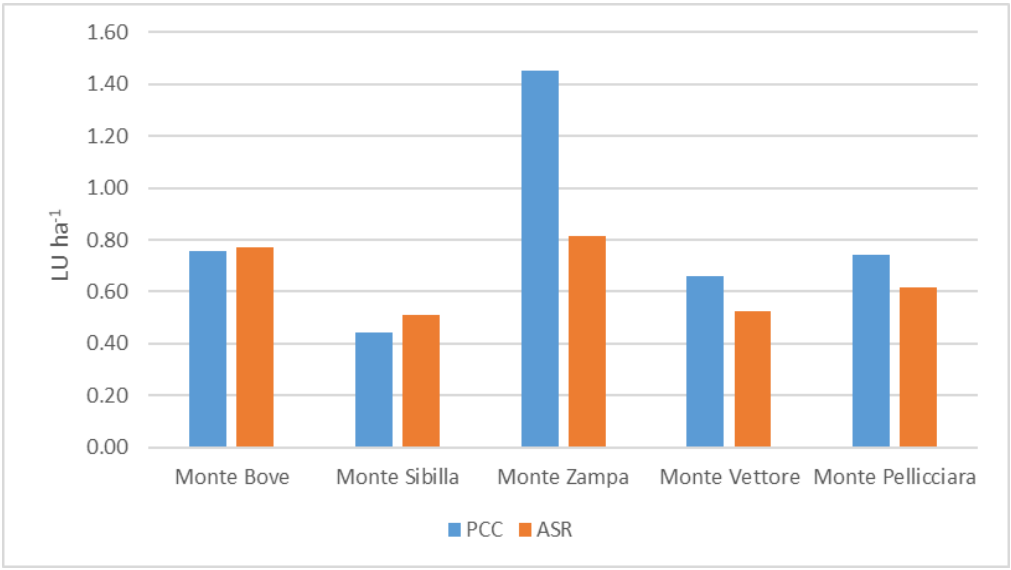

Figure 3. Potential Carrying Capacity (PCC) and Actual Stocking Rate (ASR) in the grazing areas, expressed in Standard Livestock Units (LU).

With this last regard, the most dominant *Bromopsis erecta*-grasslands (around 98% of the total grazing area), with slopes that do not imply the correction on PPV, seem responsible of the much higher PCC recorded for this compared to the other grazing areas. The large surface of this vegetation and the most probable over-estimation of the PV compared to the actual condition (i.e., generally low production that dries early in summer, especially in hot and dry summer) could further justify the divergence between the PCC and ASR recorded in the area. According to this, it is reasonable that some Specific Indexes could be reconsidered and adapted to actual field conditions, also in a climate change perspective. Indeed, it is well known that climate change can trigger more unpalatable adaptations on some species (i.e., scleromorphic leaves, caespitose habit, and so on) (Tardella et *al.*, 2016). Therefore, the specific indexes used in this study may be biased by real climatic conditions affecting this xeric vegetation from year to year.

In a perspective of a sustainable and adaptive management, grazing activity should be empowered where encroachment or other dynamic processes are ongoing or maintained under favourable conditions. Indeed, according to (Pittarello et *al.*, 2020), grazing management is the only controllable factor to preserve plant diversity and to maintain high level of forage production and quality, and for this a stocking rate in equilibrium with the vegetation carrying capacity should be adopted.

Table 2. Phytosociological associations and habitats detected in the range of five grazing areas.

Vegetation type code	Vegetation type and Syntaxa	*Habitat code*[1]
	***Sesleria apennina*-dominated grasslands**	
1	*Seslerietum apenninae* Migliaccio 1970 em. Bonin 1978	*6170*
2	*Seslerio apenninae-Dryadetum octopetalae* Biondi, Ballelli, Allegrezza, Taffetani, Frattaroli, Guitian & Zuccarello 1999	*None*
3	*Carici humilis-Seslerietum apenninae* Biondi, Guitian, Allegrezza & Ballelli 1988	*6170*
4	*Carici humilis-Seslerietum apenninae* Biondi, Guitian, Allegrezza & Ballelli 1988 subass. *dryadetosum octopetalae* Biondi, Ballelli, Allegrezza, Taffetani, Frattaroli, Gujtian & Zuccarello 1999	*6170*
	***Bromopsiserecta*-dominated grasslands**	
5	*Brizo mediae-Brometum erecti* Bruno in Bruno & Covarelli corr. Biondi & Ballelli 1982 subass. *festucetosum commutatae* Catorci, Gatti & Ballelli 2006	*6210**
6	*Brizo mediae-Brometum erecti* Bruno in Bruno & Covarelli corr. Biondi & Ballelli 1982 subass. *brizetosum mediae* Biondi, Pinzi & Gubellini 2004	*6210**
7	*Asperulo purpureae-Brometum erecti* Biondi & Ballelli ex Biondi, Ballelli, Allegrezza & Zuccarello 1995 subass. *asperuletosum purpureae* Allegrezza 2003	*6210**
8	*Potentillo cinereae-Brometum erecti* Biondi, Pinzi & Gubellini 2004 subass. *pontentilletosum cinereae* Biondi et al. 2004	*6210**
	***Sesleria nitida*-dominated grasslands**	
9	*Astragalo sempervirentis-Seslerietum nitidae* Biondi & Ballelli 1995	*6210**
10	*Polygalo majoris-Seslerietum nitidae* Biondi, Ballelli, Allegrezza & Zuccarello 1995	*6210**
	Other grassland types	
11	*Poo violaceae-Nardetum strictae* Pedrotti 1981	*6230**
12	*Senecio scopoli-Ranunculetum pollinensis* Biondi & Ballelli 1995 subass. *plantaginetosum atratae*	*6170*
13	*Gnaphalio magellensis-Plantaginetum atratae* Feoli-Chiapella & Feoli 1977	*None*
	Shrublands	
14	*Rhamno alpinae-Amelanchieretum ovalis* Pedrotti 1994	*4060*
15	*Cytiso sessilifolii-Crataegetum lavigatae* Catorci & Orsomando 2001	*5130*
16	*Junipero communis-Ericetum arboreae* Allegrezza 2003	*None*
17	*Spartio juncei-Cytisetum sessilifolii* Biondi, Allegrezza & Guitian 1988	*None*
18	*Helianthemo grandiflori-Juniperetum alpinae* Stanisci 1997	*4060*

[1]According to Council Directive 92/43/CEE “Habitat Directive” and Directive 2009/147/EC “Birds Directive”.

Table 3. Site characteristics, botanical composition (% abundance of the most abundant and frequent species) and Potential Pastoral Value (PPV) of the vegetation types. Mean values of the vegetation surveys.

	Vegetation type code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Altitude (m a.s.l.)	2072	1936	1694	1840	1332	1233	969	1159	1342	1483	1541	1863	2438	1480	948	593	875	1848
	Exposure (degrees from N)	68	206	162	150	109	128	127	203	171	152	197	49	88	123	146	258	225	154
	Slope (degrees)	17.5	22.9	48.6	20.0	16.4	17.8	24.0	34.2	52.0	41.3	8.3	16.5	14.3	34.3	20.0	15.6	35.0	11.3
	Vegetation cover (%)	86	74	88	95	100	100	88	95	62	90	100	100	80	88	99	99	100	n.a.
SI (0÷5)	**PPV (0÷100)**	11.8	6.0	16.4	7.3	26.6	26.5	28.2	21.0	2.3	15.4	12.7	19.8	15.7	2.0	2.0	1.7	11.3	3.0
1	*Sesleria apennina* + *Sesleria juncifolia* gr.	30.8	19.4	21.3	23.6				0.02	20.8	0.2				1.4				3.0
0	*Dryas octopetala*		23.5		11.2														
0	*Carex humilis*		0.9	0.2	30.4						1.2								
	Carex mucronata		17.8																
0	*Carex macrolepis*		0.9		0.1	0.1	0.1	2.2		9.2	9.0		0.9		1.3				4.3
2	*Bromopsis erecta*			3.6	0.1	15.2	20.4	32.9	41.3	10.4	1.2	1.1	1.4					1.4	2.5
	Astragalus sempervirens			0.3				9.1		1.9	0.1								
1	*Thliphthisa purpurea*			1.1				3.6	1.5	7.3	0.2							1.7	
0	*Potentilla cinerea*								22.0										
1	*Sesleria nitida* subsp. *nitida*									1.8	48.9				7.9				0.8
0	*Nardus stricta*											30.2	10.4						
1	*Brachypodium genuense*		0.2	0.6	0.7					1.9		2.2	13.4						3.7
2	*Festuca rubra* subsp. *commutata*					7.5		8.3				4.9	10.6						
1	*Briza media*					3.3	2.9					0.1	1.4					0.1	
	Bellardiochloa variegata subsp. *variegata*					0.1						3.8	9.8						
1	*Plantago atrata* subsp. *atrata*											0.0	1.7	24.2					
	Ranunculus pollinensis					0.4						0.1	1.8	10.3					
0	*Salix retusa*													12.0					
	Amelanchier ovalis subsp. *ovalis*														55.7				
	Cornus sanguinea subsp. *hungarica*															15.6			
	Rosa arvensis															12.1			
0	*Crataegus laevigata*															9.6			
	Erica arborea																17.6		
1	*Brachypodium rupestre*							1.9	0.1		0.2					4.5	1.2	17.7	
	Cytisophyllum sessilifolium														3.2		2.7	15.1	
	Spartium junceum																3.0	23.7	
0	*Juniperus communis*	0.1			0.7										0.6		7.0	2.8	41.0
	Other species	**69.1**	**37.3**	**72.9**	**33.3**	**73.5**	**76.6**	**42.0**	**35.1**	**46.9**	**39.1**	**57.6**	**48.6**	**53.5**	**29.9**	**58.2**	**68.6**	**37.5**	**44.7**

Table 4. Site characteristics, Fragility Coefficient (FC), Corrected Pastoral Value (CPV) and Potential Carrying Capacity (PCC) of the vegetation types within the grazing areas

Grazing area	Vegetation type (vegetation code in Table 1)																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	*Tot/Mean*
Monte Bove																			
Surface (ha)	26.4	.	6.1	.	.	.	.	.	.	62.5	.	.	.	.	.	34.6	.	.	***129.6***
Slope (°)	27.1	.	25.8	.	.	.	.	.	.	24.3	.	.	.	.	.	21.3	.	.	***24.6***
FC (0.5÷1.0)	0.5	.	1.0	.	.	.	.	.	.	0.8	.	.	.	.	.	1.0	.	.	
CPV (0÷100)	5.2	.	14.6	.	.	.	.	.	.	11.1	.	.	.	.	.	20.3	.	.	***12.4***
PCC (LU ha^{-1})	0.32	.	0.89	.	.	.	.	.	.	0.68	.	.	.	.	.	1.24	.	.	***0.75***
Monte Sibilla																			
Surface (ha)	58.4	.	116.9	48.6	4.6	.	.	5.5	.	165.0	.	153.9	81.2	.	.	.	.	.	***634.1***
Slope (°)	42.4	.	41.6	31.2	29.1	.	.	37.0	.	36.4	.	33.0	41.1	.	.	.	.	.	***36.5***
FC (0.5÷1.0)	0.5	.	0.5	0.5	0.5	.	.	0.5	.	0.5	.	0.5	0.5	.	.	.	.	.	
CPV (0÷100)	5.2	.	7.3	3.5	13.3	.	.	10.0	.	7.0	.	9.9	6.3	.	.	.	.	.	***7.3***
PCC (LU ha^{-1})	0.32	.	0.44	0.21	0.81	.	.	0.61	.	0.42	.	0.60	0.38	.	.	.	.	.	***0.44***
Monte Zampa																			
Surface (ha)	.	.	.	.	137.0	10.0	25.1	85.7	.	3.5	.	0.02	.	.	.	.	3.0	.	***264.2***
Slope (°)	.	.	.	.	23.0	18.8	24.8	22.8	.	30.4	.	34.1	.	.	.	.	22.1	.	***25.1***
FC (0.5÷1.0)	.	.	.	.	1.0	1.0	1.0	1.0	.	0.5	.	0.5	.	.	.	.	1.0	.	
CPV (0÷100)	.	.	.	.	26.6	26.5	24.9	20.0	.	7.0	.	9.9	.	.	.	.	11.3	.	***23.8***
PCC (LU ha^{-1})	.	.	.	.	1.62	1.61	1.51	1.22	.	0.42	.	0.60	.	.	.	.	0.69	.	***1.45***
Monte Vettore																			
Surface (ha)	94.7	11.7	12.1	15.6	.	.	.	.	.	200.2	177.5	45.6	.	.	.	9.1	.	4.4	***570.8***
Slope (°)	31.7	39.8	25.5	25.2	.	.	.	.	.	24.2	22.9	21.0	.	.	.	18.9	.	36.2	***27.3***
FC (0.5÷1.0)	0.5	1.0	1.0	0.5	.	.	.	.	.	0.8	1.0	1.0	.	.	.	1.0	.	0.5	
CPV (0÷100)	5.2	4.4	14.6	3.5	.	.	.	.	.	11.1	12.7	19.8	.	.	.	1.7	.	1.5	***10.8***
PCC (LU ha^{-1})	0.32	0.27	0.89	0.21	.	.	.	.	.	0.68	0.77	1.20	.	.	.	0.10	.	0.09	***0.66***
Monte Pellicciara																			

IV - Conclusion

The PV method and the applied GIS technologies allowed to assess the adequacy of the actual stocking rate applied on protected pastures compared to their potential carrying capacity and proved to be useful tools in identifying uneven stocking distribution. The vegetation dynamics detected in the grazing areas with respect to the applied stocking rates seem to confirm the usefulness of the method for preliminary investigations on the sustainability of grazing activities, to be based on the availability of vegetation surveys and maps.

However, based on the results the procedure seems to overestimate the communities rich in *Bromopsis erecta*, so much so that even some shrublands are enhanced in terms of PV (see type 17). Among many, the accuracy of the estimate depends mainly on the Specific Indices assigned. In this sense, improvements in the method may concern the attribution of specific indices, for example taking into account the differential use by livestock of different species or

introducing a correction to consider the palatability of the species in relation to its phenological phase.

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The role of pastoral systems in the creation and maintenance of Nature's Contribution to People in Spain

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Abstract. Pastoral systems in Spain have been consistently overrepresented in systematic reviews of pastoral and agroecological systems at both global and regional scales. These pastoral systems have been studied extensively through the Ecosystem Service lens, but an examination of Spanish pastoral systems using the Nature's Contribution to People framework was missing from the literature. The Nature's Contribution to People framework builds on the Ecosystem Services framework and aims to be more inclusive of social sciences. We hypothesise that the Nature's Contribution to People framework is well suited to the analysis of pastoral systems as socio-ecological systems where human-nature relationships are inherently linked and only decoupled for analytical purposes. In this article, a qualitative comparative analysis was conducted to explore trends throughout the literature on Spanish pastoral systems. Our results displayed that pastoral systems in Spain are regularly studied in terms of only a few dominant Nature's Contribution to People with *Habitat creation and maintenance, Food and Feed* and *Supporting identities* representing 52% of the Nature's Contribution to People in this analysis and *Habitat creation and maintenance being the most common* Nature's Contribution to People *in the analysis*. These results emphasise the importance of pastoral systems beyond food production.

Keywords: Socio-ecological systems, Mediterranean, Pastoralism, Global change, Ecosystem Services

Le rôle des systèmes pastoraux dans la création et le maintien de la contribution de la nature aux personnes en Espagne

Résumé. *Les systèmes pastoraux en Espagne ont été systématiquement surreprésentés dans les revues systématiques des systèmes pastoraux et agroécologiques à l'échelle mondiale et régionale. Ces systèmes pastoraux ont été largement étudiés à travers le prisme des Services Écosystémiques, mais un examen des systèmes pastoraux espagnols utilisant le cadre de la contribution de la nature aux personnes manquait dans la littérature. Le cadre Contribution de la Nature aux Personnes s'appuie sur le cadre services écosystémiques et vise à inclure davantage les sciences sociales. Notre hypothèse est que le cadre Contribution de la Nature aux Personnes est bien adapté à l'analyse des systèmes pastoraux en tant que Systèmes Socio-Écologiques où les relations homme-nature sont intrinsèquement liées et découplées uniquement à des fins analytiques. Dans cet article, une Analyse Comparative Qualitative a été menée pour explorer les tendances dans la littérature sur les systèmes pastoraux espagnols. Nos résultats ont montré que les systèmes pastoraux en Espagne sont régulièrement étudiés en termes de quelques contributions de la nature aux personnes dominants, avec la création et la maintenance d'habitats, la nourriture et l'alimentation et les identités de soutien représentant 52% du contribution de la nature aux personnes dans cette analyse et la création et la maintenance d'habitats étant la Contribution de la Nature aux Personnes le plus courant. Ces résultats soulignent l'importance des systèmes pastoraux au-delà de la production alimentaire.*

Mots-clés. *Systèmes socio-écologiques, Méditerranéen, Changement global, Élevage, Services écosystémiques*

I - Introduction

The Mediterranean basin has been a place of intense human activity for more than 2,000 years, with pastoral systems being an important part of human history in the region (Pardini, 2004), providing a wide range of tangible and intangible social, economic and environmental

contributions throughout the Mediterranean basin. Pastoral systems are complex socio-ecological systems, defined as an “adaptive network of biophysical and social flows generated and maintained by the movement of shepherds and livestock” (Oteros-Rozas et al., 2012). They are defined by their adaptability, which allows pastoral systems to use all available resources as pastoralists efficiently use resources that are separated both spatially and temporarily (Krätli et al., 2013). Today the role of pastoral systems in addressing many key global challenges, particularly food security and biodiversity conservation, is starting to be acknowledged, particularly in arid and semi-arid and mountain regions such as the Mediterranean basin (López-i-Gelats et al., 2011; Niamir-Fuller and Huber-Sannwald, 2020).

Spain arguably hosts some of the most studied pastoral systems in Europe (Fernández-Giménez, 2015; López-i-Gelats et al., 2016; Oteros-Rozas et al., 2014; Plieninger and Huntsinger, 2018). Thanks in part to the continued existence of nationally protected pastoral infrastructure such as drove roads. The capacity of Spanish pastoralism in providing goods and services beyond meat and milk has been largely proved, with pastoral systems being of vital importance for the maintenance of many of Spain’s biodiverse landscapes. From mountain pastures to lowland grasslands and Dehasas (Oteros-rozas, 2015; Plieninger and Huntsinger, 2018). Spain has also shown itself to be consistently prominent in meta-analysis regarding pastoral and agroecological systems, even at global scales (Dean et al., 2021; Hanaček and Rodríguez-Labajos, 2018; Plieninger et al., 2014). Highlighting a potential bias towards Spain in the agroecological and pastoral literature. Spanish pastoral systems have been extensively studied using the Ecosystem Services framework (Fernández-Giménez, 2015; Oteros-rozas, 2015), but not through the Nature’s contribution to people (NCP) framework.

The prominence of Spain in the agroecological and pastoral literature warrants an individual examination of Spanish pastoral systems in the literature as users and producers of Nature’s Contribution to People (NCP). This article aims to examine the NCP created and maintained by Spanish pastoral systems, due to its noted prominence in the agroecological and pastoral literature

NCP’s are defined as “*all the contributions both positive and negative of living nature (diversity of organisms, ecosystems and their associated ecological and evolutionary processes) to people’s quality of life*“ (IPBES Plenary 5 Decision IPBES-5/1, n.d.). The NCP framework was developed by the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES) as a response to the shortcomings of the Ecosystem Services framework concerning it's under-representation of cultural ecosystem services (non-material NCP) and its difficulty capturing context-specific world views (Díaz et al., 2018). In the NCP framework, the categorisation system is similar to that of the ecosystem services framework. There are 18 NCP which are then placed into 3 major categories, regulating NCP, material NCP and non-material NCP (Table 1).

The NCP framework has been designed to embrace complexity and the plurality of NCP, something which is extremely rare in the ES literature (Kadykalo et al., 2019). A material NCP is capable of also being a non-material NCP depending on the context. The wool from a sheep is a material NCP, but it can also carry cultural significance as seen in Turkey (Ocak, 2016). The traditional movement of livestock such as transhumance is a way to ensure sufficient fodder for livestock (a material NCP), but it is also a cultural act that helps ensure the creation and maintenance of habitats as seen in Spain (Fernández-Giménez, 2015; Oteros-rozas, 2015). The NCP concept has gained popularity in the last four years and has become an excepted framework to study socio-ecological systems (Dean et al., 2021). A systematic review of the NCP created and maintained by pastoral systems in Spain was missing from the scientific literature. There has been criticism that pastoral systems are rarely studied as holistic systems (Manzano et al., 2021), because of which, this analysis intends to examine not only the NCP created and maintained in Spanish pastoral systems but also the patterns of association between the most commonly encountered NCP to determine if Spanish pastoral systems are

studied holistically or as claimed by Manzano et al. (2021) that pastoral systems are normally studied in terms of only a few variables.

II - Methods

A systematic literature review and meta-analysis about Spanish pastoral systems was performed using the Qualitative Comparative Analysis (QCA) (Rudel, 2008; Young et al., 2006). The QCA methodology is an accepted method of the identification of trends within the literature through an inductive process of reading in the field of environmental global change and socio-ecological systems (Dean et al., 2021; López-i-Gelats et al., 2016).

Data collection for literature review

The Web of Science search engine was used to identify literature focusing on pastoral systems in the Mediterranean. To identify the literature, a custom search string was created:

"*TS=((grassland* OR rangeland* OR shrubland* OR scrubland*) AND (grazing OR pastoral) AND (livestock OR horse* OR sheep OR cattle OR goat*) AND Mediterranean*".

The search string resulted in 296 scientific papers for examination. The literature was required to display the following information as part of the selection criteria:

- Peer-review journals that contained primary data.
- Written in English and published between 2003 – 2019
- Articles should be based in Spain.
- The relationship between pastoral systems and Nature's Contribution to People should be discussed and examined.
- Characterises of the pastoral system in the region must be described
- Not set on experimental farms unless it is specifically stated that traditional practices are being reproduced

The literature extracted from the search string was then exported to a database and examined against the inclusion criteria in a four-step process (1) The publishing journal, (2) The title and keywords, (3) Analysing the abstract, (4) Analysing the full article. This initial examination resulted in 47 articles being selected for analysis. Each article was read several times to ensure that all NCP were captured for analysis. An additional 11 articles were then included based on expert recommendations in the field of Spanish pastoral systems. The database was designed to host dummy variables where NCP were coded based on their presence (1) or absence (0). Following previous analysis of NCP in terrestrial systems, only NCP which could be considered as positive were classified (Dean et al., 2021).

III - Results

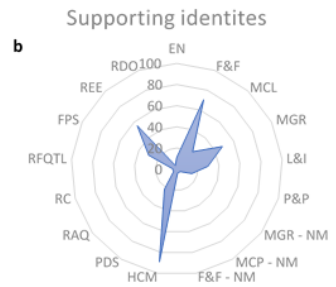
A total of 18 NCP was encountered in the analysis (Table 1). The results show that regulating NCP (n = 99) were the most common group of NCP found in the analysis, followed by material (n = 65) and non-material NCP (n = 45). Within each of these major NCP groups, a small subsection of NCP were found to dominate the analysis and accounted for 52% of all NCP in the analysis (Table 1). For material NCP, the most common NCP was *Food & Feed* (n = 29). In the non-material NCP, the dominant NCP was *Supporting identities* (n = 27) and in the regulating NCP category, the most common in NCP was *Habitat creation and maintenance* (n = 52) which was also the NCP most frequently observed in the entire analysis. Across the analysis, a median of three NCP were examined in every article. Patters of distributions emerged amount the different NCP groups, it was found that the majority of articles (n = 40) examined in this analysis contained more than 1 major NCP group (Regulating, Material, Non-

material) and 20 articles examined more NCP belonging to all 3 NCP groups. With only 19 articles examining a single NCP group. Regarding the 3 NCP that dominated the analysis, *Habitat creation and maintenance, Supporting identities, Food & Feed,* patterns of distributions were found with other NCP (Figure.1).

Food & Feed was found to be closely linked with four other NCP (Fig 1a); The material NCP *Medicinal, biochemical and genetic resources* (MGR) (59%), the non-material NCP *Supporting identities* (SI) (66%) and the regulating NCP *Habitat creation and maintenance* (HCM) (79%) and the *Regulation of extreme events* (REE) (38%). *Supporting identities* was also found to be associated with four NCP (Figure 1b) *Food & Feed* (F&F) (70%), NCP *Habitat creation and maintenance* (HCM) (79%), *Regulation of extreme events* (REE). (56%) and the material NCP *Medicinal, biochemical and genetic resources* (MGR) (48%), *Habitat creation and maintenance* was found to have 5 associations (Fig 1c), although all the associations were relatively weak. Two regulating, two material and one non-material NCP were found to be commonly found with *Habitat creation and maintenance*. The material NCP were *Food & Feed* (F&F) (44%), and *Medicinal, biochemical and genetic resources* (MGR) (38%). The regulating NCP were the *Regulation of extreme events* (REE) (35%) and the *Formation and protection of soils* (FPS) (21%). The non-material NCP that was found to be associated with *Habitat creation and maintenance* was *Supporting identities* (SI) (46%).

a

NCP	NCP ACRONYM
Energy	EN
Food & Feed	F&F
Materials companionship and labour	MCL
Medicinal, biochemical and genetic resources	MGR
Habitat creation and maintenance	HCM
Pollination and seed dispersal and other propagules	PDS
Regulation of air quality	RAQ
Regulation of climate	RC
Regulation of freshwater quantity, location and timing	RFQTL
Formation protection and decontamination of soils and sediments	FPS
Regulation of extreme events	REE
Regulation of detrimental organisms and biological processes	RDO
Learning and inspiration	L&L
Physical and psychological experiences	P&P
Supporting identities	SI
Materials companionship and labour	MCP – NM
Medicinal, biochemical and genetic resources	MGR – NM
Food & Feed	F&F – NM



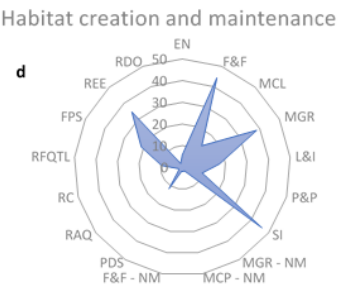


Figure 1a NCP in the analysis with acronyms. **Fig 1b.** NCP are present with *Supporting identities* in percentage. **Fig 1c**. NCP are present with *Food & Feed* in percentage. **Fig 1d.** NCP are found with Habitat creation and maintenance in percentage

NCP group	NCP	NCP ACRONYM	TOT Included (n)	Tot NCP group
Material	Energy	EN	3	
	Food & Feed	F&F	29	
	Materials companionship and labour	MCL	9	
	Medicinal, biochemical and genetic resources	MGR	24	65
Regulating	Habitat creation and maintenance	HCM	52	
	Pollination and seed dispersal and other propagules	PDS	6	
	Regulation of air quality	RAQ	1	
	Regulation of climate	RC	1	
	Regulation of freshwater quantity, location and timing	RFQTL	5	
	Formation protection and decontamination of soils and sediments	FPS	11	
	Regulation of extreme events	REE	20	
	Regulation of detrimental organisms and biological processes	RDO	3	99
Non-material	Learning and inspiration	L&L	9	
	Physical and psychological experiences	P&P	6	
	Supporting identities	SI	27	
	Materials companionship and labour	MCP – NM	1	
	Medicinal, biochemical and genetic resources	MGR – NM	1	
	Food & Feed	F&F – NM	1	45

Figure 2: NCP identified in the literature concerning Spanish pastoral systems

IV - Discussion

During the course of this analysis, we have shown that Spanish pastoral systems are most commonly associated with three NCP; *Habitat creation and maintenance*, *Food and Feed* and *Supporting identities.* This supports the results of a recent global meta-analysis of NCP in pastoral systems which found that these 3 NCP were the most common in the pastoral literature (Dean et al., 2021). Spanish pastoral systems are deeply impacted by the EU wide Common Agricultural Policy (CAP) which subsidies biodiversity-friendly farming practices (Commission, 2020), with the European Union increasingly recognising the role of pastoral systems on the environments, and their role in biodiversity management, land management and their ability to regulate grassland/rangelands as carbon sinks (Nori and Gemini, 2011). Although the historic relationship of European pastoral systems and the EU is complex (López-i-Gelats et al., 2015; Nori and Gemini, 2011; O'Rourke et al., 2016).

Spain is also considered one of the most important countries in the EU as it is considered a global biodiversity hotspot (Cuttelod et al., 2008). This helps us to understand why the results of this analysis are deeply focused on the NCP *Habitat creation and maintenance* as pastoral systems are vital for the creation of semi-natural habitats such as grasslands or rangelands that host biodiversity, but require constant maintenance to maintain the biodiversity (Squires et al., 2018). That the literature revealed that *Food & Feed* was only marginally more present than *Supporting identities* is a surprise. Cultural identity is important in pastoral systems, that is in no doubt (Fernández-Giménez, 2015) but pastoral systems both in Spain and globally are at their heart food production systems. Given the importance of pastoral systems for food production in semi-arid and arid areas such as much of the Mediterranean basin including much of Spain (Niamir-Fuller and Huber-Sannwald, 2020) and that food production is one of the primary three objectives of the CAP (Nori and Gemini, 2011) it is surprising that pastoral systems in Spain have not shown *Food & Feed* production to be a more dominant NPC. This could be because

Spain is an EU country, where industrial food and feed production are normal, and smallscale pastoral systems are being abandoned or intensified as seen in both in Spain (López-i-Gelats et al., 2015) and other parts of the EU such as Ireland and France (O'Rourke et al., 2016).

The combination of pastoral systems importance for biodiversity and the large-scale land-abandonment and intensification found in Spain could explain why researchers have focused on non-material NCP such as *Supporting identities.* As Spanish pastoral systems become less relevant economically and for food security, its value seems to have switched from food security to maintaining biodiverse landscapes, and the protection of identity and culture as a means to ensure land abandonment or intensification does not occur. As it has been demonstrated in the ecosystems services literature that cultural ecosystem services are prominent in the formation of environmental attitudes and framing (Chiesura and De Groot, 2003) highlighting their value to both policy and science.

V - Conclusion

The focus of Spanish pastoral literature on regulating NCP particularly on *Habitat creation and maintenance* showcases the importance of pastoral systems in the eyes of researchers. One explanation for this focus is the importance of Spain in the EU as a Mediterranean biodiversity hotspot, with pastoral systems being considered vital for the maintenance of biodiverse landscapes. Although pastoralism seems to be considered secondarily as food production systems and as a form of cultural identity which is a flaw as the synergies between different NCP fail to be acknowledged when researchers focus on only a small subsection of NCP. The focus on only a small subsection of NCP reflects a potential problem with researchers of pastoral systems in Spain; the simplification of complex socio-ecological systems. If pastoral systems are to be truly understood, they cannot be thought of in only a few simplified terms.

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The Use of Goat Grazing for Prevention of Forest Fires in the West Mediterranean Region of Turkey

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Abstract. In this study, the effects of goat grazing on reducing forest fires are investigated. For this purpose, trial areas were taken in 3 provinces (Antalya, Isparta and Burdur) within the study area which has rough terrain and scrubland. As a result of grazing goat flock in these areas, the amount of flammable material removed per unit area was calculated under 4 different intensities: weak grazing (70-100% of the total available aboveground biomass), medium grazing (70-40%), heavy grazing (40%-10%) and no grazing in the study area.

The amount of flammable material removed by goat grazing in study areas where grazing is allowed in the state forests is annually -756,500 tons in Antalya Province, -304,000 tons in Isparta Province, -198,000 tons in Burdur Province and totally -1,258,500 tons in entire study area. Thus, goats remove the amount of flammable material from the Western Mediterranean Forests at the rate of 61%.

Weak grazing (70-100%) in grazing classes cannot reduce the amount of flammable material. The grazing intensities that should be used to reduce the forest fire hazard are in medium grazing (70-40%) and heavy grazing (40-10%). The most suitable grazing period to preventing forest fires is the period between April 15 and June 15. Considering the presence of different forest vegetation in the study area, these grazing periods can be extended to 15 days earlier or 15 days later. Finally, the 3-month period between April 1 and June 30 is the most effective period of grazing for the prevention of forest fires.

Keywords. Forests, goat breeding, grazing, forest protection, fire prevention, Turkey.

L'utilisation du pâturage des chèvres pour la prévention des incendies de forêt dans la région de la Méditerranée occidentale en Turquie

Résumé. *Dans cette étude, les effets du pâturage des chèvres sur la réduction des incendies de forêt sont étudiés. A cet effet, des zones d'essai ont été prises dans 3 provinces (Antalya, Isparta et Burdur) au sein de la zone d'étude qui a un terrain accidenté et de la garrigue. En raison du pâturage du troupeau de chèvres dans ces zones, la quantité de matière inflammable enlevée par unité de surface a été calculée sous 4 intensités différentes : pâturage faible (70-100 % de la biomasse aérienne disponible totale), pâturage moyen (70-40 %) , pâturage intensif (40 à 10 %) et aucun pâturage dans la zone d'étude.*

La quantité de matières inflammables enlevées par le pâturage des chèvres dans les zones d'étude où le pâturage est autorisé dans les forêts domaniales est de -756 500 tonnes dans la province d'Antalya, de -304 000 tonnes dans la province d'Isparta, de -198 000 tonnes dans la province de Burdur et de -1 258 500 tonnes dans l'ensemble de l'étude. Région. Ainsi, les chèvres enlèvent la quantité de matières inflammables des forêts de la Méditerranée occidentale au taux de 61%.

Un pâturage faible (70-100 %) dans les classes de pâturage ne peut pas réduire la quantité de matières inflammables. Les intensités de pâturage qui devraient être utilisées pour réduire le risque d'incendie de forêt sont en pâturage moyen (70-40%) et en pâturage intensif (40-10%). La période de pâturage la plus appropriée pour prévenir les feux de forêt est la période entre le 15 avril et le 15 juin. Compte tenu de la présence de différentes végétations forestières dans la zone d'étude, ces périodes de pâturage peuvent être prolongées jusqu'à 15 jours plus tôt ou 15 jours plus tard. Enfin, la période de 3 mois entre le 1er avril et le 30 juin est la période de pâturage la plus efficace pour la prévention des feux de forêt.

Mots-clés. *Forêts, élevage caprin, pâturage, protection des forêts, prévention des incendies, Turquie.*

I - Introduction

Turkey is a country with a land holding of 78,000,644 hectares of which 28.6% is represented by forests. Forest fires have an important place among the factors that threaten forests (GDF, 2018).

The Mediterranean climate prevails in the south of the country, and due to the characteristics of this climate type, the region where forest fires are most common is the Mediterranean Region. Summer drought, which is among the characteristics of the Mediterranean climate, is the most important factor that prepares the ground for the outbreak of forest fires. In the period of summer drought, herbaceous plants dry up after seed maturation. On the other hand, as a result of the accumulation of leaves and availability of branches of trees, and shrubs, dry material ready to burn can easily in both forest and agricultural areas. In short, the reason why forest fires are high both in area and in numbers, especially in the Mediterranean Region, is the presence of dry grass and woody material suitable for burning during the summer drought period. Today, the General Directorate of Forestry spends a large amount of money on forest fire prevention as well as on extinguishing forest fires. However, it is possible to prevent the forest fires by making the goats eat the grass and leaves in the forest areas (Ortaş, 2010).

Contemporary forest fires management approach, besides fire extinguishing activities, aims to actively intervene in the forest for two main purposes: reducing the risk of forest fire (e.g., by controlled burning, by cutting vegetation, etc.) and restoring forest health (Mutch et al., 1993).

Animal grazing in forests is the process of reducing the amount of flammable material to reduce the risk of forest fires (Yılmaz, 2016).

With this regard, goats have important functions in preventing forest fires. Every year, thousands of kilometers of fire safety lanes and roads are established in order to keep forest fires in small areas and prevent their spread. The paths opened by the goats serve as a natural fire safety road and path. It is expensive and difficult for human beings to open and establish these paths. By doing this, goats contribute to the prevention of fires (Kaşıkçi et all., 2020).

If the goats are grazed in an area with mature trees, they do not harm the forest that benefits from them. Because they clear all the flammable material around the adult trees. Thus, the elements that increase the risk of fire spreading are eliminated. When a fire breaks out, the flames cannot spread as there is no plant residue left in the ground land. Thus, the fire in the area with mature trees cannot spread. As a matter of fact, the United States of America (USA) effectively uses goats in the fight against forest fires. In the USA, goats are deliberately grazed in forest areas (Lovreglio et.all, 2014).

In this study, it was investigated how to benefit from goats in reducing forest fires. For this purpose, trial areas were taken in three provinces within the study area and the following aspects determined: (i) the amount of flammable material removed per unit area as a result of the grazing of goat flock in these areas, and (ii) the most suitable grazing periods that can be done without damaging the forests.

II - Material and method

In this study, it was investigated how to benefit from small ruminants in reducing forest fires. For this purpose, experimental areas were taken in three provinces (Isparta, Burdur and Antalya), and the amount of combustible material removed per unit area as a result of grazing goat flocks in these areas was determined. In addition, the most suitable grazing periods that can be done without damaging the forests were determined.

Field studies can be selected based on the knowledge about the characteristics of the universe and according to the purpose of the research, this type of sampling is called purposive sampling. In purposive sampling, samples can be taken from places that are thought to represent the universe and are a typical example of the universe (Dasdemir, 2016). Purposeful sampling method was used in the selection and determination of the trial areas in this study.
Grazing classes were determined by considering the % of the total available aboveground biomass. Accordingly, the coverage rate of vegetation in the “no grazing” is 100%, “weak grazing” is between 100%-70%, “medium grazing” is between 70% and 40%, and “heavy grazing” is between 40%-10%.
Accordingly, measurements were made by taking 12 random trial areas (10 m x 10 m = 100 m2) in each of the 3 provinces of the Western Mediterranean Region in Turkey (Isparta, Burdur and Antalya), corresponding to 3 replications per each of the 4 grazing density (i.e., no grazing, weak, medium and heavy grazing). In total, the measurements were made in 36 trial areas in 2018 and 2019. In the study, representative areas were determined to meet the purpose of the study in determining the design to be selected for fieldwork (Figure 1).

Figure 1. Field study in experimental areas

In these trial areas, the feed material that could be eaten by goats was cut/plucked/collected and weighed by bringing it to air-dry weight. The value found was recorded as the amount of combustible material removed from this area.

III - Results

In this study, the importance of goat use and goat breeding in conservation of forests and prevention of forest fires in the Western Mediterranean Region of Turkey was investigated.
In this study, the factors affecting the amount of flammable materials removed by goats from forest areas; the rainfall amount of the region, the elevation of the land, the rate of vegetation covering the land, the number of grazing goats per unit area, the period of grazing were effective. In Table 1, the results obtained from the research are given in terms of the fields of study.

Table 1. Flammable material per unit area (kg ha-1) and the most suitable grazing period to prevent forest fires in the 3 provinces according to the grazing intensity

Working area	Grazing Level/Intensity	Flammable material (kg ha^{-1})	Most suitable grazing period to prevent forest fires
Antalya	No grazing	none	01 April – 01 June
	Weak grazing	-446	
	Medium grazing	-823	
	Heavy grazing	-1279	
Isparta	No grazing	none	30 April – 30 June
	Weak grazing	-395	
	Medium grazing	-841	
	Heavy grazing	-1320	
Burdur	No grazing	none	15 April – 15 June
	Weak grazing	-425	
	Medium grazing	-763	
	Heavy grazing	-1138	

Weak grazing (70-100% of the total available aboveground biomass) in grazing classes cannot reduce the amount of flammable material. Grazing intensities that should be used to reduce the risk of forest fire are medium grazing (70-40%) and heavy grazing (40%-10%).

The amount of medium grazing and heavy grazing areas in the state forests in the Western Mediterranean Region in Turkey is given in Table 2.

Table 2. Area Amounts by Grazing Density in the Western Mediterranean Region

Grazing Level/Intensity	Antalya (ha)	Isparta (ha)	Burdur (ha)
Heavy grazing	100 515.70	4 362.00	2 910.60
Medium grazing	763 007.30	354 709.90	255 251.31

Table 3. Amounts of flammable materials removed by goat grazing in areas where grazing is allowed in state forests in the Western Mediterranean Region

Working area	Grazing Level/Intensity	Amount of grazing land (ha)	Flammable material per unit (kg ha^{-1})	Removed flammable material (kg)	Total	
					(kg)	(ton)
Antalya	Heavy grazing land	100 516	-1 279	-128 560 000	-756 515 000	-756 500
	Medium grazing land	763 007	-823	-627 955 000		
Isparta	Heavy grazing land	4 362	-1 320	-5 758 000	-304 069 000	-304 000
	Medium grazing land	354 710	-841	-298 311 000		
Burdur	Heavy grazing land	2 911	-1 138	-3 313 000	-198 069 000	-198,000
	Medium grazing land	255 251	-763	-194 756 000		
Total					-1 258 653 000	-1 258 500

IV - Conclusion

Goats can be easily lived in bad environmental conditions. Because they use resources and roughage that cannot be utilized by other farm animals. It is the most important source of livelihood of the settlements in and on the edge of the forest, which do not have lands for plant production. Goats are animals that can easily turn into money at any time. They can be grown in simple and inexpensive shelters. They have a high adaptability to the growing environment and resistance to diseases. Goat breeding is mainly carried out in enterprises in forest and mountainous areas. Because due to natural conditions, other animal husbandry activities cannot be done in these areas or they are done at very low levels. Goat breeding is carried out in approximately 500 thousand enterprises in Turkey and this production line contributes to the income of approximately 3 million people (Türkoğlu et all., 2016).

The various characteristics of goats offer them advantages in applications for vegetation and vegetation management and control. Both foresters and small cattle breeders are not aware of this feature of goats in Turkey. Both sides highlighted their contrasts and could not enter into an understanding that would provide common gain. Foresters insisted that the goats should be kept away from the forest and never be allowed into the forest areas, and they did not give up on this idea for years. On the other hand, goat breeders, knowingly or unknowingly neglecting the grazing limits and rules, grazing ruthlessly, destroying the maquis and forest vegetation. For this reason, sustainable resource management has not been realized and sustainable animal breeding has not been done (Bekiroğlu and Tolunay, 2010).

Goat breeding is a low-input livestock business and requires minimal initial investment financing. In addition, the maintenance costs of the animals are low and only a medium level of labor is required for flock management.

However, sustainable resource management and sustainable animal husbandry require a high level of flock management knowledge. Goats have a variety of dietary preferences and consume a wide variety of herbaceous and woody plant species. Goats have lip and mouth structure that enables the selection and consumption of the most nutritious components of the biomass found in forest and pasture vegetation. Goats can make a feeding preference in the presence of herbaceous and woody species that they can eat in abundance in their environment. When they cannot find enough forage in the pastures, they can reach and feed on high tree branches and leaves by reaching more than 3 meters on their hind legs. Goats are better able to digest plant species with higher tannin levels than cattle or sheep (Tolunay *et. al.*, 2019).

Goat grazing prevents uncontrolled growth by eating the branches, leaves and flowers of annual or perennial herbaceous plants. Also, when the immature seeds of these plants are eaten by goats, they are completely destroyed in the digestive tract. In addition, with the reduction of vegetation and vegetation cover by goats, parasitic and parasitic animal populations such as ticks become controllable. The greatest benefit of controlling vegetation with goats will primarily be to remove combustible material that will cause major forest fires with the smallest spark in summer drought. Various methods can be used to prevent the formation of this combustible material. For example, chemical drug application can be made. This application has a cost of 50-100 Euro per hectare. However, doing this process using goats will not cost anything, and it will contribute to raising an animal that uses meat and dairy products with a monetary value of 50-100 Euro (Hart, 2020).

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Effect of woody plant cover on understory vegetation diversity in Mediterranean shrublands

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Abstract. The aim of this study was to investigate the effect of woody plant species cover on the diversity of the understory vegetation in Mediterranean shrublands. The research was conducted in Northern Greece, at the area of Ossa, Lagadas, Thessaloniki. Three different shrub cover classes were identified: open (10-40%), medium (41-70%) and dense (71-100%). Understory species vegetation measurements were conducted in four plots per each shrub cover class. Cover and composition were measured along two transects in each plot while α and β diversity indices were calculated. For α diversity the indices: a) species richness (S), b) Shannon-Wiener index (H´), c) Evenness (J), d) Simpson (D) and e) Berger-Parker index of dominance (d) were used. For β diversity the indices: a) Sorensen's (Cs) and b) Jaccard's (Cj), as well as Pielou's (PS) percentage similarity were calculated for each pair among the three shrub cover classes. The results showed that α diversity of the understory vegetation decreased from open to dense shrub cover. β diversity revealed that the three shrub cover classes differed in terms of species similarity of the understory vegetation. These findings lead to the conclusion that the diversity of the understory vegetation in Mediterranean shrublands is declined as woody species cover increase and a diversified landscape can contribute to the preservation of species richness in these ecosystems.

Keywords. Species richness, Shannon-Wiener index, Evenness, Floristic similarity

Effet du couvert végétal ligneux sur la diversité de la végétation du sous-bois dans les formations arbustives méditerranéennes

Résumé. *Le but de cette étude était de suivre l'effet de la couverture végétale ligneuse sur la diversité de la végétation du sous-étage dans les maquis méditerranéens. La recherche a été menée dans le nord de la Grèce, dans la région d'Ossa, Lagadas, Thessalonique. Trois classes de couvert arbustif différentes ont été identifiées : ouvert (10-40 %), moyen (41-70 %) et dense (71-100 %). Des mesures de la végétation des espèces de sous-bois ont été effectuées dans quatre parcelles pour chaque classe. La couverture et la composition ont été mesurées le long de deux transects dans chaque parcelle tandis que les indices de diversité α et β ont été calculés. Pour la diversité α, les indices : a) richesse spécifique (S), b) indice Shannon-Wiener (H´), c) régularité (J), d) Simpson (D) et e) indice de dominance Berger-Parker (d) ont été utilisés. Pour la diversité β, les indices : a) de Sorensen (Cs) et b) de Jaccard (Cj), ainsi que le pourcentage de similarité de Pielou (PS) ont été calculés pour chaque paire parmi les trois classes étudiées. Les résultats ont montré que la diversité α de la végétation du sous-étage a diminué d'un couvert arbustif ouvert à dense. La diversité β a révélé que les trois classes de couvert arbustif différaient en termes de similarité des espèces de la végétation du sous-étage. Ces résultats conduisent à la conclusion que la diversité de la végétation du sous-étage dans les formations arbustives méditerranéennes diminue à mesure que le couvert d'espèces ligneuses augmente et qu'un paysage diversifié peut contribuer à la préservation de la richesse spécifique de ces écosystèmes.*

Mots-clés. *Richesse en espèces, Indice de Shannon-Wiener, Uniformité, Similitude floristique*

I - Introduction

Shrublands constitute a land use type that plays an important role in the Mediterranean area. Woody species are a major component of them. They contribute in the production of wood, fruits and forage for the animals, especially during the unfavourable time in winter and summer, as well as they protect the ecosystem from soil erosion, they help in the retention of the hydrological balance of the water basins and they improve the landscape in terms of recreation and aesthetic value (Papanastasis, 1999; Ispikoudis and Chouvardas, 2005).

Furthermore, in shrubland communities, woody species cover plays an important role in shaping the microclimate of the understory vegetation. They affect the temperature and the humidity of the ground layer, especially during periods of extreme environmental conditions such as the low temperature values in winter and the hot and dry season in late spring and summer (Moro *et al.*, 1997; Eviner and Chapin III, 2003). They also affect the quantity and the quality of the light that reaches the ground layer, modifying the growth conditions of the understory plants (Martens *et al.*, 2000; Valladares and Guzman, 2006).

In Mediterranean area, during the last decades, traditional land uses extensification and/ or abandonment has been taking place (Naveh and Lieberman, 1984; Barbero *et al.*, 1990; Pinto Correia, 1993; Farina, 1998; Caraveli, 2000). This has had as a result the encroachment of woody species in open areas (Tasser and Tappeiner, 2002; Ispikoudis and Chouvardas, 2005; Papanastasis and Chouvardas, 2005) and the consequently increase of woody species cover in shrublands that is expected to continue happening in the future (Chouvardas and Vrahnakis, 2009).

Plant diversity has been found to increase in the first stages of vegetation succession and to decrease as succession proceeded (Bonet and Pausas, 2004; Papadimitriou *et al.*, 2004; Dolle *et al.*, 2008). Nonetheless not many researches have focussed on the influence of the increase of woody plant species in the Mediterranean shrublands on the diversity of the understory vegetation. The aim of this study was to investigate the effect of woody plant species cover on the diversity of the understory vegetation in Mediterranean shrublands.

II - Materials and methods

The research was conducted in North Greece, at the area of Ossa in Lagadas County nearby the city of Thessaloniki (Figure 1). The altitude of the study area reaches a mean of 550m a.s.l.. The mean annual precipitation is approximately 586mm and the mean annual air temperature is 12.1ºC. There, three different shrub cover classes were identified: open (10-40%), medium (41-70%) and dense (71-100%). These classes followed the classification of Papanastasis and Chouvardas (2005) that studied the land use changes in the wider area. The dominant species was *Quercus coccifera* L. in its shrub form, while *Quercus pubescens* Willd. co-existed on the woody species layer, as well as there were scattered shrubs of *Pyrus amygdaliformis* Vill. and *Cistus incanus* L.

Figure 1. Study area

For each of the three above shrub cover classes, four plots of 0.1ha were selected resulting in a total of twelve plots under study. In each plot cover and composition of the understory vegetation were measured along two transects. The line-point method was used (Cook and Stubbendieck, 1986), while multiple contacts were recorded when species were overlapping in

a point. The following α diversity indices were calculated using the composition data (Magurran, 1988; 2004):

$H' = -\sum_{i=1}^{s} p_i \, lnp_i$a) species richness (S)

b) Shannon-Wiener index (H´):

$$J = \frac{H'}{ln\,S}$$

c) Evenness (J):

$$D = \sum_{i=1}^{s} p_i^2$$

d) Simpson (D):

$$d = \frac{N_{max}}{N}$$

e) Berger-Parker index of dominance (d):

where pi: the proportion of individuals of species i in the sample,
N_{max}: the number of individuals of the most abundant species,
N: the total number of individuals in the sample.

Furthermore, for β diversity the following similarity indices were calculated (Magurran, 1988; 2004) for each pair of the three shrub cover classes:

$C_s = \frac{2j}{a+b}$a) Sorensen's (Cs) index:

$$C_j = \frac{j}{a + b - j}$$

b) Jaccard's (Cj) index:

where j: the number of species present in both areas (A and B) under comparison
a: the total number of species present in A area and
b: the total number of species present in B area

These similarity indices take values from 0 (no common species between the two areas) to 1 (all species common in both areas)

As well as, Pielou's percentage similarity (PS) (Pielou, 1984) for each pair of the three shrub cover classes:

$$PS = 200 \times \frac{a}{2a + b + c} = 100 \times \frac{2a}{2a + b + c}$$

where a: the number of species present in both areas (A and B) under comparison
b: the number of species present only in A area and
c: the number of species present only in B area

One way Anova was used for the investigation of statistical differences of the mean of the α diversity indices between the three classes. When significantly differences were found, they were further investigated with Duncan multiple range test at the 0.05 probability level (Fowler *et al.*, 1998). The software package SPSS Statistics 25.0 was used for all the analyses.

III - Results and discussion

The α diversity indices of the understory vegetation of the three shrub cover classes are presented in table 1. Species richness (S) and Shannon-Wiener index (H´) decreased as shrub cover increased. More specifically, species richness was significantly higher in the open shrubland, followed by the medium and lower in the dense shrubland. Additionally, Shannon-Wiener index (H´) appeared the largest value in the open shrubland, while it did not differ significantly among the other two shrub cover classes.

On the other hand, the Evenness (J), Simpson (D) and Berger-Parker index of dominance (d) did not show any significant difference between the three classes (Table 1). Evenness (J) had a mean value of approximately 0.79 in all classes. As far as, Simpson (D) and Berger-Parker (d) indices are concerned, they followed the same trend and they increased from open to dense shrub cover class even though not significantly.

These results indicate that the open shrubland showed the highest α diversity on the understory vegetation and it decreased with the increase of shrub cover. Furthermore, low values of the Simpson (D) index expresses higher diversity (Magurran, 2004) and the above indications are supported by the trend that this index followed. Additionally, Berger-Parker index of dominance (d) revealed that as shrub cover decreased, understory vegetation tended to have less dominant species. Finally, Evenness (J) of the species of the understory did not seem to differentiate among the three classes. A decline of species diversity with the increase of shrub cover was also found by Vrahnakis *et al.* (2005) in kermes oak shrublands. Furthermore, our results come in agreement with other researches such as Bonet and Pausas (2004), Papadimitriou *et al.* (2004) and Dolle *et al.* (2008) who found that higher woody species cover caused by succession after land use extensification and/ or abandonment had a negative impact on floristic diversity.

Table 1. α diversity indices of the understory vegetation of the three shrub cover classes

Diversity indices	Open shrubland	Medium shrubland	Dense shrubland
Species richness (S)	18.25a[1]	8.75b	5.50c
Shannon-Wiener index (H´)	2.35a	1.65b	1.40b
Evenness (J)	0.81a	0.76a	0.79a
Simpson (D)	0.15a	0.27a	0.34a
Berger-Parker index of dominance (d)	0.28a	0.40a	0.44a

[1]Different letters in the same line indicate significant differences ($p \leq 0.05$) according to the Duncan test.

The Sorensen's similarity index (Cs), the Jaccard's similarity index (Cj) and the Pielou's percentage similarity (PS) of the understory vegetation for each pair of the three shrub cover classes are shown in tables 2, 3 and 4 respectively. As far as, the Sorensen index (Cs) is concerned, open shrubland showed the highest similarity with the medium shrubland and the lowest with the dense shrubland. On the other hand, the medium and the dense shrublands had the highest value for this index.

Table 2. Sorensen's similarity index (Cs) of the understory vegetation for each pair of the three shrub cover classes

Sorensen's (Cs)	Open shrubland	Medium shrubland	Dense shrubland
Open shrubland	1.00		

Medium shrubland	0.54	1.00	
Dense shrubland	0.48	0.62	1.00

The Jaccard's similarity index (Cj) followed the same trend with the Sorensen's similarity index (Cs) (Table 3). Even though the values of this index were smaller, the highest similarity of the understory vegetation was among the medium and the dense shrublands, too.

Table 3. Jaccard's similarity index (Cj) of the understory vegetation for each pair of the three shrub cover classes

Jaccard's (Cj)	**Open shrubland**	**Medium shrubland**	**Dense shrubland**
Open shrubland	1.00		
Medium shrubland	0.37	1.00	
Dense shrubland	0.31	0.44	1.00

The Pielou's percentage similarity (PS) expresses β diversity as a percentage (Pielou, 1984). Its values had the same trend as the previous two indices (Table 4). Open shrubland showed a little more than 50% similarity with medium shrubland, while medium and dense shrublands had approximately 60% similarity in the species of the understory vegetation.

Table 4. Pielou's percentage similarity (PS) of the understory vegetation for each pair of the three shrub cover classes

Pielou's (PS)	**Open shrubland**	**Medium shrubland**	**Dense shrubland**
Open shrubland	100		
Medium shrubland	54.29	100	
Dense shrubland	47.76	61.54	100

The study of the β diversity revealed that the three shrub cover classes differed in terms of species similarity of the understory vegetation. Similar results have been found by Papadimitriou *et al.* (2007) during the study of secondary succession in Mediterranean landscapes. It should be noted that in terms of the similarity of the understory vegetation, the medium and the dense shrublands appeared with the highest values than any other pair of the three classes.

IV - Conclusions

Our results suggest that the diversity of the understory vegetation in Mediterranean shrublands is declined as woody species cover increase. Open shrublands have the highest α diversity on the understory vegetation. As shrub cover increase, more dominant species appear in the understory. These findings are in relation with the β diversity outcomes and indicate that a diversified landscape can contribute to the preservation of species richness in these ecosystems.

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Vegetative and reproductive plant height of species populations in relation to land use changes in Mediterranean rangeland ecosystems

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Abstract. Plant height is a functional trait that is directly related with plant competitive ability and its capacity to tolerate or avoid disturbance and environmental stress. The aim of this paper was to study the vegetative and reproductive plant height of plant populations of the same species in relation to land use changes in Mediterranean rangelands. At the area of Lofiskos, Lagadas County, Thessaloniki, N. Greece, four land use types were selected: a) abandoned arable field, b) grassland, c) open shrubland and d) dense shrubland with four replicates each, representing four stages of secondary succession after land use extensification and/ or abandonment. Vegetative and reproductive plant height of the populations of plant species that were abundant in at least two of the land use types was measured. Vegetative plant height was significantly different between the populations of the same species for the 71% of the species under study, while reproductive plant height was significantly different for the 64% of the species studied. In both cases, the majority of the species appeared significantly higher height in their populations in the advanced stages of succession. Vegetative and reproductive plant height of species population's responds to land use changes caused by extensification and/or abandonment in Mediterranean rangelands.

Keywords. Plant Functional Traits - Secondary succession – Extensification - Abandoned field – Grassland - Shrubland

Hauteur végétative et reproductive des populations de plantes en relation avec les changements d'utilisation des terres dans les parcours méditerranéens

Résumé. *La hauteur de la plante est un trait fonctionnel qui est directement lié à sa capacité compétitive et à son aptitude à tolérer ou à éviter les perturbations et le stress environnemental. L'objectif de cet article était d'étudier la hauteur végétative et reproductive des populations végétales d'une même espèce en relation avec les changements d'utilisation des terres dans les parcours méditerranéens. Dans la région de Lofiskos, comté de Lagadas, Thessalonique, Grèce du Nord, quatre types d'utilisation des terres ont été sélectionnés : a) champs arables abandonnés, b) prairies, c) zones arbustives ouvertes et d) arbustaies denses avec quatre répétitions chacune, représentant quatre étapes de succession secondaire après l'extensification et/ ou l'abandon de l'utilisation des terres. La hauteur végétative et reproductive des populations d'espèces végétales abondantes dans au moins deux des types d'utilisation des terres a été mesurée. La hauteur végétative des plantes était significativement différente entre les populations d'une même espèce pour les 71% des espèces étudiées, tandis que leur hauteur reproductive était significativement différente pour les 64% des espèces étudiées. Dans les deux cas, la majorité des espèces semblaient avoir une hauteur significativement plus élevée dans leurs populations aux stades avancés de la succession. La hauteur végétative et reproductive des populations de plantes répond aux changements d'utilisation des terres causés par l'extensification et/ou l'abandon dans les parcours méditerranéens.*

Mots-clés. *Traits fonctionnels de la plante - Succession secondaire - Extensification - Champ abandonné - Prairie - Arbuste*

I - Introduction

Plant height is a functional trait that is directly related with plant competitive ability and its capacity to tolerate or avoid disturbance and environmental stress (Weiher *et al.*, 1999; Cornelissen *et al.*, 2003; Lavorel *et al.*, 2007; Pérez-Harguindeguy *et al.*, 2013). The ecological importance of this trait has been globally recognised and it has been largely used in a number

of plant ecological strategy schemes (Westoby *et al.*, 2002). According to Grime (2001), plant height can determine the survival and the relative abundance of a species during its competition for light.

Land use changes are the main factor that affects terrestrial ecosystems more than any other factor of environmental change (Vitousek *et al.*, 1997; Sala *et al.*, 2000; Chapin III *et al.*, 2002). They usually consist of two opposite directions, intensification on the one hand and extensification and abandonment on the other (Chapin III *et al.*, 2002; Poschlod *et al.*, 2005). In the rural areas of the Mediterranean ecosystems, abandonment and/ or extensification of traditional land uses usually occur (Caraveli, 2000; Mulligan *et al.*, 2004; Papanastasis and Chouvardas, 2005). The above changes have led to woody species encroachment on open areas and sequentially to vegetation secondary succession to shrublands and woodlands (Tatoni *et al.*, 2004; Chouvardas and Vrahnakis, 2009).

Plant height is a trait that is expected to respond to disturbance (Cornelissen *et al.*, 2003; Lavorel *et al.*, 2007). Short plants have been found to be favoured by grazing over tall ones by many researchers such as Pakeman (2004), de Bello *et al.* (2005) and Diaz *et al.* (2007). On the other hand, it has been found that tall plants increase as vegetation succession proceeds (Prach *et al.*, 1997; Kahmen and Poschlod, 2004; Castro *et al.*, 2010). The plant height of the populations of a species during an environmental gradient or change is expected to vary (Garnier *et al.*, 2007; Pérez-Harguindeguy *et al.*, 2013) but no many studies have focussed on investigating this. The aim of this paper was to study the vegetative and reproductive plant height of the same species populations in relation to land use changes in Mediterranean rangelands.

II - Materials and methods

The research took place at the area of Lofiskos, Lagadas County that is located near the city of Thessaloniki in North Greece. The altitude of the area is approximately 500m a.s.l., with a mean annual air temperature of 12.1ºC and a mean annual rainfall of 586mm. Four land use types with four replicates each were selected: a) abandoned arable field, b) grassland, c) open shrubland and d) dense shrubland. These four land use types represent four stages of secondary succession after land use extensification and/ or abandonment.

For fourteen plant species (Table 1 and 2) that were abundant in at least two of the above-indicated land use types, as it was found by Zarovali *et al.* (2007), vegetative and reproductive plant height of their populations was measured for each type separately. The measurements followed the protocols of Cornelissen *et al.* (2003) and Pérez-Harguindeguy *et al.* (2013) and were taken on healthy and vigorous plants that were in open or in the least shadowed places. Vegetative plant height was measured as the vertical distance of the highest main photosynthetic tissues of a plant (leaves) and the soil surface, excluding any exceptional branches. In accordance, reproductive plant height was measured as the vertical distance of the upper limit of the reproductive organs of a plant (inflorescence) and the soil surface. Both traits were measured on twenty individuals of each species and each land use type that it was abundant. In some cases, vegetative and reproductive plant height was identical.

Differences of the mean vegetative and reproductive height of the populations of a species between the land use types were investigated using the t – test and one way Anova when a species was abundant in two or more land use types respectively (Fowler *et al.*, 1998). In the last case, when significantly differences were found, Duncan multiple range test was used for further investigation at the 0.05 probability level. The software package PASW Statistics 18.0 (SPSSInc., 2009) was used for all the analyses.

III - Results and discussion

Vegetative plant height was significantly different between the populations of the same species for the 71% of the species studied (Table1). On the contrary, the rest 29% of the species, including the grasses *Chrysopogon gryllus* (L.) Trin. and *Taeniatherum caput-medusae* (L.) Nevski and the woody species *Pyrus amygdaliformis* Vill. and *Quercus coccifera* L., did not appear significant differences among their populations for this trait.

Table 1. Vegetative plant height (cm) of each species population for the different land use types.

Species	Abandoned field	Grassland	Open shrubland	Dense shrubland
***Chrysopogon gryllus* (L.) Trin.**	26.25a[1]	27.25a	25.10a	28.95a
***Dactylis glomerata* L.**	10.45c	20.45b	16.80βc	37.00a
***Dianthus pinifolius* Sm.**	-	7.85b	-	10.95a
***Dichanthium ischaemum* (L.) Roberty**	-	21.45b	26.25a	-
Genista carinalis Griseb.	-	9.45c	13.50b	18.90a
***Plantago lanceolata* L.**	9.7b	14.10a	-	-
***Pyrus amygdaliformis* Vill.**	-	263.00a	234.00a	-
***Quercus coccifera* L.**	-	-	263.50a	248.75a
***Taeniatherum caput-medusae* (L.) Nevski**	5.68a	6.78a	-	-
***Thymus sibthorpii* Benth.**	-	10.15b	9.90b	13.25a
***Trifolium angustifolium* L.**	22.40a	-	-	17.10b
***Trifolium hirtum* All.**	10.90b	6.60c	12.70b	20.30a
***Trifolium ochroleucon* Huds.**	6.70c	-	9.25b	12.95a
***Vicia cracca* L.**	40.50a	28.60b	26.80b	-

[1]Different letters in the same line indicate significant differences ($p \leq 0.05$) according to the t – test and the Duncan test when a species was abundant in two or more land use types respectively.

As table 1 showed, the majority of the species had significantly higher vegetative height in their populations in the advanced stages of vegetation succession, compared with the ones in the early stages. This was the case for the 57% of the species studied. Even though, the populations of these species were not all measured in the same land use types, they followed the same trend.

On the other hand, the legumes *Trifolium angustifolium* L. and *Vicia cracca* L. appeared with different trends. They both had significantly higher vegetative height in their population in the abandoned field (an early stage of vegetation succession) and lower in their population(s) on the other land use types.

As far as the reproductive plant height was concerned, it was found to be significantly different among the various land use types for the populations of the 64% of the species studied (Table 2). The rest 36% of the species, more than in the case of the vegetative plant height, did not show significantly differences between their populations for this trait. This was the case for the species *Dichanthium ischaemum* (L.) Roberty, *Plantago lanceolata* L., *Pyrus amygdaliformis* Vill., *Quercus coccifera* L. and *Trifolium angustifolium* L..

The reproductive plant height of the species populations followed the same trend with vegetative plant height. In this case, the 50% of the species had significantly larger reproductive height in their populations on the advanced stages of vegetation succession compared with the ones on the early stages.

Table 2. Reproductive plant height (cm) of each species population for the different land use types.

Species	Abandoned field	Grassland	Open shrubland	Dense shrubland
***Chrysopogon gryllus* (L.) Trin.**	158.25a[1]	139.15b	128.80b	136.80b
***Dactylis glomerata* L.**	54.35c	77.60b	76.00b	93.25a
***Dianthus pinifolius* Sm.**	-	39.55b	-	46.00a
***Dichanthium ischaemum* (L.) Roberty**	-	80.50a	71.10a	-
Genista carinalis Griseb.	-	17.10c	20.10b	28.35a
***Plantago lanceolata* L.**	41.65a	44.40a	-	-
***Pyrus amygdaliformis* Vill.**	-	263.00a	234.00a	-
***Quercus coccifera* L.**	-	-	263.50a	248.75a
***Taeniatherum caput-medusae* (L.) Nevski**	27.35b	32.90a	-	-
***Thymus sibthorpii* Benth.**	-	15.70b	14.65b	18.80a
***Trifolium angustifolium* L.**	28.15a	-	-	24.65a
***Trifolium hirtum* All.**	16.15b	10.60c	18.10b	27.10a
***Trifolium ochroleucon* Huds.**	11.35c	-	14.70b	18.80a
***Vicia cracca* L.**	41.00a	35.90ab	33.60b	-

[1]Different letters in the same line indicate significant differences ($p \leq 0.05$) according to the t – test and the Duncan test when a species was abundant in two or more land use types respectively.

Nevertheless, the populations of two species appeared the opposite trend. Those species were *Vicia cracca* L., as in the case of vegetative height, and *Chrysopogon gryllus* (L.) Trin. In both cases, the population of the abandoned field (early stage of vegetation succession) had significantly greater reproductive height than the other populations of the species.

In both cases, vegetative and reproductive plant height, the majority of the species appeared significantly higher height in their populations in the advanced stages of succession and lower in the early stages. This finding comes in agreement with a number of researches, which concluded that plant height increased as vegetation succession proceeded (Prach *et al.*, 1997; Prach and Pysek, 1999; Kahmen and Poschlod, 2004; Castro *et al.*, 2010), as well as, with the reduction of grazing intensity (Westoby, 1999; de Bello *et al.*, 2005; Louault *et al.*, 2005; Peco *et al.*, 2005; Pakeman and Marriott, 2010). Plant competitive ability is closely related with its height, so this trait has a high response to disturbance (Weiher *et al.*, 1999; Diaz *et al.*, 2001; Cornelissen *et al.*, 2003; Lavorel *et al.*, 2007).

It must be noted that the populations of some species did not follow the above general trend of the majority of the species. This was probably because they found more favorable conditions in other stages of vegetation succession and also due to the more intensive competition for light in the later stages (Grime, 2001). Finally, the populations of a small number of species did not appear any significant difference in their vegetative and/ or reproductive height. The woody species *Pyrus amygdaliformis* and *Quercus coccifera* were two of them that did not show any difference among their populations for both traits. As woody species, they were taller from all

the other, so competition for light was less for them and this was probably the reason why their height remained the same.

IV - Conclusions

Both vegetative and reproductive plant height of species populations respond to land use changes caused by extensification and/ or abandonment in Mediterranean rangeland ecosystems. The majority of the species appear with higher vegetative and reproductive height in their populations in the advanced stages of succession. Nevertheless, some species populations do not follow the general rule, depending on their competitive ability and their niche differentiation.

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Perspectives, opinions, and perceptions of pastoralists on their sustainability: the case of the Pyrenean region of Pallars in Spain

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Abstract. Traditional small-scale livestock farming activity in the Spanish Eastern Pyrenees is nowadays influenced by market globalization trends as well as regional factors such as nature protection regulations and tourism. This study addressed pastoralists´ perspectives, opinions, and perceptions regarding the challenges that threaten their sustainability. We carried out a face-to-face survey with 103 pastoralists in Pallars (Catalonia) during 2018. The stagnation in sales' prices of products was considered the biggest challenge and one of the underlying causes of the farms' low financial profitability. Pastoralists also pointed out the highly burdening bureaucracy, the lack of generational turnover, and the difficult coexistence with wildlife as important problems undermining the livestock sector in the region. Although most participants positively considered their increasingly valued role in the conservation of biodiversity, their perception of protected natural areas was mostly negative. Respondents reported a total of 613 conflicts with wildlife during the previous year. Wild boars were the species most frequently mentioned for damaging meadows, crops, and infrastructures, causing road accidents, and disease transmission. Vultures were held responsible for attacks on flocks while deer species were signalled for fodder competence. These results confirm the multiple adverse menace factors of pastoralism and highlight the urgent need to establish favourable policies that involve local actors in decision-making processes to overcome these obstacles.
Key words: Mountain farming, global change, protected areas, wildlife, conservation, socio-ecological systems.

Perspectives, opinions et perceptions des pasteurs sur leur durabilité: le cas de la région du Pallars dans les Pyrénées

Résumé. *L'activité traditionnelle d'élevage à petite échelle dans les Pyrénées-Orientales espagnoles est aujourd'hui influencée par les tendances de la mondialisation du marché ainsi que par des facteurs régionaux tels que les réglementations de protection de la nature et le tourisme. Nous avons réalisé une enquête auprès de 103 pasteurs du Pallars (Catalogne) en 2018. La stagnation des prix de vente des produits y est considérée comme le plus grand défi et l'une des causes sous-jacentes de la faible rentabilité financière des exploitations. Les pasteurs ont également souligné la lourdeur de la bureaucratie, le manque de renouvellement des générations et la difficile coexistence avec la faune sapant ce secteur d'activité. La plupart considèrent positivement leur rôle de plus en plus valorisé dans la gestion de l'environnement, mais leur perception des zones naturelles protégées est majoritairement négative. Ils ont signalé 613 conflits avec la faune au cours de l'année précédente. Le sanglier est l'espèce la plus citée, elle endommage les prairies, les cultures, les infrastructures, cause des accidents de la route et la transmission de maladies. Les vautours sont tenus pour responsables des attaques contre les troupeaux tandis que les herbivores se disputent le fourrage. Ces résultats confirment les multiples facteurs de menace négatifs du pastoralisme et soulignent le besoin urgent d'établir des politiques favorables qui impliquent les acteurs locaux dans les processus décisionnels pour surmonter ces obstacles.*

Mots-clés. *Agriculture de montagne, changement global, aires protégées, faune sauvage, conservation, systèmes socio-écologiques*.

I - Introduction

Pastoral communities constitute key components of the mountain social-ecological systems whose historical interaction with nature influence the production of ecosystem services to society (Walker et al., 2004). Mountains are hotspots of cultural and biological diversity, play an essential role in the hydrological cycle and are iconic elements of the landscape. In Europe, mountains cover 36% of total area, of which, 49% belong to the Natura 2000 Network Sites and 33% are High Natural Value (HNV) agricultural land (European Environment Agency, 2010). Indeed, a broad range of target conservation habitats and species rely on, or are associated with low-intensity farming for its maintenance, especially with grazing practices (Halada et al., 2011).

However, many of these semi-natural habitats are threatened by simultaneous trends of land use intensification and abandonment patterns influenced by political and socioeconomic transformations in recent decades (Anderson and Mammides, 2020). Small-scale extensive farming systems are in decline due to the reduced viability of their productions that are labour intensive and find it difficult to compete and differentiate in the global markets. Furthermore, context-specific drivers do also operate at regional level. For example, in the Pyrenees, the coexistence between pastoralists, tourists and wildlife could be conflictive while pastoralists also face technical and management challenges at farm level.

The uncertainty and the multiple obstacles that hamper the sustainability of pastoralists in European mountain areas compromise socio-economic and environmental goals with relevance in rural development, food production and nature conservation. Therefore, it is necessary to broaden scientific knowledge to understand the driving factors leading to the current situation. While much effort has been done in the scientific and technical study of these changing dynamics, less attention is focused on pastoralist´s points of views. This study aims to explore pastoralists´ perspectives, opinions, and perceptions on their own sustainability in the Pyrenees and test the influence of the geographical location to perceive these challenges.

II - Material and methods

2.1 Study area

The study was undertaken in Pallars Jussà (PJ) and Pallars Sobirà (PS) counties in Catalonia, in the Spanish Mid-Eastern Pyrenees (**Fig. 1**). This mountainous territory is characterised by a rugged orography and harsh climate that host a great wildlife population including many target conservation species such as bear (*Ursus arctos*), grey wolf (*Canis lupus*) and the four European vultures. The main economic activity has traditionally been based on small-scale farming with sheep, goats, cows and, more recently, horses herds moving to mountain pastures in the summer and falling to the valleys in winter. However, farming has undergone many difficulties and changes in recent decades causing the decrease in farms numbers while increasing livestock heads. The economy is shifting towards the tertiary sector driven by the establishment of a dense network of protected areas and multiple tourist claims (i.e. ski resorts, cultural museums). These changes threaten the sustainability of this ecosystem and its public benefits.

Fig. 1. Localization of Pallars counties.

2.2 Data collection and analysis

Within the PACTORES project, we surveyed 103 pastoralists (47 in PJ and 56 in PS) through in-depth face-to-face interviews between May and July 2018 to characterize farming systems in Pallars. While the information gathered was broad and addressed key technical, management and socio-economic characteristics of farms, here are reported the results about the opinions, perceptions and attitudes towards their main challenges, regulations of protected areas and wildlife conflicts. Specifically, the questions asked were:

1. What do you think are currently the more important challenges that livestock in the region must overcome to continue? (Respondents should choose four items from a list).
2. How do you consider the impact of protected natural areas on mountain livestock? (Answers were presented in a five-point Likert scale ranging from very negative to very positive. Don´t know option was also included)
3. What do you think about the fact that the role of livestock as a conservation of biodiversity/nature is increasingly valued? (Answers were presented in a five-point Likert scale ranging from very negative to very positive. Don´t know option was also included)
4. What do you think about the expansion of new ungulates that there were not present a few years ago? (Answers were presented in a five-point Likert scale ranging from very negative to very positive. Don´t know option was also included)
5. Could you indicate the incidents with wildlife in the last 12 months and the species of fauna you believe is responsible? (Respondents were allowed to name any number of incidents)

We applied a descriptive statistical analysis through frequency distributions to describe the information of the complete sample and cross-tabulations to examine differences between the two administrative counties (Pallars Sobirà and Pallars Jussà). Fisher's exact test was used to identify significant relationships for dichotomous variables whereas Pearson chi-squared test was carried out for variables with more than two categorical levels.

III - Results and discussion

3.1 Prioritization of challenges

The first question revealed that the low sales prices of products were considered the biggest challenge and one of the underlying causes of the farms' low financial profitability, which is consistent with previous studies in the Mediterranean (**Fig.2**; Ruiz et al., 2020). Unlike these studies, farmers perceived the highly-burdening bureaucracy as the second limitation, which is a differentiating aspect in the Pyrenees (Morales-Reyes et al., 2017). This special dissatisfaction with the administration could be linked to the important role of communal property regimes and the top-down establishment of protected areas regardless of the opinion of local actors (Beltran and Vaccaro, 2010). The lack of generational turnover was considered the third limitation and the main farm internal factor although it could be motivated by the low socio-economic attractiveness of the sector. Therefore, it is not surprising that the fifth challenge was related with the coexistence with wildlife. This prioritization of external challenges from markets and policies beyond the control of pastoralists indicates their unfavourable position to

face their main obstacles and highlights the need to generate participatory solutions among stakeholders (Belanche et al., 2021).

Our study also revealed differences in the perception of challenges between the two nearby territories. Pastoralists in the most mountainous region, PS, perceived more relevant the rural abandonment, the change in the socio-cultural profile of people living in the region, inexperienced to live with livestock and the loss of the best land by urbanization pressure. On the other hand, pastoralists in PJ highlighted the low sales prices of livestock products, the new social and environmental functions increasingly demanding to the sector and other challenges related with the lack of association networks among farmers. These geographical differences are possibly due to the counter-urbanisation demographic trends in PS (López-i-Gelats et al., 2009) and the higher production and intensification in PJ with more dependence on supplementary feedstuff and hence sensitiveness to the volatility of inputs prices.

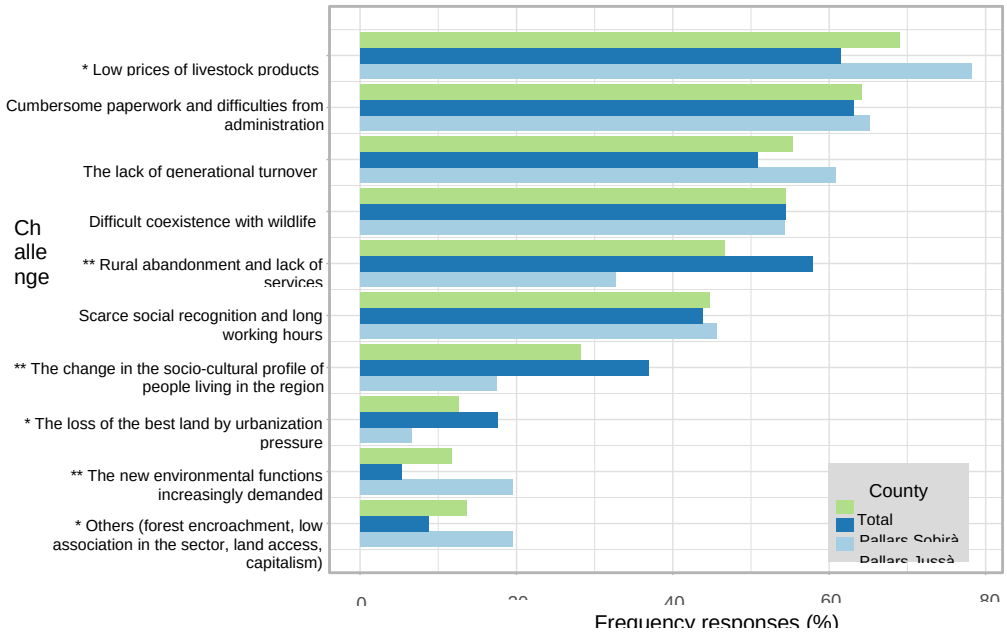

Fig. 2. Prioritization of the challenges that livestock in the region must overcome to continue. Significance between countries according to Fisher's Exact Test: *** p< 0.01; ** p< 0.05; * p< 0.1.

3.2 Perceptions and opinions on protected areas

The impact of protected areas on the livestock sector was perceived negatively or very negatively by more than half of the respondents in both counties (**Fig 3**). The negative perception about the expansion of new ungulates was also overwhelming in our survey and was substantially worse for respondents in PS where protected areas are more widespread. In contrast, pastoralists positively considered their increasingly valued role in the conservation of biodiversity and nature, which offers a great opportunity to encourage their participation through the implementation of payment schemes that could support the economic viability of farms, improve their social recognition while increasing the success of conservation policies.

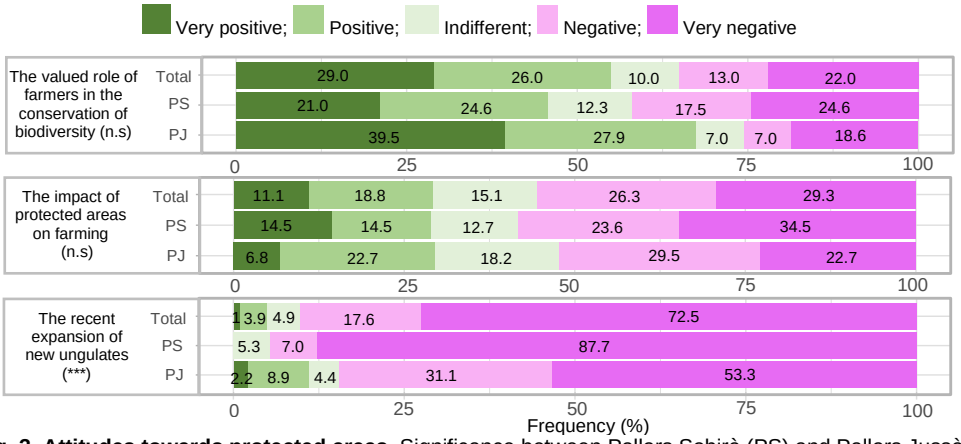

Fig. 3. Attitudes towards protected areas. Significance between Pallars Sobirà (PS) and Pallars Jussà (PJ) according to Pearson chi-squared test: *** p< 0.01; ** p< 0.05; * p< 0.1; n.s. not significant.

3.3 Incidents with wildlife

The compilation of the complaints about incidents in the last 12 months with wildlife revealed a conflictive and unstable relationship between pastoralists and the growing populations of wild fauna due to the improvement of their habitats for land abandonment and management policies in protected areas. Consistent with other studies (Storie and Bell, 2015), wild boars prompt the most negative attitudes among farmers and were identified as the first responsible of damages caused on meadows, crops, infrastructures, road accidents, and disease transmission (**Table 1**). Besides, deer species were signalled for fodder competence. These damages represent important economic expenses to farmers and erode trust in public administration raising contestation towards the conservationist discourses. For instance, pastoralists usually complain about the strict sanitary controls to which they are subjected, while wild fauna is the main responsible for the spread of infectious diseases.

In a territory where predators like bear and more sparsely wolf coexist, it was remarkable that the most signalled species for attacks on the herd were avian scavengers such as vultures. In the absence of precise data on livestock predation and taking into account that the majority of investigated evidences are caused by domestic dogs, this negative perception on vultures could be explained by the lack of carrion availability in the field, changes in husbandry practices, the increase of vulture's population and the social magnification of the problem (Margalida et al., 2021). Nonetheless, this incipient conflict could trigger the use of illegal poison leading to unwanted effects for target conservation species. Therefore, reconciling livestock production and wildlife conservation would be crucial for the sustainability of both. Finally, while guard dogs and fencing grazing areas are expensive but successful preventive strategies, long-term solutions should be based on precise information and promote local participation to be effective.

Table 1. Complaints about the type of incident with wildlife and the animal hold as responsible in the last 12 months.

Incident	PJ	PS	Tot.	Sig	Incident	PJ	PS	Tot.	Sig
Damage to land	**91.3**	**96.5**	**94.2**	**n.s**	**Attacks on flocks and predation**	**43.5**	**66.7**	**56.3**	******
Wild boar	89.1	84.2	86.4	n.s	Vultures	23.9	43.9	34.9	**
Fallow deer	0.0	47.4	26.2	**	Fox	32.6	33.3	33.0	n.s
Red deer	4.3	40.3	24.3	***	Bear	0.0	14.0	7.8	**

Roe deer	8.7	33.3	22.3	**	Wild boar	6.5	0.0	2.9	*
Fodder competence	**63.0**	**94.7**	**80.6**	***	Eagle	2.2	0.0	0.9	n.s
Roe deer	39.1	47.4	43.7	n.s	Wild dogs	2.2	0.0	0.9	n.s
Red deer	19.6	56.1	39.8	***	**Roads accidents**	**30.4**	**43.9**	**37.9**	**n.s**
Fallow deer	10.9	56.1	35.9	***	Wild boar	21.7	19.3	20.4	n.s
Wild boar	19.6	45.6	34.0	*	Roe deer	10.9	17.5	14.6	n.s
Others	0.0	14.0	7.8	*	Fallow deer	0.0	8.8	4.8	**
Damage to facilities	**52.2**	**86.0**	**70.9**	***	Red deer	0.0	3.5	1.9	n.s
Wild boar	34.8	64.9	51.5	**	Others	0.0	3.5	1.9	n.s
Roe deer	21.7	36.8	30.1	*	**Disease transmission**	**6.5**	**21.0**	**14.6**	**
Red deer	13.0	42.1	29.1	**	Wild boar	4.3	8.8	6.8	n.s
Fallow deer	6.5	47.4	29.1	***	Fox	0.0	8.8	4.9	*
Others	0.0	3.5	1.9	ns	Roe deer	4.3	5.3	4.9	n.s
					Red deer	0.0	1.7	1.0	n.s
					Fallow deer	0.0	1.7	1.0	n.s

Others: herbivores such as male ibex, mouflon, and hare. Significance between Pallars Sobirà (PS) and Pallars Jussà (PJ) according to Fisher's Exact Test: *** p< 0.01; ** p< 0.05; * p< 0.1 and n.s. not significant.

IV - Conclusion

The debate on the sustainability of pastoralism in Pallars is broad and complex. In a global change context, pastoralists operate under changing conditions with multiple and interconnected constraints that give rise to diverse perceptions. External difficulties associated with markets and policies revealed the weakness position of pastoralists to face their main challenges while accenting the necessity to develop favourable policies for increasing their sustainability. We found that the relevance of the challenges was influenced by the geographical location. Pastoralist in the high mountainous region were threatened by rural abandonment and tourism opposite tends whereas in the medium mountainous by technical and management issues.

The opinions expressed about the relationship between grazing, protected areas and wildlife were conflictive, which stresses the importance of promoting dialogue between stakeholders (farmers, administration, conservation groups etc.). In turn, pastoralists agreed in their social recognition for biodiversity conservation, which could facilitate their participation in Payment for Ecosystem Services schemes to maintain grazing in protected areas. Likewise, the implementation of incentives could be a successful regional action for reinforcing the economic viability in farms and build social empowerment through participation and engagement to address these challenges.

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Livestock and Climate Change in North Africa

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Abstract. A growing body of evidence links livestock to climate change (CC). However, a comprehensive analysis is lacking in North Africa (viz. Algeria, Egypt, Libya, Morocco, and Tunisia). Therefore, this paper analyses the dual relationship between livestock and CC in North Africa, drawing upon a systematic review of 32 documents identified in March 2021 through the Web of Science. Most studies focus on CC adaptation while mitigation is generally overlooked. Livestock contribution to greenhouse gas (GHG) emissions depends on livestock species and pastoral systems. Climate change affects livestock productivity, and fodder and feed production. The livelihoods of North African pastoralists are vulnerable to CC because they are largely based on rainfed mixed and pastoral livestock systems. However, livelihood vulnerability depends on pastoral mobility, farm typology and household livelihood assets. Livestock breeders adopted different strategies to adapt to CC such as herd size reduction and livelihoods diversification. Sustainable management of pastures and rangelands can help not only mitigating livestock-related GHG emissions and increasing carbon sequestration but also improving pastures resilience and pastoral communities' adaptation to CC. Research is needed to accommodate the imperative of CC mitigation while ensuring the adaptation of the livelihoods of livestock farmers and pastoralists to the changing climate in North Africa.

Keywords. animal husbandry, pastoralism, pasture, climate change mitigation, climate change adaptation, Maghreb, Mediterranean.

Élevage et changement climatique en Afrique du Nord

***Résumé**. De plus en plus de preuves établissent un lien entre l'élevage et le changement climatique (CC). Cependant, une analyse complète fait défaut en Afrique du Nord (Algérie, Égypte, Libye, Maroc et Tunisie). Par conséquent, cet article analyse la double relation entre l'élevage et le CC en Afrique du Nord, en s'appuyant sur une revue systématique de 32 documents identifiés en mars 2021 via le Web of Science. La plupart des études se concentrent sur l'adaptation au CC tandis que l'atténuation est généralement négligée. La contribution du bétail aux émissions de gaz à effet de serre (GES) dépend des espèces animales et des systèmes pastoraux. Le changement climatique affecte la productivité du bétail et la production de fourrage. Les systèmes de subsistance des pasteurs nord-africains sont vulnérables au CC car ils reposent en grande partie sur des systèmes d'élevage mixtes et pastoraux qui dépendent des précipitations. Cependant, la vulnérabilité des systèmes de subsistance dépend de la mobilité pastorale, de la typologie des exploitations et des moyens des ménages. Les éleveurs ont adopté différentes stratégies pour s'adapter au CC telles que la réduction de la taille des troupeaux et la diversification des moyens de subsistance. La gestion durable des pâturages et des parcours peut aider non seulement à atténuer les émissions de GES liées à l'élevage et à augmenter la séquestration du carbone, mais également à améliorer la résilience des pâturages et l'adaptation des communautés pastorales au CC. La recherche est nécessaire pour répondre à l'impératif de l'atténuation des CC tout en assurant l'adaptation des moyens de subsistance des éleveurs et des pasteurs au changement climatique en Afrique du Nord.*

***Mots-clés**. élevage, pastoralisme, pâturage, atténuation du changement climatique, adaptation au changement climatique, Maghreb, Méditerranée.*

I - Introduction

Livestock production plays a central role in the social, economic and environmental sustainability of agri-food systems and results essential in the implementation of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) (FAO, 2018a, 2018b; Serra Prieto et al., 2019). Indeed, livestock production has strong linkages with, among others, SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 6 (Clean water and sanitation), SDG 13 (Climate action) and SDG 15 (Life on land) (FAO, 2018b). Livestock has been one of

the fastest-growing agricultural sectors in developing countries and helped decreasing poverty levels (Loayza & Raddatz, 2010; Robinson et al., 2011). Livestock products contribute significantly to the human diet both in terms of calorie and protein intake (Rosegrant et al., 2009). Furthermore, animal-source foods are very rich in nutrients, high-quality proteins and essential micronutrients, which are difficult to obtain from plant-based foods (Murphy & Allen, 2003). However, the total number of live animals has dramatically increased over the last decades (FAOSTAT, 2021b) with a consequent increase in the use of and pressure on natural resources. Moreover, the livestock sector contributes to biodiversity reduction, deforestation and land degradation (Millennium Ecosystem Assessment, 2005; Steinfeld et al., 2006), but also provides invaluable ecosystem services (FAO, 2018b).

A growing body of literature deals with the relations between climate change and agriculture. Agriculture is a major contributor to climate change through greenhouse gases (GHG) emissions (FAO, 2016; HLPE, 2012). Indeed, agriculture, forestry and other land uses (AFOLU) account for about one-fifth of GHG emissions worldwide (FAO, 2016). The GHG emissions from agriculture in Africa are among the fastest-growing in the world (Tongwane & Moeletsi, 2018). Moreover, agriculture is one of the sectors that are most affected by climate change (FAO, 2016; HLPE, 2012). Therefore, agriculture is central both for climate change mitigation and adaptation (FAO, 2016; Torquebiau, 2017). However, the literature on the relations between climate change and agriculture generally overlooks livestock, especially in developing countries (Gautier et al., 2016). The livestock sector contributes significantly to climate change through direct GHG emissions, from manure and enteric fermentation (Gerber et al., 2013; Hickman et al., 2011; Tongwane & Moeletsi, 2018). Moreover, climate change has direct and indirect effects on livestock (FAO, 2018a). Climate change also affects the livelihoods of pastoralists and their food security (Davies et al., 2014; Rivera-Ferre & López-i-Gelats, 2012).

The Mediterranean (cf. North Africa, Near East, Southern Europe and Balkans) is one of the most affected regions by climate change (MedECC, 2019). Data from FAOSTAT show that the region of North Africa has an important livestock flock that is dominated by sheep. Permanent meadows and pastures represent one of the most important land users in the region. Indeed, the share of land under permanent meadows and pastures in land area ranges from 7.56% in Libya to 47.05% in Morocco; while its share in agricultural land ranges from 48.75% in Tunisia to 86.64% in Libya (Table 1). These elements make it clear that livestock has a central role to play both in climate change mitigation (e.g. pasture management affecting GHG emissions) and adaptation (e.g. impacts of climate change on pastoral communities' livelihoods). Research and sound data are essential to elucidate such multifaceted relations. Therefore, this paper analyses research on the relationship between livestock and climate change in North Africa. In particular, it addresses both climate change mitigation and adaptation by analysing the contribution of the livestock to climate change in terms of GHG emissions as well as the adaptation of the North African livestock breeders and pastoral communities to the changing climate.

Table 1. Live animals, pasture and permanent meadows in North African countries**.**

Items	**Livestock (head) - 2019**				**Share of land under permanent meadows and pastures - 2018**	
	Camels	Cattle	Goats	Sheep	In Agricultural land (%)	In Land area (%)
Algeria	416,519	1,780,591	4,986,116	29,428,929	79.41	13.79
Egypt	119,885	4,898,893	3,462,740	5,132,106	NA	NA
Libya	66,667	229,890	2,663,801	7,562,220	86.64	7.56
Morocco	60,808	3,328,000	5,993,000	21,591,000	69.84	47.05
Tunisia	237,516	645,125	1,163,281	6,370,844	48.75	30.57
Source	FAOSTAT (2021b)				FAOSTAT (2021a)	

NA: No available data.

II - Methods

The paper draws upon a systematic review of all documents (journal articles, book chapters, conference articles) indexed in the Web of Science (WoS). A search was performed on 31 March 2021 using the search query: *(livestock OR animal OR cattle OR sheep OR goat OR camel OR pastoralism OR grazing OR rangeland OR pasture) AND ({climate change} OR "climate variability" OR "global warming" OR "greenhouse gas" OR GHG) AND ("North* Africa" OR Maghreb OR "South* Mediterranean" OR Algeria OR Egypt OR Libya OR Morocco OR Tunisia)*. The search on WoS yielded 229 documents. Two eligibility criteria were considered: geographical coverage (viz. dealing with at least one of the North African countries) and thematic focus (viz. addressing both livestock and climate change). Following the scrutiny of titles, abstracts and full-texts, 197 documents were excluded. Therefore, 32 research articles were included in the systematic review (Table 2).

Table 2. List of the selected documents.

Year	Number	References
2021	1	Aribi and Sghaier (2021)
2020	2	Yawson (2020); Znaidi et al. (2020)
2019	2	Ouled Belgacem et al. (2019); Rouabhi et al. (2019)
2018	4	Amamou et al. (2018); Petit and Boujenane (2018); Semara et al. (2018); Souissi et al. (2018)
2017	2	Ibidhi et al. (2017); Lazarev (2017)
2016	3	Dadamouny and Schnittler (2016); Jaber et al. (2016); Martin et al. (2016)
2015	5	Arabi et al. (2015); El Shaer (2015a); El Shaer (2015b); McCarl et al. (2015); Müller et al. (2015)
2013	4	Annicchiarico et al. (2013); Daoudi et al. (2013); Frenette-Dussault et al. (2013); Ouled Belgacem and Louhaichi (2013)
2012	1	Freier et al. (2012)
2011	4	Annicchiarico et al. (2011a); Annicchiarico et al. (2011b); Freier et al. (2011); Gamoun et al. (2011)
2008	2	Herrero et al. (2008); Thomas (2008)
2003	1	Wellens (2003)
1999	1	Parish and Funnell (1999)

* As of 31 March 2021

III - Results and Discussion

The analysis of the geography of research shows that not the same attention is devoted to the nexus between livestock and climate change in all North African countries (Table 3). Indeed, the highest number of the selected studies was performed in Tunisia, followed by Morocco, Algeria then Egypt. This is rather surprising considering that Egypt is the most populous country in the region with an important research system but rather understandable considering the low share of pastures and rangelands in the country's land. In the meantime, there is no study on the livestock-climate change nexus in Libya, which indicates a huge research gap in the country. This result might be due to the low importance of the livestock sector in the Libyan GDP as well as the unrest situation in the country. Moreover, there is no single article that addresses the relationship between livestock and climate change in the whole of North Africa but there are some multi-country studies (Lazarev, 2017). There are some Africa-wide studies; for example, Herrero et al. (2008) analyse the methane emissions from cattle, goats and sheep from 2000 to 2030 across African regions (East, West, Southern, Central and North Africa, and Horn of Africa). Further articles have a more Mediterranean or global perspective. For instance, Annicchiarico et al. (2013) analyse optimal forage grass germplasm for drought-prone

environments in different Mediterranean countries (viz. Algeria, France, Italy, Morocco and Portugal).

Only a few of the selected articles addresses the contribution of livestock to GHG in North Africa. As in many other regions, livestock has a significant contribution to GHG emissions. Ibidhi et al. (2017) show that regardless of the pastoral system (viz. pastoral system using barley, agro-pastoral system using cereal crop-residues, or agro-pastoral system using barley), sheep meat (28 CO_2-eq/kg) has a higher carbon footprint than chicken meat (3 CO_2-eq/kg) in Tunisia. Among the three pastoral systems, the agro-pastoral system using cereal crop-residues has the highest carbon footprint. In their analysis of methane emissions from African domestic ruminants (viz. cattle, goats and sheep) from 2000 to 2030, Herrero et al. (2008) put that emissions per tropical livestock unit (TLU, 250 kg bodyweight) can vary from 21 to 40 kg per TLU and per year, depending on the production system (emissions being higher in mixed crop-livestock systems than in pastoral systems) and the region (emissions being higher in the Horn of Africa, West and East Africa than in North Africa). The literature also analyses strategies to mitigate GHG emissions from livestock. These include the management of pastures and rangelands. The use of land as pasture decreases its carbon stocks as well as its capacity to sequester organic carbon (Znaidi et al., 2020). The literature also shows the intricate global connections when it comes to climate change. For instance, Yawson (2020) shows that the projected impacts of climate change as well as climate mitigation policies in the UK (cf. Global North) can reduce the land area for barley and create large deficits in supply with a consequent decrease in feed barley exports to Algeria and Tunisia (cf. Global South), which rely on feed barley supply from the UK and Europe, thus increasing their vulnerabilities. Therefore, it is important to combine climate change mitigation with climate justice in order to avoid negative side-effects and externalities.

Table 3. North African countries where research was performed.

Country or region	Number of documents	References
Algeria	4	Arabi et al. (2015); Daoudi et al. (2013); Rouabhi et al. (2019); Semara et al. (2018)
Egypt	3	Dadamouny and Schnittler (2016); El Shaer (2015a); McCarl et al. (2015)
Morocco	7	Freier et al. (2011); Freier et al. (2012); Frenette-Dussault et al. (2013); Martin et al. (2016); Müller et al. (2015); Parish and Funnell (1999); Petit and Boujenane (2018)
Tunisia	8	Amamou et al. (2018); Aribi and Sghaier (2021); Gamoun et al. (2011); Ibidhi et al. (2017); Ouled Belgacem et al. (2019); Souissi et al. (2018); Wellens (2003); Znaidi et al. (2020)
North Africa*	1	Lazarev (2017)
Africa**	1	Herrero et al. (2008)
Global***	8	Annicchiarico et al. (2013); Annicchiarico et al. (2011a); Annicchiarico et al. (2011b); El Shaer (2015b); Jaber et al. (2016); Ouled Belgacem and Louhaichi (2013); Thomas (2008); Yawson (2020)

* This category includes documents dealing with at least two countries from North Africa.
** This category includes documents addressing at least a North African country and another one from Sub-Saharan Africa.
** This category includes documents dealing with at least another country outside Africa.

The analysed literature addresses the effects of climate change on livestock across North Africa as well as adaptation strategies. The impacts of climate change on livestock are both direct and indirect. Direct impacts regard the effects on livestock productivity/performance (Amamou et al., 2018; McCarl et al., 2015). Amamou et al. (2018) argue that the greatest impact of climate change in Tunisia would be on cattle performance. In the Middle East and North Africa (MENA) region, El Shaer (2015b) postulates that "*Grasslands, livestock, and water resources are likely to be most vulnerable to climate change in the region because they are located mostly in marginal areas*" (p. 7). Indirect impacts concern the effects of climate change on the production of fodder and feed as well as on pastures and rangelands. In fact, climate change affects feed

and fodder quantity and quality (Amamou et al., 2018; Annicchiarico et al., 2013; Annicchiarico et al., 2011a; Arabi et al., 2015; Wellens, 2003). Gamoun et al. (2011) found that plant cover, richness, and diversity in arid communal rangeland in southern Tunisia changes with soil and rainfall variations. Amamou et al. (2018) suggest that climate change will affect forage production in Tunisia. The vulnerability of rangeland plant species to climate change changes from a species to another depending, among others, on how broad are ecological niches and species palatability (Ouled Belgacem & Louhaichi, 2013). Referring to the arid steppes of eastern Morocco, Frenette-Dussault et al. (2013) suggest that the "*effects of climate change will strongly modify plant community structure in arid steppes, possibly accentuating the process of desertification, and reducing the pastoral value of the vegetation*". The sustainable management of rangelands is important not only to mitigate GHG emissions but also to improve their resilience and adaptation to climate change, especially in arid environments, such as those of North Africa (Ouled Belgacem et al., 2019).

The literature also addresses the measures and strategies for the adaptation of livestock and pastoral communities to the changing climate. The adaptation of livestock to climate changes from a breed to another. For instance, Petit and Boujenane (2018) show that Timahdite and D'man sheep breeds are more adapted to rainfall change and temperature variation, respectively, in Morocco. In this context, some articles deal with the perceptions of herders and pastoral communities about climate change and variability (Amamou et al., 2018). The same authors put that almost all the surveyed Tunisian dairy farmers perceived the impact of climate change on their farms. Many scholars highlight the vulnerability of the livelihoods of pastoralists and livestock breeders to climate change in North Africa (Aribi & Sghaier, 2021; Daoudi et al., 2013; Martin et al., 2016; Thomas, 2008). Referring to the Arab region, Jaber et al. (2016) argue that "*local livestock production is largely based on rainfed mixed and pastoral livestock systems making it vulnerable to the effects of climate change and water scarcity*" (p. 899). Souissi et al. (2018) assume that 55% of the farms in Tunisia are resilient to climate change as "*They are diversified and mostly grow cereals, vegetables, and forage crops combined with livestock, increasing their capability to mitigate climate change by reorganizing crop activities*" (p. 637). However, livelihood vulnerability is moderated by many factors such as farm typology (Amamou et al., 2018), degree of reliance on family labour (Aribi & Sghaier, 2021), and household livelihood assets (Daoudi et al., 2013). Depending on the pastoral household characteristics, climate change interacts with numerous other endogenous and exogenous sources of variability in determining the level of livelihood vulnerability/security such as income needs and pastoral mobility level (Martin et al., 2016).

Livestock breeders have adopted different strategies to adapt to climate change (Amamou et al., 2018; Daoudi et al., 2013). Tunisian dairy farmers focus on increasing water availability for livestock and crop production, and improving livestock housing conditions (Amamou et al., 2018). Another strategy to cope with climate risk consists in providing livestock with supplementary fodder but this supplementation might result in overstocking and rangeland degradation (Müller et al., 2015). Semara et al. (2018) found that strategies adopted by cattle farmers in Setif (Algeria) to adapt to climate change include the reduction in the herd size. However, the diversity of the livestock farming systems can be among the strategies put in place to adapt to climate change. For instance, referring to the region of Setif (Algeria), Rouabhi et al. (2019) put that "*The main changes in agricultural activities for adapting to climate constraint were a reduction of areas devoted to rainfed crops (cereals) and the adoption of an intensive farming system based on poultry, cattle breeding and intensive crops*" (p. 79). Adaptation strategies can also simply encompass moving from a pastoralism system to another. Freier et al. (2012) show that future livelihood strategies of transhumant pastoralists in semi-arid Morocco include 'sedentarity' and localized pastoralism. Proposals from scholars for improving the adaptation of herders and pastoralists to climate change range from promoting livelihoods diversification and resilience to establishing climate warning systems (Table 4).

Table 4. Proposals for improving the adaptation of livestock breeders and pastoralists to climate change in North Africa.

Adaptation measure	Reference
Providing direct aid to the most affected households	Aribi and Sghaier (2021)
Payment for environmental services (e.g. carbon sequestration) in rangelands	Thomas (2008)
Sustaining households' livelihoods diversification	Aribi and Sghaier (2021) El Shaer (2015a) Thomas (2008)
Developing alternative production and management systems	El Shaer (2015b) Thomas (2008)
Breeding of more drought and heat tolerant germplasm	Thomas (2008)
Reintroducing traditional grazing systems practices for improving rangelands	Ouled Belgacem et al. (2019)
Promoting participatory and inclusive governance systems at grassroots community's level	Lazarev (2017)
Developing early warning systems for climate extremes	Aribi and Sghaier (2021) Thomas (2008)

IV - Conclusions

This paper provides a comprehensive review of the dual relationship between livestock and CC in North Africa. The geography of the research suggests that most studies have been carried out in Tunisia and Morocco. Meanwhile, the analysis of the selected documents shows that most studies focus on CC adaptation while CC mitigation is generally overlooked. The livestock sector has a significant contribution to GHG emissions, especially methane. However, emissions depend, inter alia, on livestock species and pastoral systems. Sustainable management of pastures and rangelands can help mitigating livestock-related GHG emissions. The analysed literature addresses the effects of CC on livestock across North Africa as well as adaptation strategies. The impacts of CC on livestock are both direct and indirect. Direct impacts regard effects on livestock productivity/performance. The adaptation of livestock to CC changes from a breed to another. Indirect impacts concern the effects of CC on the production of fodder and feed as well as on pastures and rangelands. Grasslands and livestock are vulnerable to CC because they are located mostly in marginal areas. CC affects feed and fodder quantity and quality. However, the vulnerability of rangeland plant species to CC changes from a species to another. The effects of CC will likely modify plant community structure and affect the pastoral value of the vegetation in arid and semi-arid rangelands. The literature also addresses the measures and strategies for the adaptation of livestock and pastoral communities to the changing climate. The livelihoods of North African pastoralists and livestock breeders are vulnerable to CC because they are largely based on rainfed mixed and pastoral livestock systems. However, livelihood vulnerability depends on pastoral mobility and is moderated by many factors such as farm typology and household livelihood assets. Livestock breeders have adopted different strategies to adapt to CC such as the reduction in the herd size and the diversification of livelihoods. Given the high vulnerability of North Africa to the adverse impacts of CC, the main focus of the current research is on CC adaptation and resilience. Strategies for CC mitigation and adaptation in the North African livestock sector need to be contextualized and to take into account the diversity of livestock farming systems in the region to achieve effectiveness, efficacy and sustainability. It is important to promote sustainable grassland-based, extensive livestock systems while improving ecosystem services in North Africa. The article suggests that climate mitigation policies should also consider the uneven impacts of CC on the livelihoods of rural communities in North Africa.

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Pastoralism and biodiversity in Burkina Faso and Niger: A review

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Abstract. Burkina Faso and Niger are two landlocked countries in Sahelian West Africa. Pastoralism is one of the most important livelihood strategies in both countries and can play a central role in biodiversity conservation. This paper analyses the state of research on the relation between pastoralism and biodiversity in Burkina Faso and Niger. It draws upon a systematic review of 36 documents identified through the Web of Science. Literature analysis shows that the effects of pastoralism are rather mixed as they are context-specific and depend on many factors such as grazing intensity and livestock species. In general, pastoralism has a negative effect on plant species diversity, especially in terms of abundance, but with distinct effects on woody (trees and shrubs) and herbaceous species. Pastoralism can also impact the diversity of wild fauna. On the other hand, while there is a general trend towards the erosion of indigenous livestock genetic diversity, due inter alia to cross-breeding, pastoralism and traditional knowledge of pastoral communities result fundamental in the conservation of local, indigenous livestock breeds. Further research is needed to promote sustainable management of pastures and grasslands that ensures biodiversity conservation while preserving pastoral communities' livelihoods in Burkina Faso and Niger.

Keywords. agro-pastoralism, plant diversity, animal diversity, genetic diversity, species diversity, Sahel, West Africa.

Pastoralisme et biodiversité au Burkina Faso et au Niger : une revue de la littérature

Résumé. *Le Burkina Faso et le Niger sont deux pays enclavés d'Afrique de l'Ouest sahélienne. Le pastoralisme est l'une des stratégies de subsistance les plus importantes dans les deux pays et peut jouer un rôle central dans la conservation de la biodiversité. Cet article analyse l'état des recherches sur la relation entre le pastoralisme et la biodiversité au Burkina Faso et au Niger. Il est basé sur une revue systématique de 36 documents identifiés via le Web of Science. L'analyse de la littérature montre que les effets du pastoralisme sont plutôt mitigés car ils sont spécifiques au contexte et dépendent de nombreux facteurs tels que l'intensité du pâturage et les espèces de bétail. En général, le pastoralisme a un effet négatif sur la diversité des espèces végétales, notamment en termes d'abondance, mais avec des effets distincts sur les espèces ligneuses (arbres et arbustes) et herbacées. Le pastoralisme peut également avoir un impact sur la diversité de la faune sauvage. D'autre part, alors qu'il existe une tendance générale vers l'érosion de la diversité génétique du bétail indigène, due entre autres aux croisements, le pastoralisme et les connaissances traditionnelles des communautés pastorales sont essentiels à la conservation des races de bétail indigènes et locales. Des recherches supplémentaires sont nécessaires pour promouvoir une gestion durable des pâturages et des prairies qui assure la conservation de la biodiversité tout en préservant les moyens de subsistance des communautés pastorales au Burkina Faso et au Niger.*

Mots-clés. *agro-pastoralisme, diversité végétale, diversité animale, diversité génétique, diversité des espèces, Sahel, Afrique de l'Ouest.*

I - Introduction

Burkina Faso and Niger are two landlocked countries in Sahelian West Africa. Both countries are in the low human development category (UNDP, 2019) and affected by multiple forms of

malnutrition (FAO et al., 2018; USAID, 2018b, 2018a). Burkina Faso (BF) and Niger also should fill the gap in terms of sustainable development and the implementation of the Sustainable Development Goals (SDGs) (Sachs et al., 2017). In 2018, 83.5% of the population in Niger and 70.6% in BF lived in rural areas (World Bank, 2021). Agriculture is a leading sector for the economy of BF and Niger. According to the World Bank's data, agriculture contributes to 28.6% of GDP in BF and 39.6% in Niger, while employment in agriculture is at 75.9% in Niger and 28.6% in BF. While the share of land under permanent meadows and pastures in agricultural land is 49.59% in BF and 61.76% in Niger, their share in the land area is 21.93% in BF and 22.72% in Niger (FAOSTAT, 2021). Therefore, pastoralism is one of the most important drivers of land use in BF and Niger.

There is an ongoing academic debate on the role of pastoralism in biodiversity decline, especially in resource-poor regions such as the Sahel. Some scholars point out pastoralism as a major cause of land degradation and desertification (Boussaïd et al., 2018; Zerboni & Nicoll, 2019) and deforestation (Campbell et al., 2017; Mebirouk-Boudechiche et al., 2016), mainly because of overgrazing (Boussaïd et al., 2018; Zerboni & Nicoll, 2019). Meanwhile, other scholars reject the direct link between pastoralism and desertification (Blanco et al., 2015), and argue that pastoralism and agro-pastoralism are compatible with biodiversity conservation (Davis, 2005). In this context, the present paper analyses the state of research on the relation between pastoralism and biodiversity in BF and Niger; in particular, it sheds light on the relationships between pastoralism, on the one hand, and plant diversity, animal diversity and ecosystem diversity, on the other hand.

II - Methods

The paper draws upon a systematic review (Moher et al., 2009) of all documents indexed in the Web of Science (WoS). A search was carried out on 18 March 2021 using the following Title-Abs-Key search query: *(pastoralism OR pastoralist OR pastoral OR grazing OR rangeland OR pasture) AND (diversity OR diverse) AND (Burkina OR Niger OR "West* Africa" OR Sahel)*. The initial search yielded 137 documents. Three eligibility criteria were considered during the selection of documents to be included in the systematic review: geographical coverage (viz. document deals with Burkina Faso and/or Niger); thematic focus (viz. document deals with both pastoralism and biodiversity); and document type (viz. only research articles, book chapters or conference papers were selected; reviews, letters to editors, commentaries and/or notes were discarded). Following the screening of titles, 27 documents were excluded as they do not refer to BF or Niger; documents covering wider geographical areas (e.g. West Africa, Sahel, Sub-Saharan Africa) were kept for further analysis. Further 25 documents were excluded following the scrutiny of abstracts as they do not meet at least one of the eligibility criteria. In particular, articles that deal with the diversity of insects and arthropods were excluded. Additionally, 49 documents were discarded following the analysis of full-texts. Therefore, only 36 documents met all the eligibility criteria and were included in the systematic review (Table 1).

Table 1. List of the selected documents.

Year	Documents number	References
2019	3	Leßmeister et al. (2019); Naah and Braun (2019); Sanou et al. (2019)
2018	2	Sanou et al. (2018); Zliobaite et al. (2018)
2017	4	Naah and Guuroh (2017); Tindano et al. (2017); Vall et al. (2017); Volpato et al. (2017)
2016	3	Bocksberger et al. (2016); Rasmussen et al. (2016); Zinsstag et al. (2016)
2015	5	Abdussamad et al. (2015); Brugière et al. (2015); Diarisso et al. (2015); Sanon et al. (2015); Traoré et al. (2015)
2013	1	Mueller (2013)
2012	1	Sawadogo et al. (2012)
2011	1	Ayantunde et al. (2011)

Year	Documents number	References
2009	2	Hiernaux et al. (2009); Savadogo et al. (2009)
2008	4	Kiem et al. (2008); Klop and Prins (2008); Savadogo et al. (2008); Traoré et al. (2008)
2007	1	Devineau and Fournier (2007)
2006	3	Jamnadass et al. (2006); Kiema and Sanon (2006); Thiollay (2006)
2005	1	Mortimore and Turner (2005)
2003	2	Madsen et al. (2003); Söderström et al. (2003)
1999	2	Devineau (1999); Hiernaux and Gérard (1999)
1998	1	Hiernaux (1998)

III - Results and Discussion

Different scholars dealt with the diversity of grasses and fodder trees in pastures and rangelands in BF and Niger. Madsen et al. (2003) identified 131 common vascular plant species in two reference sites located in traditionally managed agro-pastoral landscapes of the Sahelian and Sudanean zones of Burkina Faso, while Naah and Guuroh (2017) identified 135 species of forage plants in the area ranging from northern Ghana to central Burkina Faso. Naah and Braun (2019) point out that agro-pastoralists in northern Ghana and southern-central Burkina Faso exhibited extensive local ecological knowledge (LEK) on habitat types, forage species diversity, abundance trends, and ecological drivers. Furthermore, Naah and Guuroh (2017) show that both ethnicity and environmental harshness (e.g. aridity) can markedly shape the body of local ecological knowledge of agro-pastoralists on forage plants in Ghana and Burkina Faso. However, local knowledge is not always validated by and consonant with modern science as shown by Abdussamad et al. (2015) in the case of genetic variation and colour phenotypes of dromedaries in the Nigeria-Niger corridor.

Many scholars highlight that pastoralism and grazing reduce species abundance and/or richness, although a distinction between herbaceous and woody species is necessary in this regard. Sanou et al. (2018) argue that intensive grazing resulted in a reduction in species diversity and a change in species composition with a decrease in the richness of perennial grasses. The effect of pastoralism on species richness and abundance is particularly true for herbaceous species (Leßmeister et al., 2019; Savadogo et al., 2009). In their analysis of vegetation changes over the past decades in savannah ecosystem in south-eastern Burkina Faso, Leßmeister et al. (2019) found no change in species composition and richness of woody vegetation but their abundance decreased; meanwhile, there was a considerable change in the species composition of herbaceous vegetation and species richness increased; in particular, grazing leads to a decrease in the abundance of fodder herbaceous species preferred by the livestock. Hiernaux (1998) found no clear relationships between species response to grazing (in terms of species composition and spatial distribution) and palatability in Sadore (Niger). Referring to Burkina Faso, Mueller (2013) warns that "*In many areas, tiger bush vegetation had completely disappeared or had been dramatically reduced over the last 50 years probably as a result of increased anthropogenic pressure and grazing. Still existing tiger bush stands are often degraded*" (p. 153) and in Kotchari area (south-eastern Burkina Faso), while Sawadogo et al. (2012) show that pastures located outside the protected area (W National Park) tend to be the most degraded with problems in trees regeneration and a decrease of perennial herbaceous species. However, the impact of pastoralism depends on grazing intensity (Leßmeister et al., 2019; Sanou et al., 2018). Hiernaux et al. (2009) argue that changes in grazing pressure, land use, and soil fertility triggered changes in species composition with a strong reduction in diversity from rangelands to fallows in Fakara region (Niger).

While many scholars highlight the negative effects of pastoralism on biodiversity, Zinsstag et al. (2016) point out the positive role of pastoralism in the conservation of biodiversity and put "*it*

appears that pastoral social ecological systems are hotspots of cultural and biological diversity. They are multifunctional in that they generate diversified sources of income and contribute to sustained natural resource management" (p. 693). In this respect, Devineau and Fournier (2007) argue that cattle herding does not affect herbaceous species richness in Sudan-type savannah (Bondoukuy, western Burkina Faso) and that there is no clear evidence of lower species richness due to this anthropogenic disturbance. Similarly, Jamnadass et al. (2006) suggest that grazing has not caused a loss of the genetic diversity of wild forage species in western Niger. Traoré et al. (2015) found that grazing was associated with more tree species and stem density in the Sudanian woodland of Burkina Faso and recommend revising the current regulation that prohibits grazing to accommodate herders' interests. Likewise, Savadogo et al. (2008) argue that in the Sudanian savannah-woodlands of Burkina Faso, over a 10-year period (1994-2003), grazing tended to favour perennial grasses diversity.

Pastoral activities have also an impact on wildlife (Brugière et al., 2015; Zliobaite et al., 2018). As a matter of fact, pastoralism can create competition with wild animals and, consequently, affect their diversity and abundance (Brugière et al., 2015; Zliobaite et al., 2018). For instance, Brugiere et al. (2015) suggest that pastoralism (especially mobile, transhumant pastoralism) may explain the extinction pattern of large predators (viz. lions, cheetahs, and wild dogs) in Western and Central Africa. Livestock species also compete with wild large herbivorous mammals (Zliobaite et al., 2018). Pastoralism can also affect the populations of birds in West Africa (Söderström et al., 2003; Thiollay, 2006); for instance, Thiollay (2006) postulates that hunting, and habitat degradation and fragmentation, mainly due to intensive cattle grazing and woodcutting, have contributed to a decline of the passerine bird community in the Sudanian belt of Burkina Faso.

Pastoral activities have also an impact on the diversity of domesticated animals. Many articles point out that indigenous livestock genetic resources are being eroded. One threat to indigenous livestock breeds is represented by uncontrolled mating. For instance, Abdussamad et al. (2015) highlight that dromedaries in the Nigeria-Niger corridor exhibit a high genetic diversity, which might be due to the continuous gene flow with other dromedary populations during transhumance. The erosion of the local livestock genetic resources goes hand in hand with that of the traditional, indigenous knowledge associated with local, indigenous breeds. For instance, Volpato et al. (2017) argue that the demise of pastoral livelihoods represents a serious threat to piebald (painted) camels across the Sahara and Sahel. According to Ayantunde et al. (2011), "*Pastoralism is not only a livestock-based livelihood strategy but also a way of life with socio-cultural norms and values, and indigenous knowledge revolving around livestock*" (p. 30) and any programme for the conservation of animal genetic resources or their improvement should consider the diversity of goals and preferences among livestock keepers (Tindano et al., 2017).

IV - Conclusions

This paper provides a comprehensive analysis of the literature dealing with the relation between pastoralism and biodiversity in Burkina Faso and Niger. In general, the scholarly literature shows a negative impact of pastoralism on plant diversity (in terms of richness, abundance and composition) and animal diversity (wild herbivorous mammals, predators as well as birds) in Burkina Faso and Niger. However, the literature analysis suggests that the effects of pastoralism are rather mixed; they are context-specific and depend on many factors (e.g. grazing intensity, livestock species). Effects on plant diversity differ between woody (trees and shrubs) and herbaceous species. There is a general trend towards the erosion of indigenous livestock genetic diversity due to uncontrolled mating and cross-breeding, but pastoral communities' traditional knowledge is fundamental for the conservation of local livestock breeds. Therefore, the present literature is far from being conclusive which highlights the need for future studies on pastoralism-biodiversity nexus. The review clearly shows the importance of science-informed and evidence-based tailored management of pastures and grasslands in

Burkina Faso and Niger to balance the twin imperatives of biodiversity conservation and pastoralism development.

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Restoration of pseudoalpine grasslands in Oiti National Park, Central Greece

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Abstract. Pseudoalpine grasslands of Oiti National Park are degraded due to the interruption of the traditional land use practices including transhumance, periodical burning and firewood collection resulting in the dominance of competitive plants and, especially, the invasion of the dwarf juniper (*Juniperus communis ssp. nana*). The objective of this research was to study the treatments applied imitating traditional management practices for the restoration of grassland flora. In the autumn of 2013, prescribed burning was applied and after one year an area covered with "wolf" grasses was cut. In addition, an area outside the core of the park that was grazed by sheep was divided into three grazing intensity treatments. In all areas, 33 pairs of protected with mesh wire and freely grazed plots were established in spring of 2015. At the end of the growing period, in July, cover and species composition was ocularly estimated, while biomass was measured in quadrats (2015 and 2016). Except the burning treatment, cutting and grazing did not affect plant cover while species composition was positively influenced especially by burning and cutting that favored low growing species with higher nutritional value (*Festuca alpina* and *F. polita*). In contrast, biomass was significantly affected only by burning and grazing. It is concluded that moderate sheep grazing should be legally allowed in the core of the Park including the use of prescribed burning which is very effective in controlling dwarf juniper.

Keywords: prescribed burning - cutting of herbaceous plants - grazing intensity - biomass

Restauration des prairies pseudoalpine dans le parc national Oiti, Grèce centrale

Résumé. *Les prairies pseudoalpines du parc national d'Oiti sont dégradées en raison de l'interruption des pratiques traditionnelles d'utilisation des terres, y compris la transhumance, le brûlage périodique et la collecte de bois de chauffage entraînant la dominance de plantes compétitives et, en particulier, l'invasion du genévrier nain (Juniperus communis ssp. nana). L'objectif de cette recherche était d'étudier les traitements appliqués imitant les pratiques de gestion traditionnelles pour la restauration de la flore des prairies. A l'automne 2013, des brûlages dirigés ont été pratiqués et au bout d'un an une zone couverte d'herbes « à loups » a été coupée. De plus, une zone à l'extérieur du cœur du parc qui était pâturée par des moutons a été divisée en trois traitements d'intensité de pâturage. Dans toutes les zones, 33 paires de parcelles protégées avec des grillages et des parcelles pâturées librement ont été établies au printemps 2015. À la fin de la période de pâturage, en juillet, la couverture et la composition des espèces ont été estimées oculairement, tandis que la biomasse a été mesurée en quadrats (2015 et 2016). À l'exception du brûlage, la coupe et le pâturage n'ont pas affecté la couverture végétale tandis que la composition des espèces a été positivement influencée en particulier par le brûlage et la coupe qui ont favorisé les espèces à faible croissance et à valeur nutritionnelle plus élevée (Festuca alpina et F. polita). En revanche, la biomasse n'a été significativement affectée que par le brûlage et le pâturage. Il est conclu que le pâturage modéré des moutons devrait être légalement autorisé dans le cœur du parc, y compris l'utilisation du brûlage dirigé qui est très efficace pour contrôler le genévrier nain.*

Mots-clés. *Brûlage dirigé - coupe de plantes herbacées - intensité de pâturage - biomasse*

I - Introduction

Nomadic animal husbandry was the main factor in the creation and shaping of meadow landscapes in the mountain ranges of the country (Ispikoudis et *al*. 2004), which include the grasslands of the pseudo-alpine zone. Not only sheep grazing (to a lesser extent goats and large animals) contributed to their preservation, but also the habit of nomadic breeders to set fires at the end of the summer grazing season (Fotiadis et *al*. 2004), shortly before leaving for the winters, in order to control the weeds (herbaceous and woody), as well as the frequent cutting of the woody plants of the grasslands to meet their needs for fuel. With the reduction of nomadic livestock from 1960 onwards, the cover and composition of the vegetation of these ecosystems gradually changed, but also their shrinkage due to the expansion of the forest resulting in the reduction of biodiversity (Papanastasis 2012). A typical case of the above developments is the mountain complex of Oiti, in Central Greece. The sheep farming that was practiced in the past, mainly by Sarakatsani, but also in general the traditional activities have disappeared, after its proclamation as a National Park (Government Rule 56 / A BD 218/1966), when grazing in its core was completely banned. The consequence of these developments was that certain competing species prevailed in the grasslands of the pseudo-alpine zone and invaded woody plants, thus altering their flora (Mantzanas et *al*. 2014).

The purpose of the work was to study the treatments applied in imitation of the traditional management activities for the flora of the degraded grasslands of the Oiti National Park.

II - Materials and methods

Oiti is located in region of Fthiotida and has a maximum height of 2152 m. According to Karetsos (2002), the natural vegetation consists mainly of fir forests (*Abies cephallonica*) and secondarily of grasslands, which grow in the forest in the pseudo-alpine zone, and which also contain the dwarf cedar bush (*Juniperus communis spp. nana*) in various degrees of cover. The latter is represented by the priority habitat type with code 6230 * which represents rich in species of grasslands with Nardus, in a silicate substrate of the mountainous area (Ministry of Environment, Physical Planning and Public Works 1999). In October 2013, the dwarf cedar was burned as planned, as an imitation of the fires set by the nomadic shepherds in Oiti, before the creation of the National Park (NP) in 1966. Also, in the fall of 2014, the tall grasses were cut with a machine. Both of these treatments took place at the "Livadies" site, in the area of the core of the NP, where, although prohibited, there was occasional grazing by free-range cattle. The cutting of the plants was repeated in the autumn of 2015. In addition, in the location "Alubei", which is located on the edge of the core and is grazed by sheep, areas with three grazing intensities (intense, moderate, light) were distinguished. In all these places were placed in the spring of 2015 (before the start of grazing) thirty three (33) pairs of protected (wire cages) and free of grazing (control) sampling surfaces, with dimensions 1.5x1.5 m each. Specifically, 12 pairs were placed in the burning treatment (6 in burnt dwarf cedar and 6 in adjacent unburned area), 12 in the cutting treatments (from 6 in two different positions) and 9 pairs in the three grazing intensities (three in each intensity). These surfaces were moved to neighbouring locations in the spring of 2016. In July 2015 (at the end of the growing season), measurements of vegetation cover and composition were made on the sampling surfaces. Cover was assessed visually in each area by two independent observers and included the percentage of area of each frame covered with vegetation, dry matter and bare soil. For the composition, the three dominant plant species on each surface were identified, also by two independent observers. Then, two square frames measuring 0.50x0.50 m each were randomly placed in each surface, where the above ground biomass was cut with scissors and transferred to the Laboratory for drying and weighing. The biomass measurements were repeated in July 2016. The biomass data of each year were analyzed with the statistical plan of the combined factors with the SPSS

22 program.

III - Results and discussion

Except the burnt treatments, which resulted in reduced vegetation coverage and increased bare soil and dry matter relative to the unburned, the other treatments had no significant effect on vegetation cover, either soil or dry matter (Table 1). The cutting had a significant effect on the fequency of the species, because it enhanced the low-growing species, such as *Astragalus hamosus, Festuca alpina* and *Hieracium hoppeanum*, at the expense of the high-growing species (*Agrostis gigantea, Filipendula vulgaris* and *Thymus longicaulis*) (Table 2).

Table 1. Plant cover in three treatments

Site	Treatment	Protection	Cover		
			Vegetation	Bare soil	Dry matter
Livadies	Cut	Yes	85.0	10.2	4.8
		No	81.3	11.7	7.0
Livadies	Not cut	Yes	85.4	6.7	7.9
		No	84.6	7.9	7.5
Aloubei	Heavy grazing	Yes	75.8	10.0	14.2
		No	67.5	17.5	15.0
Aloubei	Moderate grazing	Yes	82.5	10.8	6.7
		No	70.8	15.0	14.2
Aloubei	Light grazing	Yes	89.2	5.0	5.8
		No	71.7	13.3	15.0
Livadies	Burnt	Yes	35.0	40.4	24.6
		No	36.7	42.0	21.3
Livadies	Not burnt	Yes	57.5	25.8	16.7
		No	52.5	24.6	22.9

Table 2. Frequency (%) of dominant species in cutting treatment

Plant species	Cut		Not cut	
	Protection	Control	Protection	Control
Agrostis gigantea	-	-	25	8
Astragalus hamosus	42	42	17	8
Centaurea nervosa	42	42	83	50
Festuca polita	17	17	8	-
Festuca alpina ssp. *briquetii*	67	67	58	67
Filipendula vulgaris	-	-	8	25
Galium verum	42	42	-	50
Hieracium hoppeanum	33	33	17	17
Thymus longicaulis ssp. *longicaulis*	-	-	17	17
Trifolium medium	25	25	50	42
Other species	33	33	17	17

Among the three degrees of grazing, intense grazing had a greater effect than moderate and especially light, because it reduced the dominant species, such as *Festuca alpina* (Table 3). The effect of burning was greater, which enhanced the presence of photophious species *Centaurea solstitialis, Galium verum, Polygonum arenarium* and *Verbascum epixanthinum*,

which in fact did not exist in the flora of the neighbouring (without dwarf) grassland (Table 4). It is speculated that the seeds of these species should have been in the ground (bank), under the dwarf cedar.

Table 3. Frequency (%) of dominant species in grazing treatment

	Heavy grazing		Moderate grazing		Light grazing	
Φυτικό είδος	**Protection**	**Control**	**Protection**	**Control**	**Protection**	**Control**
Agrostis gigantea	33	33	-	-	-	-
Astragalus hamosus	33	33	-	-	-	-
Festuca alpina ssp. *briquetii*	100	83	83	100	100	100
Filipendula vulgaris	-	-	33	17	50	83
Galium verum	17	-	-	-	50	17
Plantago holosteum	33	-	-	-	17	17
Poa bulbosa	33	17	-	17	-	-
Trifolium arvense	-	-	50	33	-	-
Trifolium fragiferum	-	-	-	17	67	-
Trifolium repens	33	33	33	33	-	50
Other sprcies	17	67	100	83	17	33

Table 4. Frequency (%) of dominant species in burning treatment

	Burnt		**Not burnt**	
Φυτικό είδος	**Protection**	**Control**	**Protection**	**Control**
Astragalus hamosus	8	8	50	25
Centaurea solstitialis	33	17	-	-
Festuca alpina ssp. *briquetii*	25	42	58	83
Galium verum	58	50	-	-
Hieracium hoppeanum	-	8	25	25
Hypericum perforatum	-	8	25	8
Plantago holosteum	-	-	75	11
Polygonum arenarium	25	25	-	-
Thymus longicaulis ssp. *longicaulis*	-	8	17	33
Verbascum epixanthinum var. *epixanthinum*	33	17	-	-
Other species	33	75	50	33

Regarding biomass yield, the cutting treatment did not give statistically significant differences, in contrast to the burning treatment, where there were significant differences between 2015 and 2016 (Tables 5 and 7), which shows that the second treatment was more efficient than the first. Regarding grazing treatment, it reduced production in both years, but statistically significant differences were found only in the second year (2016). In contrast, there were no statistically significant differences in burning treatments, which means that grazing intensity was slightly at the core of the national park.

Table 5. Average yield biomass (Kg/ha) in cutting treatment

Year		
	Cut	**Not cut**
2015	2,639 a*	2,339 a
2016	2,226 a	1,766 a
	Protection	**Control**
2015	2,654 a	2,325 a

2016	2,575 a	1,417 b

* Same letters on the same line show that there are no statistical differences in the significance level of 0.05.

Table 6. Average yield biomass (Kg/ha) in grazing treatment

Year	Heavy grazing	Moderate grazing	Light grazing
2015	1,326 b*	1,758 b	4,681 a
2016	1,733 a	1,826 a	2,141 a
	Protection		**Control**
2015	3,165 a		2,012 b
2016	3,099a		703 b

* Same letters on the same line show that there are no statistical differences in the significance level of 0.05.

Table 7. Average yield biomass (Kg/ha) in burning treatment

Year		
	Burnt	**Not burnt**
2015	1,629 a*	601 b
2016	1,311a	742 b
	Protection	**Control**
2015	1,256 a	975 a
2016	1,257a	796 a

* Same letters on the same line show that there no statistical differences in the significance level of 0.05.

In contrast, grazing statistically significantly reduced biomass on grazed areas outside the core of national park. Statistically significant effects were moderate and, in particular, intense grazing only in the first year of 2015 (Table 6).

IV - Conclusions

Both prescribed burning and cutting are effective methods for repairing degraded pseudo-alpine grasslands. Burning is more drastic but can be applied once to control dwarf cedar in pseudo-alpine grasslands, while favoring photophilous herbaceous species and enhancing aboveground biomass. Cutting, on the other hand, is a less effective method, although it can control competing species, but it must be applied on an annual basis. It turns out that in order to restore the pseudo-alpine grasslands of Oiti mountain, controlled burning should be introduced as a management tool and the normal (moderate) grazing of livestock in the core of national park, mainly sheep, should be allowed.

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Survey of olive agrosilvopastoral systems in Chalkidiki, N. Greece

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Abstract. Olive (*Olea europea* L.) is an important evergreen tree species of Mediterranean area that is planted in order to produce table olives and olive oil. Olive agrosilvopastoral systems are found in many regions of Greece; in combination with natural vegetation and/or intercropping. These systems are threatened by abandonment or conversion to intensive monocultures. The aim of this study was to identify olive agrosilvopastoral systems in the region of Chalkidiki, North (N) Greece and evaluate their characteristics. In order to achieve this, the Corine Land Cover classification system of land use types was applied on google earth satellite images and onsite observations were conducted. Three different systems were identified; a) silvoarable systems with trees in rows intercropped with cereals, b) silvoarable systems with scattered trees intercropped with cereals, and c) silvopastoral systems with scattered trees with natural vegetation and grazing. These systems were mainly found in the Corine land cover type 223 (olive groves) and occupied 12.052.64 ha of the study area. The majority of the systems were silvopastoral with scattered trees and natural vegetation. The preservation of the agroforestry systems of the area was mainly due to the occupation of the local population with tourism. The adoption of the new CAP agri-environmental measures by farmers could contribute further to their exploitation.

Keywords. Corine Land Cover –Silvoarable -Silvopastoral systems-Tree arrangement

Enquête sur les systèmes agrosylvopastoraux d'olivier à Chalkidiki, Grèce du Nord

Résumé. *L'olivier (Olea europea L.) est une importante espèce arboricole de la Méditerranée qui est plantée pour produire des olives de table et de l'huile d'olive. Les systèmes agrosylvopastoraux d'olivier sont identifiés dans de nombreuses régions de la Grèce, en combinaison avec la végétation naturelle et/ou les cultures intercalaires. Ces systèmes sont menacés par l'abandon ou la conversion en monocultures intensives. L'objectif de cette étude était d'identifier les systèmes agrosilopastoraux d'olivier dans la région de Chalkidiki, Grèce du Nord, et d'évaluer leurs caractéristiques. À cette fin, le système de classification des types d'utilisation des terres « Corine Land Cover » a été appliqué sur les images satellitaires Google Earth et des observations sur le site ont été également effectuées. Trois systèmes différents ont été identifiés: a) les systèmes agrisylvicoles, avec des arbres en rangées intercalées avec de céréales, b) les systèmes agrisylvicoles avec des arbres épars intercalées avec de céréales et c) les systèmes sylvopastoraux avec des arbres épars avec végétation naturelle et pâturage. Ces systèmes se trouvaient principalement dans le type d'occupation des sols Corine 223 (oliveraies) et occupaient 12.052.64 ha de la zone couverte par l'étude. La majorité des systèmes étaient les systèmes silvopastoraux avec des arbres épars et de la végétation naturelle. La préservation des systèmes agroforestiers de la région était principalement due au fait que la population locale s'occupe du tourisme. L'adoption des nouvelles mesures agro-environnementales de la « PAC » par les agriculteurs pourrait contribuer davantage à leur exploitation.*

Mots-clés.*Corine land cover — agro-sylviculture — systèmes sylvopastoraux — arrangement des arbres*

I - Introduction

The presence of the olive (*Olea europea* L.) in the Mediterranean dates back from 60,000 to 80,000 years ago according to pollen study analysis (Schultz et *al*. 1987). The technique of inoculation of wild olives was developed as early as 1,000 BC as well as the co-cultivation with cereals and legumes. The combination of olive trees with livestock was one of the first forms of agroforestry (Schultz et *al*. 1987). Olive is the most widespread cultivated tree in Greece, covering an area of 700,000 ha (EUROSTAT 2016, den Herder et *al*. 2017), of which, approximately 125,000 hectares are silvoarable and silvopastoral systems (Papanastasis et *al*. 2009). According to Pantera et *al*. (2018), olive trees alone or in orchards are found in all parts of the country with a mild Mediterranean climate. Olive trees are considered to be among the least demanding of nutrients among cultivated trees and that is why they are planted in relatively barren and rocky areas and in soils derived mainly from limestone (Papanastasis et *al*. 2009). The main products of the olive groves are edible olives and olive oil, while the secondary products include animal feed and firewood.

The cultivation of olives in Chalkidiki is a traditional practice, which increased greatly at the end of the twentieth century, with its area amounting to 26,743 hectares and the production of edible olives and olive oil amounting to 112,870 and 52,250 tons respectively (National Statistical Service 2015). However, in Chalkidiki as in the rest of Greece, traditional agroforestry systems are in danger of being abandoned or converted to intensive monocultures, with consequent loss of biodiversity, ecosystem stability and accumulated cultural knowledge (Sidiropoulou 2013). For this reason, it is considered necessary to locate, inventory and record their characteristics (Sidiropoulou 2013). Specifically in the area of Chalkidiki a first survey was made by Sidiropoulou (2011) where it was found that agroforestry systems with an area> 10 ha occupy 3,652 ha, while later, within the European project AGFORWARD (2014-2017), an experimental surface was installed in a specific area of Kassandra peninsula in order to highlight the advantages of co-cultivation of olive trees aged 80 years with barley and vetch (Pantera 2014, Mantzanas et *al*. 2016, Mantzanas et *al*. 2021).

The purpose of this research was the inventory of the olive agroforestry systems of the Region of Chalkidiki and the investigation of their characteristics.

II - Materials and methods

The research was carried out in the region of Chalkidiki in North Greece, where there is extensive traditional olive grove systems. For the mapping procedure, maps of the pan-European Corine Land Cover Inventory (CLC) 2012 (European Environment Agency 2018) and ArcGIS Geographic Information Systems software were used. From the classification system of CLC 2012, the polygons belonging to the codes '223 - Olive groves', '242 - Complex cultivation patterns' and '243 - Land principally occupied by agriculture, with significant areas of natural vegetation' were selected. In each of these polygons, the percentage of olive agroforestry systems was estimated using satellite imagery (base map Arc GIS). In order for a system to be characterized as agroforestry, the requirements were: the minimum distance between the trees and the minimum distance between the tree rows to be at least 10 m and the total density of trees should not exceed 100 trees / ha.

Furthermore, onsite observations were conducted in order to verify the data of the mapping procedure of the olive agrosilvopastoral systems in the region of Chalkidiki, N. Greece. Additionally, their main characteristics were recorded in representative systems. More specifically, twenty sampling plots were selected in various exposures and slopes. They were distinguished in the following three categories based on the tree layer and the understory vegetation: a) silvoarable systems with trees in rows intercropped with cereals, b) silvoarable

systems with scattered trees intercropped with cereals, and c) silvopastoral systems with scattered trees with natural vegetation and grazing. In each plot; tree density (tree/ha), tree arrangement, total tree height (m), breast height diameter (m) and canopy diameter (m) were measured.

III - Results and discussion

The total estimated area of agrosilvopastoral systems in the region of Chalkidiki exceeds 12,000 ha and occupies 4,13% of the total area of the region (Table 1). From the initial number of 255 land cover polygons (potential areas of olive agrosilvopastoral systems) of the CLC-2012 program, it was estimated that 38 % of them include agrosilvopastoral systems. Out of these polygons, the olive groves (code 223) include the largest percentage (> 30 %). In total, the average percentage of olive agrosilvopastoral systems among the investigated CLC-2012 polygons was 20 %.

Table 1. Number, areas (ha) and percentage (%) of olive agrosilvopastoral systems in Corine Land Cover 2012 polygons, in the region of Chalkidiki.

Corine Land Cover codes	Number of polygons	Total area (ha)	Area of agroforestry systems (ha)	Percentage of agroforestry systems (%)
223 - Olive groves	44	30,700.32	9,325.18	30.37
242 – Complex cultivation patterns	17	9,745.18	748.48	7.68
243 - Land principally occupied by agriculture, with significant areas of natural vegetation	36	21,889.08	1,978.98	9.04
Total	**97**	**62,334.58**	**12,052.64**	**19.34**

The distribution of the olive agrosilvopastoral areas in the region of Chalkidiki, showed that the largest percentage of them is located in Kassandra peninsula, the western part of Sithonia peninsula and in an area southeast of the city of Polygyros in the center part of the region (fig. 1). All these areas are situated near the coastal lines. In the areas far from the shores, local people are more intensively engaged in the production of olives fruits and olive oil and for this reason the co-cultivation of agrosilvopastoral systems has been abandoned. In these areas' farmers tend to fill the gaps in their olive groves with new trees to increase olive production. In coastal areas, on the other hand, the local people are more actively engaged with tourism and that resulted in conservating the olive agrosilvopastoral areas. According to the same data (fig. 1), Kassandra peninsula maintains the largest number of polygons with dense coverage of olive agrosilvopastoral systems, possibly due to a milder terrain. Olive agrosilvopastoral systems that have been maintained until today in Chalkidiki, may be better utilized in the future, with the adoption by the farmers of the new agri-environmental measures of the Common Agricultural Policy (CAP) (Mantzanas et *al*. 2017).Of the twenty representative agrosilvopastoral systems that their main characteristics were recorded, the 20 % of them were silvoarable and they were located in Kassandra peninsula (Table 2). Similar results were found in a previous research that was conducted in the area (Sidiropoulou 2011). The silvoarable system with the largest extent (10 ha) was located in Kassandra peninsula and it was the only one with a linear tree arrangement intercropped with oat cereals. The density of the trees in this system reached the number of 60 trees/ha. This was due to the fact that the linear tree arrangement facilitates the agricultural processes allowing higher tree densities in comparison with the scatter tree

arrangement. The other three silvoarable systems, they were also intercropped with cereals but with scattered trees arrangement and low tree density.

Fig. 1. Distribution map of olive agrosivlopastoral systems (Corine Land Cover 2012) and sampling sites in Chalkidiki region**.**

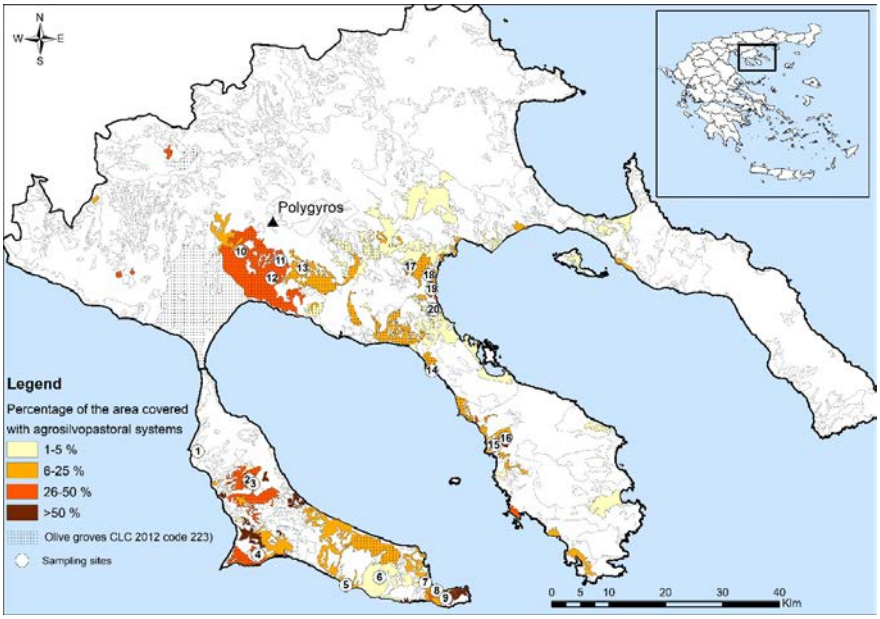

Table 2. Characteristics of olive agrosilvopastoral systems in selected areas of Chalkidiki, N. Greece

a/a	System type[1]	Exposure/slope (%)	Tree density (tree c/ha)	Tree arrangement[2]	Total tree height (m)	Breast height diameter (m)	Canopy diameter (m)	Inderstory type[3]
1	SA	W-15	60	L	9	0.85	10	Oat
2	SA	0	30	S	5	0.45	6	Barley
3	SA	0	30	S	6	0.5	5	Barley
4	SA	0	40	S	6	0.6	6	Barley
5	SP	NW-30	40	S	6	0.5	5	NV
6	SP	SW-10	50	S	6	0.5	7	AF
7	SP	NW-20	50	S	6	0.6	7	NV
8	SP	NW-20	60	S	6	0.6	7	AF
9	SP	0	65	S	8	0.6	8	NV
10	SP	0	60	S	4.5	0.5	5	AF

11	SP	0	50	S	4.5	0.55	5	NV
12	SP	0	70	S	4.5	0.8	6	NV
13	SP	SE-5	80	S	4.5	0.4	5	NV
14	SP	0	40	S	5	0.3	3	NV
15	SP	0	40	S	4	0.3	5	NV
16	SP	0	80	S	5.5	0.4	5	NV
17	SP	0	60	S	5	0.45	4	NV
18	SP	0	70	S	5	0.4	6	NV
19	SP	0	90	S	5.5	0.5	7	NV
20	SP	0	70	S	4	0.5	4	NV

Abbreviations: [1]SA: Silvoarable, SP: Silvopastoral, [2]L: Linear, S: Scattered, [3]NV: Native vegetation, AF: Abandoned field

The majority of the systems under study (80 %) were silvopastoral. In three of them, the abandonment of the previous agricultural use was obvious, while only one of them seemed to preserve an almost linear tree arrangement. The majority of the silvopastoral systems appeared a tree density of 40-60 trees/ha, nonetheless one of them had a very high tree density reaching the 90 trees/ha.

Regarding the biometric characteristics of the trees, their average values ranged in 5.3 m height, 0.5 m of breast height diameter and 5.6 m canopy diameter. The characteristics of the trees of the silvoarable system located in the area of the rural prisons appeared much higher values than the average ones and deviated from the other systems. This was probably due to the positive effect of the long term of intensive intercropping with cereals.

IV - Conclusions

Olive agroforestry is a traditional land use practice in the region of Chalkidiki. The European Corine Land Cover program can be used as an inventory tool for agroforestry systems, however, their distinction into silvoarable or silvopastoral requires on the spot control. The results of the survey showed that 30 % of the area of olive groves is managed in the form of agroforestry. Most of the systems consisted of silvopastoral systems with scattered trees and natural vegetation in the understory. The involvement of the inhabitants with the tourism in the coastal areas resulted in the preservation of the agroforestry systems. Farmers interest in these systems may increase in the future with the adoption of the new agri-environmental measures of the CAP.

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Spatio-temporal changes analysis (1984 – 2017) of a grazed Cretan landscape using Landsat satellite images

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Abstract. Research on spatio-temporal changes on grazed landscapes of Greece in general and of Crete specifically, indicates that forests, as in all Mediterranean, are expanding. Nowadays, such studies often use digital image analysis methods applied on multispectral satellite images. The recent open access availability of ground reflectance products derived from historical Landsat imagery, which have been geometrical and atmospheric corrected, is expected to increase their use for land use/land cover change research. The aim of this paper was to study the spatio-temporal changes of a typical Cretan landscape (Municipality of Sfakia) and to test the efficiency of the recently available Landsat products, for these purposes. Landsat images of 1984, 2001 and 2017 were processed by classification techniques using remote sensing and GIS software. Forest orthophoto maps and relevant inventory data were also collected, and landscape metrics were calculated. Data analysis of spatio-temporal changes showed a gradual expansion in size and density of forest in silvopastoral areas and of silvopastoral areas in phrygana, increasing landscape heterogeneity. The abandonment of marginal agricultural areas, in combination with the reduction of wood harvesting, are the most important factors of landscape changes in relation to animal husbandry evolution. If this trend continues, it is possible for this Cretan landscape to degrade.

Keywords. Sfakia - remote sensing - open access data - landscape metrics.

Analyse des changements spatio-temporels (1984 – 2017) d'un paysage crétois pâturé à l'aide d'images satellite Landsat.

Résumé. Les recherches sur les changements spatio-temporels sur les paysages pâturés de la Grèce en général et de la Crète en particulier, indiquent que les forêts, comme dans toute la Méditerranée, sont en expansion. De nos jours, ces études utilisent souvent des méthodes d'analyse d'images numériques appliquées sur des images satellites multispectrales. La récente disponibilité en libre accès des produits de réflectance du sol dérivés de l'imagerie historique Landsat, géométriquement et atmosphériquement corrigées, devrait augmenter leur utilisation pour la recherche sur l'utilisation des terres/les changements de couverture terrestre. L'objectif de cet article était d'étudier les changements spatio-temporels d'un paysage crétois typique (Municipalité de Sfakia) et de tester l'efficacité des produits Landsat récemment disponibles, à ces fins. Les images Landsat de 1984, 2001 et 2017 ont été traitées par des techniques de classification à l'aide de logiciels de télédétection et de SIG. Des orthophotocartes forestières et des données d'inventaire pertinentes ont également été recueillies, et des mesures du paysage ont été calculées. L'analyse des données des changements spatio-temporels a montré une expansion progressive de la taille et de la densité de la forêt dans les zones sylvopastorales et des zones sylvopastorales dans les garrigues, augmentant l'hétérogénéité du paysage. L'abandon des zones agricoles marginales, conjugué à la réduction de l'exploitation du bois, sont les facteurs les plus importants des changements du paysage en relation avec l'évolution de l'élevage. Si cette tendance se poursuit, il est possible que ce paysage crétois se dégrade.

Mots-clés. *Sfakia – télédétection - données en libre accès - métriques de paysage.*

I - Introduction

Research on the grazed landscapes of Greece shows that they have undergone significant changes over time. These changes are mainly concern the size and distribution of their land use/ cover units and have as a result the large expansion of forests and shrublands (Chouvardas, 2007; Chouvardas *et al.,* 2013; Rapti *et al.,* 2018; Nasiakou *et al.,* 2021). These changes have strong anthropogenic causes (e.g., land abandonment due to socio-economic changes), follow similar changes of the Mediterranean landscapes and are considered very important for the evolution of grazing landscapes, such as those of Southern Crete (Papanastasis, 2012). Specifically, for the landscapes of southwestern Crete (White Mountains - include part of Municipality of Sfakia), Papanastasis (2012), reports that they have undergone drastic changes due to population abandonment, which for the period from 1945 to 1989 resulted forests' expansion at the expense of shrubland and phryganic areas.

Studies of spatio - temporal change of landscapes and vegetation types in general are usually conducted through photointerpretation analysis of time series set of aerial photographs (Chouvardas, 2007), through digital processing of multispectral satellite images with a variety of techniques (Lu *et al.,* 2004), or more recently through object recognition technics of remote sensing (Perakis *et al.,* 2015).

Multispectral images of Landsat satellites are the oldest and most popular series of satellite products. Being available since 1972, they are suitable for the study of changes over a long period of time. This popularity was promoted significantly after 2008 when the US Geological Survey (USGS) allowed free access of Landsat products, causing a significant increase in their use (Miller *et al.,* 2013). Pre-processing stages of the digital processing of multispectral satellite images such as Landsat images, usually cause technical difficulties, specifically in geometric and atmospheric corrections (Song *et al.,* 2001; Perakis *et al.,* 2015), becoming less attractive for non-specialized remote sensing researchers (Young *et al.,* 2017). In March 2017, USGS announced the free distribution of a new satellite Landsat product which was geometrically and atmospherically corrected (C1-Level 2 - ground reflectance, US Geological Survey, 2018), promoting even more the use of satellite imagery for applications such as the study of landscape evolution.

The present research aimed to study the spatio - temporal changes of a typical landscape of southwestern Crete (Municipality of Sfakia) in order to collect information about the diverse Cretan landscapes promoting the knowledge especially for the grazed silvopastoral and phryganic areas, and to examine the possibilities of using the new geometrically and atmospherically corrected open-accessed Landsat multispectral satellite products.

II - Materials and methods

The Municipality of Sfakia (M. Sfakia) in the prefecture of Chania, Crete was selected as study area. M. Sfakia includes nine main settlements of 1889 inhabitants in total covering a total land area of 46,700 hectares. The landscape of the study area is dominated by silvopastoral and phryganic areas, which are mainly grazed by sheep ang goats. Silvopastoral areas are dominated in the upper story mainly by *Pinus brutia* Ten. (Pine), *Cupressus sempervirens* L. (Cypress) and in a lesser extent by *Quercus coccifera* L. Phryganic areas are dominated mainly by *Sarcopoterium spinosum* (L) Spach., *Euphorbia acanthothamnos* Heldr. Sartori ex Boiss. and *Verbascum spinosum* L. Pine and Cypress are also dominate at the forests, mixed or unmixed. The altitude of the area ranges between 0 to 2453 meters, while forest boundaries reach 1600 meters. Finally, the main productive activities the area are agriculture, animal husbandry and tourism.

In order to identify and evaluate the spatio - temporal changes among the different land use/cover types of the landscape, three multispectral satellite images of Landsat (C1-Level 2, ground reflectance) were collected for three time periods: the oldest available was in 1984 (TM5), the intermediate was in 2001 (TM5) and the newest was in 2017 (OLI8). All three images

were produced during summer and had no cloud cover. Supervised classification technique was applied to all satellite images using the algorithm of maximum likelihood (Perakis *et al*., 2015), in Erdas Imagine software. All spectral channels except thermal infrared (TM5, OLI8) and ultra-blue (band -1, OLI8) were used. Accuracy assessment was conducted in stratified random sampling of 300 points for each time period (Congalton, 1991). Several additional data were used as support material for the selection of the training areas, but also for the assessment of the classification accuracy. This material included a) satellite images from Google Earth from 1984 to 2017, b) digital images of unsupervised classification (K - MEANS) of 8 classes for each time period, c) orthophoto maps of 1991 and d) the digital maps of the Corine Land Cover. In order to assess the accuracy of the 1984 classification, assumptions of non-change of land use were made in some cases, based on the orthophoto maps of 1991. A total of 72 training areas were selected (7 to 22 per class), considering the total area and vegetation variety of the classes. The selected classification classes consisted of 6 categories of land use/cover types: agricultural areas (including settlements), water bodies, barren or sparsely vegetated areas, phryganic areas, silvopastoral areas (tree coverage 10 - 40%) and forests (40 - 100% tree coverage). Silvopastoral areas contained a small percentage of kermes oak shrubs. Finally, a post-processing data methodology was applied in ArcGIS software to the outcomes of the final classification; process which included the application of majority filter and an increasement of the minimum cartographic area to 1 hectare (Generalization tools, ArcGIS).

In order to examine the effect of socio-economic changes (population development, employment data) and pastoral activities (number of sheep and goats) on landscape evolution, statistical data were collected from the Hellenic Statistical Authority (1961 - 2011) and from the Payment and Control Agency for Guidance and Guarantee Community Aid (PCAGGCA, 2021). Field visits were also organized in order to collect information directly from the local population.

Finally, the ArcGIS Patch Analyst software was used to analyze landscape pattern (landscape metrics, McGarigal and Marks, 1995). In details, six indicators of spatial heterogeneity in landscape level were calculated: Number of Patches (NumP), Mean Patch Size (MPS, ha), Edge Density (ED, m/ha), Interspersion Juxtaposition Index (IJI, %), and Shannon' s Diversity and Evenness Index (SDI and SEI) (McGarigal and Marks, 1995; Chouvardas, 2007).

III - Results and discussion

The estimation of the classification accuracy was considered satisfactory with the percentages of total accuracy ranging from 89.67%, 85.3% and 88.67% for the time periods of 1984, 2001 and 2017 respectively. The kappa statistical coefficient also showed values of 0.8665, 0.8115 and 0.8573, respectively. The evolution of the categories of land use/ cover types for the research period are given in Table 1.

Table 1 data reveled that land use/ cover types that increase in area during the time period (1984 and 2017) are forests (> 40%) and agricultural areas (> 30%) and in a lesser extent silvopastoral areas. An exception to the above trend is the significant reduction by 20% of phryganic areas. Barren or sparsely vegetated areas and water bodies remained practical unchanged. The above changes are presented in the maps of Figure 1 (A, B and C) of the land use/ cover type evolution. In these maps a gradual conversion of silvopastoral areas to forests in the central and western parts of the landscape is observed, along with a gradual conversion of phryganic areas to silvopastoral areas to the east. By further analyzing the results of landscape changes over the time period (1984 to 2017), it emerged that from the initial surface of the landscape of 1984, 72% remained unchanged (Fig. 1, D – stable landscape), compared to a 28% of area that underwent same kind of change (Fig. 1, D – transformed landscape).

Table 1. Temporal evolution (1984 - 2017) of land use / cover types in M. Sfakia landscape of Southwest Crete

Land use/cover types	Area (Ha)			Change (%)
	1984	2001	2017	1984 - 2017
Agricultural areas	1630.71	1729.89	2150.28	31.86
Phryganic areas	21,116.07	19,243.98	16,535.43	-21.69
Silvopastoral areas	8239.86	7914.33	9366.57	13.67
Forest	6350.22	8350.83	8987.22	41.53
Barren or sparsely vegetated areas	9010.71	9013.68	9120.87	1.22
Water bodies	5558.49	5547.87	5659.83	1.82
Total	51,906.06	51,800.58	51,820.20	-0.17

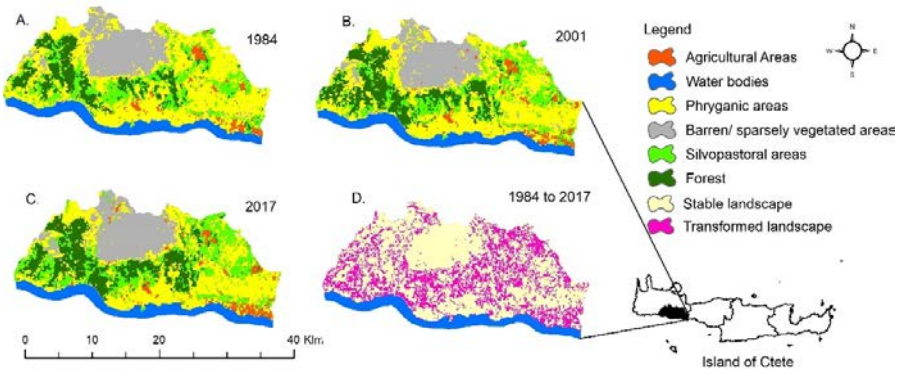

Fig. 1. Spatio - temporal distribution of land use/cover types in M. Sfakia landscape of Southwest Crete for A) 1984, B) 2001, C) 2017 and D) 1984-2017

According to figure 1, the stable part of the landscapes occupies areas of barren/ sparsely vegetated and phryganic areas in the north-center and south-east territories, respectively. Overall, the above data (Table 1, Figure 1), suggest that the conversion of phryganic areas into silvopastoral areas can be consider a transitional stage of development that will lead in the future to their further transformation into forests.

Table 2 presents the results of the landscape metrics of M. Sfakia landscape over time. The differences of NumP and MPS values indicate that the landscape becomes intertemporal fragmented and therefore presents an increase of its heterogeneity.

Table 2. Landscape metric value for M. Sfakia landscape for the period 1984 to 2017

Years	NumP[1]	MPS[2]	ED[3]	IJI[4]	SDI[5]	SEI[6]
1984	714	72.70	31.92	51.17	3.34	0.51
2001	807	64.19	35.13	51.11	3.60	0.54
2017	926	55.96	35.2	52.27	3.78	0.55

[1]Number of Patches, [2]Mean Patch Size (ha), [3]Edge Density (m/ha), [4]Interspersion Juxtaposition Index (%), [5,6] Shannon' s Diversity and Evenness Index

At the same time, ED values increase, indicating an increase of ecotone length per unit area, while the IJI index shows a slight improvement of patch distribution in the landscape. Finally, the SDI and SEI indices show increased diversity over time. The above results are in contrast with the trend of evolution of many other Greek landscapes, where the expansion of forests causes reduced landscape diversity and produce homogeneous landscapes (Chouvardas, 2007;

Chouvardas *et al.,* 2013; Rapti *et al.,* 2018; Nasiakou *et al.,* 2021).

Statistical data showed that local population of the M. Sfakia decrease by 24% between 1981 and 2011 with a limited aging trend, while the percentage of employees in the primary economic sector decreased for the same period from 69% to 57% of the economically active population. The above demographics suggest that the traditional land management practices (agricultural activities and extensive pastoral activities) are probably preserved. In addition, statistics show (Table 3) that farm animals (mainly sheep and goats) have shown a continuous increase since 1971, an increase which reaches the maximum total number in 2011 (more than 150,000 sheep and goats). The total increase of sheep and goats between 1991 - 2011 was 16%, Table 3.

Table 3. Temporal evolution of the numbers (heads) of farm animals and percentage (%) of their change in M. Sfakia landscape between 1971 to 2017

Farm animals	1971	1991	2000	2011	2017	% of change 1991 - 2011	% of change 2011-2017
Sheep	28,862	66,362	76,349	113,001	83,181	+15.05	-26.39
Goats	10,193	33,521	39,259	37,023	26,540	+17.12	-28.31
Total	39,055	99,883	115,608	150,024	109,721	+15.74	-26.86

Farm animals decreased since 2000 for goats and since 2011 for sheep (total reduction of farm animals between 2011 - 2017 was 27%, Table 3). The above fact is confirmed by the reports of the local population to the researchers during the summer of 2017. From the same reports, as well as from the Spatio - temporal distribution data (Figure 1), it is found that forest expanded in many marginal agricultural areas mainly in the central parts of the landscape. Also, the same reports of the local people suggested that there was a significant reduction over time in the collection of firewood and building timber from forests, which promoted a further forest expansion. The latter trend was also confirmed in an earlier study concerning the development of the landscape of Western Crete / White Mountains (Papanastasis and Kazaklis, 1998).

The above results suggests that the strong trend of forest expansion in the landscape can be mainly attributed to land abandonment and the reduction of firewood and timber collection and less to the impact of livestock activity over time that has remained high over time. It is noted that the reduction in sheep and goats over the last decade (2011 to 2017, Table 3) and the possible continuation of this trend in the future, is expected to negatively affect landscape evolution, causing a further expansion of forests and even greater reduction of phryganic areas. These changes, if they are confirmed as in other Greek landscape, will probably lead to a significant reduction of landscape diversity, and eventually transform this greatly heterogeneous landscape to a homogeneous one.

IV - Conclusions

Image processing of the geometrically and atmospherically corrected open-access satellite Landsat products provided satisfactory results for the spatio - temporal change analysis at M. Sfakia's landscape. Data analysis showed a trend in gradual transformation of silvopastoral areas into forests and of phryganic areas into silvopastorals. These changes resulted an increase of landscape heterogeneity, which promoted landscape diversity. These results were mainly attributed to land abandonment and the reduction of firewood and timber collection. Livestock activities remained high over the time period of 1991 to 2011 and had less significant impact to landscape transformations. Farm animal numbers reduced over the last decade (2011 – 2017) and its possible further reduction in the future will probably promote forest expansion and may eventually lead to a significant reduction of the landscape diversity and heterogeneity. This trend of change should be investigated in the future, especially under the influence of the

effect of the global climatic changes in semiarid environments, as those of southwestern Crete.

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The impact of animal husbandry on Thessaly's landscape, Greece

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Abstract. Animal husbandry, especially the transhumant sheep and goat farming system, was one of the main factors shaping Greece's rural landscapes for centuries. The last few decades, the abandonment of this traditional, extensive form of animal husbandry, combined with the changes in animal breeds and the increase of animals being kept indoors and given complementary feeds, had a great impact on the landscape. In the area of Thessaly there is a long history of livestock grazing which affected landscape structure. In the lowlands, a characteristic zone with grasslands around the villages is present, contrary to the rest of Greece where it is limited. This study aims to provide an insight on landscape changes during the last century. For this purpose, landscape structure of Thessaly's lowland grasslands was studied using Corine Land Cover 1990 and 2018 in a G.I.S. environment. Overall, the communal grasslands around the urban, lowland areas of Thessaly occupied 7807,1 ha in 1990 and only 4255,8 ha in 2018 (-45,5%). In Western Thessaly these areas were more extensive, probably due to the seasonal movements of transhumants that exploited the lowland grasslands during the winter season. In Eastern Thessaly they occupied a smaller area, probably because transhumants spent the winter at the foothills, leaving the extensive plains exclusively for agricultural exploitation.

Keywords. land use changes, grasslands, transhumance, Corine Land Cover.

L'impact de l'élevage d'animaux sur le paysage de Thessalie, Grèce

Résumé. L'élevage d'animaux, en particulier le système d'élevage ovin et caprin transhumant, a été l'un des principaux facteurs qui ont façonné les paysages ruraux de la Grèce depuis des siècles. Au cours des dernières décennies, l'abandon de cette forme d'élevage traditionnelle et extensive, combinée avec l'évolution des races animales et avec l'augmentation du nombre d'animaux sédentaires et bénéficiant d'aliments complémentaires, a eu un impact considérable sur le paysage. Dans la région de Thessalie, il existe une longue tradition de pâturage du bétail qui a affecté la structure du paysage. Dans les plaines, une zone caractéristique avec des prairies autour des villages est présente, contrairement au reste de la Grèce où celle-ci est limitée. Cette étude vise à donner un aperçu des changements du paysage au cours du dernier siècle. À cette fin, la structure paysagère des prairies de basse altitude de Thessalie a été étudiée en utilisant Corine Land Cover 1990 et 2018 dans un environnement G.I.S. Dans l'ensemble, les prairies communales autour des zones urbaines et les plaines de Thessalie occupaient 7 807,1 ha en 1990 et seulement 4 255,8 ha en 2018 (-45,5 %). En Thessalie occidentale, ces zones étaient plus étendues, probablement en raison des mouvements saisonniers de transhumants qui exploitaient les prairies de plaine pendant la saison hivernale. En Thessalie orientale, ils occupaient une zone plus réduite, probablement en raison du fait que les transhumants passaient l'hiver aux piémonts, laissant ainsi les plaines extensives exclusivement pour l'exploitation agricole

Mots-clés. *Changements d'utilisation des terres, prairies, transhumance, Corine Land Cover*

I - Introduction

Animal husbandry is one of the factors that shaped Mediterranean landscapes for centuries (Farina, 1998; Ispikoudis et al., 2004). The way pastoral societies managed natural ecosystems was a combination of a variety of historical and social factors (Sidiropoulou et al., 2015; Basupi et al., 2017). In addition, the impact of grazing on the landscape depended on both the type and

the intensity of livestock grazing (Kakouros, 2008). The huts, the stables, the sheds and the watering points, the paths and the bridges, the impact on the soil and the vegetation, led in the long run to the creation of characteristic landscapes of high ecological and aesthetic value in various parts of the country (Ganatsou et al., 2008; Papanastasis and Ispikoudis, 2012). Transhumance, the extensive animal (mainly sheep and goat) system based on livestock displacement constitutes an important but declining element of the European cultural tradition (Bunce et al., 2004). Since 1960s, there was a decrease in transhumance, which led to land use changes in both winter and summer grasslands (Leffler et al., 2014; Sidiropoulou et al., 2015).

Transhumance in Greece was characterized by sustainable use of pastures, low fixed capital endowments and intensive use of human labor (Laga et al., 2012). According to Chatzimichali (2007) in the 1960s the number of transhumance herd animals was about 2,000,000 but has declined since. In the region of Thessaly, in Central Greece, during the 19th century, animal husbandry was a major economic and social factor of development (Economou, 2007). Especially in Western Thessaly, the intense mountainous terrain and the extensive summer pastures played a decisive role both in the development of animal husbandry and in the general survival of the people, especially during the period of Ottoman rule and occupation (Manolopoulos, 2003). In addition, the presence of transhumant ethnic groups Sarakatsani and Vlachs was very strong. When autumn began, they migrated with their flocks from the mountain pastures of Pindos or Macedonia and set up their camps in the plains, protected from the harsh winter weather (Economou, 2007). Summer mountain pastures were communal, while winter pastures were usually private and transhumants had to pay rent (Nasioka, 2012).

Today in Thessaly, as in most of Greece, livestock activity has changed (Ispikoudis et al., 2004; Mitka, 2009). Livestock farms have been modernized, grazing time has been reduced due to increased use of complementary feeds, transhumance is almost abandoned and animals graze in a small radius around the sheds (Katsaros, 2009; Mitka, 2009; Sidiropoulou et al., 2015). The number of animals nowadays in transhumance herds Greece has dropped to 1,000,000 (PCAGGCA, 2011), of which 400,000 are found in Thessaly (Laga et al., 2012).

The purpose of this research was to study the impact of animal husbandry on Thessaly's landscape and give an insight on the factors that influenced livestock management in the past.

II - Materials and methods

Thessaly is located in central Greece and consists of the regional units of Karditsa, Magnisia, Larisa and Trikala, which occupy an area of 263,799 ha, 236,019 ha, 538,560 ha and 338,612 ha respectively (islands not included) (Fig. 1). About 50% of the region are lowland areas, most of which are located in the central part of Thessaly and constitute the Thessalian plain (Christakis, 2013).

In the present research, land use/cover maps were produced for 1990 and 2018 using the corresponding Corine Land Cover inventory (EEA, 2012). The lowland areas in each prefecture (≤200m altitude) were isolated with the help of a 3D Digital Terrestrial Model (NASA, 2009). A zone of radius of 1,000m from the mountain foothills was created with the 'buffer' command of ArcMap 10.1 (ESRI, 2011) which was removed in order for the survey to include exclusively villages located in lowland areas and not adjacent to mountains. The following categories were selected and isolated from the Corine Land Cover maps: 231-pastures and 321-natural grasslands (Bossard et al., 2000). Finally, additional data for the research were obtained from the aerial photographs of 1945 (National Land Registry and Mapping SA, 2018).

Figure 1. Study area: Regional units of Karditsa, Magnisia, Larisa and Trikala.

III - Results and discussion

The analysis of the land use/cover map of Corine Land Cover for 1990 and 2018 showed that in the lowlands of Thessaly there is a characteristic zone with grasslands around the villages (Fig. 2), in contrast to the rest of Greece where this phenomenon is observed to a limited extent.

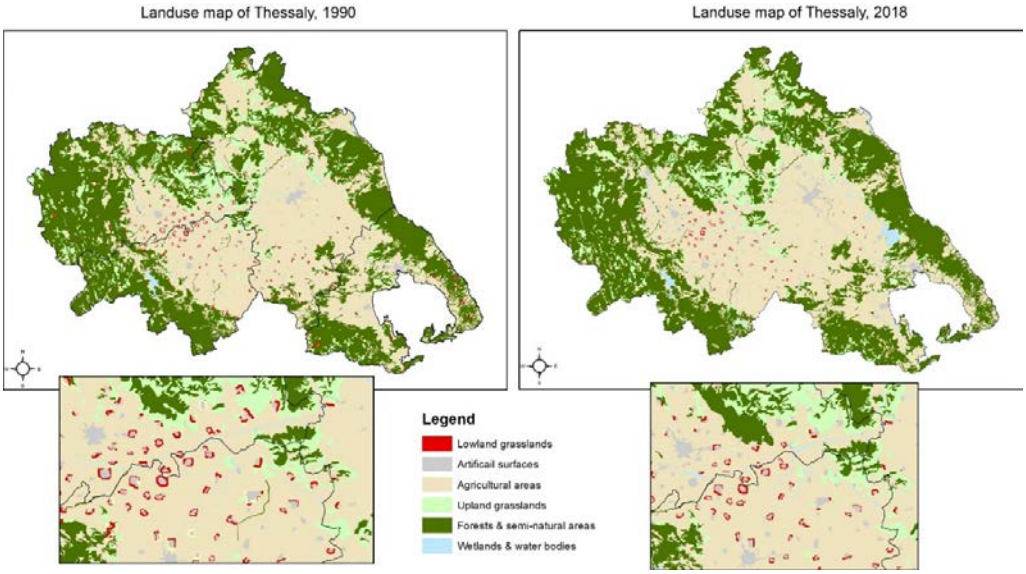

Figure 2. Land use maps of Thessaly, Greece for 1990 and 2018 (EEA, 2012).

In Western Thessaly (regional units of Trikala and Karditsa) these areas occupied 5616.9 ha in 1990 and in Eastern Thessaly (regional units of Larisa and Magnisia) only 2190.2 ha. In 2018 they appear decreased by 42.1% and 54.1% respectively (Fig. 3).

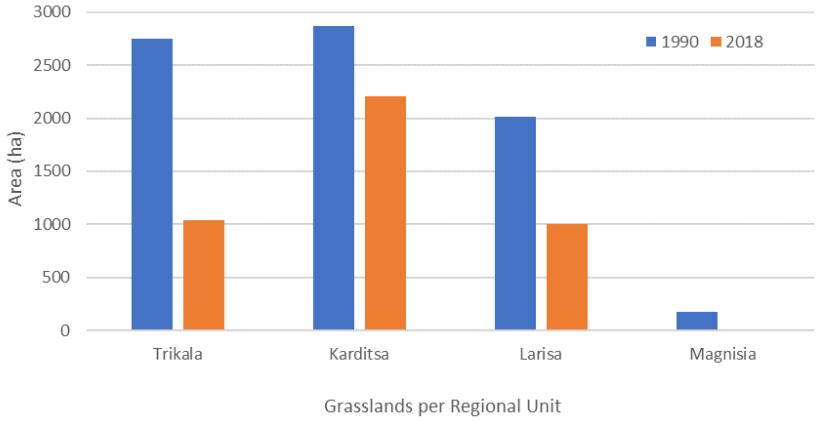

Figure 3. Land use changes between 1990 and 2018 in the regional units of Karditsa, Magnisia, Larisa and Trikala, Greece.

These grasslands occur in between the villages and the extensive agricultural crops and their width ranges from about 150m to 1,000m (Fig. 4a). They were communal and resulted from the need to provide for the animals during winter in the past. The villagers used their most fertile fields for this purpose because they were close to the villages and they usually had plenty of running water and safe places to keep their animals. These areas remained unchanged until today because in 1955 (article 197 of the Agricultural Code and Law 3194/1955) they were granted to the nearest Municipalities and Communities for the common use of their habitants and any use other than grazing was strictly prohibited (Chiotis, 1997).

Figure 4. The village Megala Kalyvia in the prefecture of Trikala: a) community grasslands around the village nowadays (Google Earth Pro, 39º29.869'N, 21º47.275'E, 2014) and b) traces from the livestock facilities around the village in 1945 (National Land Registry and Mapping SA, 2018).

For many years, these grasslands were the main source of cheap and valuable feed for animals in the lowland areas of Thessaly. According to Chiotis (1997), the necessary facilities for animal husbandry were the hut for shepherd, the storehouse for feeds, the shed, the watering cans and the milking pen for animals. These structures were not permanent and were dismantled as soon

as the grazing period ended. However, as they were constructed in the same places each time, they left their mark on the ground (Fig. 4b). Construction materials were abundant in the surrounding area: willow and wicker rods, wood, thorns and tree branches (Chiotis, 1997).

The greater presence of these community grasslands in Western Thessaly seems to be due to a combination of factors. They were used not only from the permanent population, but also by transhumants during the winter (Dasiou, 2014). The need for grazing areas was such that transhumants also rented large, uncultivated areas from the local landowners (Nasioka, 2012). The strong presence of animal husbandry in the area is reflected in the maps of the Austro-Hungarian Army of 1914 (Eötvös Loránd University, 2009). Toponyms such as Vlahinaköj (Vlach village), Longos (shrubland area), Megala Kalivia (big huts), Nomi (property), indicate the systematic use of certain areas for livestock activities.

On the contrary, in Eastern Thessaly, most of the transhumants spent the winter at the foothills, where the conditions were ideal for sheep and goats (protection from winds and low temperatures, fertile grasslands, existence of water sources (Dasiou, 2014), leaving the extensive plains, with the most scattered villages, exclusively for agricultural exploitation (Gourgioti, 1983). The existence of Lake Karla, which was dried up in 1962, played an important role, occupying a large part of the eastern plain (20000 ha). The surrounding villages were more connected with the diverse economy of the lake, mainly with fishing (Goutis, 2013; Dodouras et al., 2014). In 1907 refugees from eastern Romulia were added to the population composition of Thessaly (indigenous permanent residents and nomads) and from 1921 to 1923 refugees from Pontus and Mikra Asia settled mainly in eastern and southern Thessaly (Oikonomou, 2007; Patronis, 2015). They were given land which they used almost exclusively for agricultural exploitation.

The agrarian reform (Law 1702/1917) that was implemented with the arrival of the refugees in 1922 (Patronis, 2015), with the aim of expropriating the land and distributing it to the farmers, marked the beginning of the abandonment of transhumance, as it resulted in the reduction of winter grasslands (Tsakanika and Ispikoudis, 2004). Nowadays, the overall form of livestock activity has changed and stable livestock farming is predominant. Grazing time has decreased due to increased use of complementary feeds (Mitka, 2009) resulting to the gradual homogenization of the landscape and the loss of its biodiversity.

IV - Conclusions

The intense development of animal husbandry in Western Thessaly, contrast to the more extensive development of agriculture in Eastern Thessaly in the past, led to the creation of a characteristic mosaic of land uses. Understanding the operation of pastoral communities is directly related to grassland management and can promote the integration of historical background in land use planning. In Greece, a relatively small effort has been made for an integrated development approach. However, interventions in pastoral landscapes require rational management of all natural resources in order to develop policies that contribute to their conservation and the development of the local economy.

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The effects of global warming on goat breeding in the West Mediterranean Region of Turkey

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Abstract. In this study, the effects of global warming on goat breeding were investigated. The research area is the Western Mediterranean Region in Turkey including Antalya, Isparta and Burdur provinces. In the region, goat breeding is done with traditional methods.
The downward trend in precipitation in Antalya will continue and will remain well below the long-term average total precipitation values. Total rainfall will decrease to 871.6 mm in 2025. In addition, the increase in average temperatures will be +0.7 °C and the average temperature will be 19.6 °C in 2025. In this case, it is concluded that the drought will be more serious in the coastal areas of the Mediterranean Climate Region. In the province of Isparta, where the average annual precipitation amount is 570.2 mm, the annual rainfall amount will decrease to 535 mm in 2025. In addition, the average temperature in Isparta will be 13.5 ºC in 2025. According to future projections, there will be a strong increase in average temperatures in Burdur and the increase in average temperatures will be +0.7 °C. The average temperature, which is currently 13.2 °C in Burdur, will be 13.9 °C in 2025. Burdur Province, whose monthly total rainfall amount is 428.1 mm, is expected to decrease below 400 mm in 2025 with a decrease of 35 mm. In this case, it turns out that the drought will be experienced in extreme condition in Burdur Province.
Goat breeding is carried out mainly in enterprises in forest and mountain areas in Turkey. Global warming will bring much negativity to human beings, cause some plant and animal species to disappear or decrease but drought-resistant species will survive in future. Goat is very adaptive and it is resistant to drought and thirsty. Hair goat is also very resistant to drought and thirsty, and is fed with woody plant species that are resistant to drought and thirsty. In this respect, the effects of drought and global warming will be felt less on this hair goat production.

Keywords. Sustainable goat breeding, maquis areas, drought, global warming, Turkey.

Les effets du réchauffement climatique sur l'élevage des chèvres dans la région méditerranéenne occidentale de la Turquie

Résumé. *Dans cette étude, les effets du réchauffement climatique sur l'élevage caprin ont été étudiés. La zone de recherche est la région de la Méditerranée occidentale en Turquie, y compris les provinces d'Antalya, d'Isparta et de Burdur. Dans la région, l'élevage caprin se fait avec des méthodes traditionnelles.*
La tendance à la baisse des précipitations à Antalya se poursuivra et restera bien en deçà des valeurs moyennes des précipitations totales à long terme. Les précipitations totales diminueront à 871,6 mm en 2025. De plus, l'augmentation des températures moyennes sera de +0,7 °C et la température moyenne sera de 19,6 °C en 2025. Dans ce cas, il est conclu que la sécheresse sera plus grave. Dans les zones côtières de la région climatique méditerranéenne. Dans la province d'Isparta, où la quantité annuelle moyenne de précipitations est de 570,2 mm, la quantité annuelle de précipitations diminuera à 535 mm en 2025. De plus, la température moyenne à Isparta sera de 13,5 °C en 2025. Selon les projections futures, il y aura sera une forte augmentation des températures moyennes à Burdur et l'augmentation des températures moyennes sera de +0,7 °C. La température moyenne, qui est actuellement de 13,2 °C à Burdur, sera de 13,9 °C en 2025. La province de Burdur, dont la pluviométrie mensuelle totale est de 428,1 mm, devrait passer sous les 400 mm en 2025 avec une diminution de 35 mm. Dans ce cas, il s'avère que la sécheresse sera vécue dans des conditions extrêmes dans la province de Burdur.

L'élevage de chèvres est principalement réalisé dans des entreprises situées dans des zones forestières et montagneuses en Turquie. Le réchauffement climatique apportera beaucoup de négativité aux êtres humains, entraînera la disparition ou la diminution de certaines espèces végétales et animales, mais les espèces résistantes à la sécheresse survivront à l'avenir. La chèvre est très adaptative et elle est résistante à la sécheresse et à la soif. La chèvre à poils est également très résistante à la sécheresse et à la soif, et se nourrit d'espèces végétales ligneuses résistantes à la sécheresse et à la soif. A cet égard, les effets de la sécheresse et du réchauffement climatique se feront moins ressentir sur cette production de poils de chèvre.
Mots-clés. *Elevage caprin durable, zones de maquis, sécheresse, réchauffement climatique, Turquie.*

I - Introduction

Global warming and climate change are among the environmental problems that threaten the world. Climate change is defined as statistically significant changes in the average state of the climate or its variability over tens or more years (Türkeş, 2008). Climate change may occur due to natural internal processes and external forcing factors, and human-induced changes in the composition of the atmosphere or land use (Türkeş, 2010; Türkeş, 2012).

The potential effects of global climate change, expected to have some global and regional impacts focus on agriculture, forest, clean water resources, sea level, energy, human health, and biodiversity (Doğan and Tüzer, 2011). Turkey covers an area of approximately 780,000 km2 and has three different bio-geographical regions. This attribute makes our country rich in terms of biological diversity. Climate change, drought, and land degradation threaten the integrity of ecosystems. Deforestation and desertification are reducing the ecological resilience and richness of globally significant biodiversity. There are various activities that lead to land degradation. However, overgrazing (heavy, premature, uncontrolled, etc.) is generally cited among the main causes of land degradation (Anonymous, 2014).

In Turkey, some of the sheep and goats grazed in pastures or maquis areas in the forests in the form of animal husbandry. The relations between forest resources and sheep and goat husbandry should not be seen as just grazing animals in forests and utilizing the branches and leaves of trees and shrubs that make up the forest as nutrients. The natural conditions of our country, the habits of the society, the expansion of agricultural lands to the detriment of forest and pasture lands, the inefficiency of pasture lands as a result of years of overuse stand before us as the results of these relations.

In order to eliminate the negativities caused by animal grazing in forests, various studies, such as improvement of pastures, arranging grazing plans, reducing the number of animals by changing breeds, encouraging barn livestock, etc., are being carried out by the relevant units, whether in the state or private sector. However, the fact that the problem has not been resolved shows that the studies carried out are far from sufficient.

II - Material and method

In determining the effects of drought and global warming in the Western Mediterranean Region, climate data were analyzed to show the impacts of drought and global warming in Antalya, Isparta, and Burdur provinces.

3.4 Antalya Province Findings

According to the data of the General Directorate of Meteorology, the climate values in Antalya are; Average Temperature 18.7 (°C), Average Highest Temperature 24.1 (°C), Average Lowest Temperature 13.7 (°C), Average Sunbathing Time 97.5 (hours), Average Number of Rainy Days 72.5, Annual Total Rainfall 1085.3 (mm) The Highest Temperature is 45.0 (°C) and the Lowest Temperature is -4.6 (°C). A warm and temperate climate prevails in Antalya, and there is much more precipitation in winter than in summer. According to Köppen-Geiger's climate classification, the climate of Antalya is called Csa (Csa; Winter is warm, Summer is very hot and dry, Mediterranean climate Type).
July is the driest month of the year in Antalya province with 4.5 mm of precipitation. With an average precipitation rate of 265.3 mm, the highest precipitation rate is seen in December. Antalya province is one of the centers that receive the most precipitation in the Mediterranean Region.
The air masses that affect our country, especially over the Central Mediterranean, are forced to rise in the Taurus Mountains on the Southwest Anatolian coasts and cause frontal-orographic precipitation. As a result of these effects, it is stated that the annual average total rainfall in Antalya is 1109 mm. The change tendency of precipitation was examined, and a regular decreasing trend emerged from 1975 to 1995. After this year, there was an increase in precipitation until the 2000s, but after 2001, it continued with a faster decrease every year compared to the previous year. Especially 2007 (694.3 mm) and 2008 (289.3 mm) years were the years with the highest decrease (Bahadır, 2011).
Bahadır (2011) concluded that the decreasing trend in precipitation in Antalya will continue and the long-term average total precipitation values will remain well below. So much so that the precipitation that is predicted to be 950 mm in 2010 will decrease to 871.6 mm in 2025. In this case, it is concluded that drought will occur more severely in the coastal areas of the Mediterranean Climate Region. In Antalya, July and August are the hottest months of the year, with a temperature of 34.0°C. The average temperature in January is 14.9 °C, which is the lowest average of the year. The average temperature in Antalya in 2010 was 18.9 oC. According to the findings of the future analysis, it is predicted that there will be a severe increase in the average temperatures in Antalya, and the amount of rising in the average temperatures in the 15-year period will be 0.7 °C. It is expected that the average temperature in Antalya will be 19.6 oC in 2025 (Bahadır, 2011).

3.5 Isparta Province Findings

Average Temperature 12.2 (°C), Average Highest Temperature 18.3 (°C), Average Lowest Temperature 6.1 (°C), Average Sunbathing Time 85.0 (hours), Average Number of Rainy Days 99.3, Annual Total Rainfall 570.2 (mm) The Highest Temperature was 41.2 (°C), and the Lowest Temperature was -21.0 (°C). The climate is warm and temperate in Isparta. In winter, there is much more rainfall than in summer. According to Köppen-Geiger, the climate is Csa. (Csa; Warm in winter, very hot and dry in summer, Mediterranean Climate Type).
The average annual temperature of Isparta is 12.2 °C. The annually average rainfall is 570.2 mm. Isparta, located on the northern skirts of the Taurus Mountains, does not receive as much precipitation as the south-facing stations of the Taurus Mountains, as it stays in the rain.
It states that the long-term average annual precipitation in the province of Isparta is 508 mm. When the variation of precipitation between years in Isparta province is examined, a rapid decrease has emerged from 1978 to 1998. Especially after 1983, dry years have been experienced one after another, and the precipitation amount has remained below the average precipitation rate.

Over time, after the beginning of the 2000s, although there were increases and decreases in precipitation in Isparta province, it received a precipitation rate above the average. However, the precipitation rate, which started to decrease after 2006 again, formed the least rainy year with a total precipitation value of 283 mm in 2008. It is stated that the decreasing trend in the future in Isparta province will continue, and the rate of decrease will be 35 mm in the 15-year period (Bahadır, 2011). Thus, in Isparta, where the average annual precipitation is 570.2 mm, the annual precipitation rate will decrease to 535 mm in 2025. With a temperature of 30.5 °C in Isparta, August is the hottest month of the year. The average temperature in January is 6.1 °C, which is the lowest average of the year.
It is stated that the average temperatures of Isparta in 2010 were 12.8 °C. The future trend in average temperatures in Isparta will be in the form of an increase, and this trend will continue until 2025. However, the high amount of increase has emerged as a result of being strongly affected by global warming. The rate of increase is predicted to be around 0.7 oC in the 15-year period from 2010 to 2025, and the average temperature, which was 12.8 oC in 2010, is estimated to rise to 13.5 oC in 2025 (Bahadır, 2011).

3.6 Burdur Province Findings

According to the data of the General Directorate of Meteorology, the annual climate values in Burdur are; Average Temperature 13.2 (°C), Average Highest Temperature 19.4 (°C), Average Lowest Temperature 7.5 (°C), Average Sunbathing Time 89.0 (hours), Average Number of Rainy Days 88.6, Annual Total Rainfall 428.1 (mm), the Highest Temperature is 41.0 (°C), and the Lowest Temperature is -16.7 (°C). The climate is warm and temperate in Burdur. In winter, there is much more rainfall than in summer. According to Köppen-Geiger, the climate is Csa. (Csa; Warm in winter, very hot and dry in summer, Mediterranean Climate Type).
The average annual temperature of Burdur is 13.2 °C. The average annual rainfall is 428.1 mm. With a temperature of 32.1 °C in Burdur, August is the hottest month of the year. The average temperature in January is 2.5 °C, which is the lowest of the year. In Burdur, like Antalya and Isparta, the decreasing trend in precipitation will continue and will be well below the long annual average total precipitation values. The average temperature in Burdur was 13.2 °C. According to the forecasts for the future, there will be a severe increase in average temperatures in Burdur by 0.7 °C. The average temperature in Burdur, which is currently 13.2 °C, will be 13.9 °C in 2025. In Burdur province, where the average total amount of precipitation is 428.1 mm, it is expected that the precipitation rate will decrease by approximately 35 mm by 2025, to below 400 mm. In this case, the result of extreme drought in Burdur province will emerge.

IV - Conclusion

Global climate change, which has become one of the most important problems today, has brought many discussions and scenarios. Many researchers investigate the effect of it. Also, climate assessment analyses are carried out using different methods. The purpose of using these methods is to achieve more accurate assessments about climates and to make rational plans for the future (Bahadır, 2011).
The results of many climates analyses made for our country has emphasized that the Southeastern Anatolia Region, especially the Mediterranean coasts and our areas where the Mediterranean climate is effective, will be under the influence of global warming (Bahadır and Saraçlı, 2010; Özdemir and Bahadır, 2010a; Özdemir and Bahadır, 2010b). From these studies, Bahadır and Saraçlı (2010) examined the change in synthetic climate data in Isparta and stated that there would be an increase in precipitation and temperature.
According to various climate models used in the IPCC 3rd Assessment Report, the annual average temperatures over Turkey until 2050 are between 1-3 °C considering only the

increases in greenhouse gases; considering the changes in greenhouse gases and sulfate particles, an increase of 1-2 °C is predicted. In precipitation, it is predicted that it will show itself as a decreasing trend in the Mediterranean climate zone in our country (Apak and Ubay, 2007).
In addition, when Türkeş's studies on precipitation changes in Turkey are examined, it is stated that annual precipitation tends to decrease throughout the country, and after 1970, dry periods intensified (Türkeş, 1996). As for a global scale, it has been emphasized while precipitation increases between 0.5% and 1% every decade in middle and high latitudes of the northern hemisphere, it decreases by approximately 3% every decade in a significant part of the subtropical lands, including the Mediterranean Basin (Türkes, 2002).
In studies covering 500 years of climatology and climate changes in Europe, especially the change in temperature was examined and it has been concluded that the temperature increase in high latitudes is higher than in low latitudes. When the spatial distribution was examined, it was found that there was an increase of 0.5 °C in the Mediterranean Basin, 0.7 °C in Central Europe, and 0.9 °C in northern Europe. In the aforementioned study, an average of 0.5°C increase in temperature occurs in the Mediterranean Region of our country and Turkey in a broad sense (Brazdil et al., 2010).
It is predicted a drier climate will emerge in the region in the future. It is important to plan the use of primarily climate-related elements such as agricultural production and water resources in the region and to present them by taking into account the change trends in the climate. Thus, investments will be more rational and long-lasting and will contribute to the strategy of the country (Bahadır, 2011).
Despite the motive for the intensification of agricultural production is to feed the increasing population, the demand for organic or ecological products has increased in parallel with the awareness of the society in recent years. Due to the breeding system, hair goat breeding, which is suitable for this structure or may become convenient with a few regulations, is carried out in a large portion of Turkey (Keskin et al., 2017).
In the studies carried out in this regard, the projection of which feed and animal species will be compatible with which region in the livestock-based scenarios to be put forward according to the assumptions and climate models foreseen for the future over animal production has become an essential issue. The economic importance of goats has increased in recent years. In addition, goats can maintain their productivity in extreme climatic conditions with some favorable aspects they have. In particular, it effectively utilizes some feed resources that cannot be exploited by other farm animals and causes less methane emission than other species. This situation puts hair goats and hair goat breeding in an advantageous position in climate change.

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Assessment of the environmental and social value of Lake Doirani

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Abstract. Doirani is a cross-border lake between Greece and the Former Yugoslav Republic of Macedonia and belongs in Kilkis. The importance of this wetland has led to its protection by European and National Legislation. In recent years, the water balance of the lake has been disturbed and has led to the decline of the fauna and the avifauna. Regarding the aesthetic value of the lake, on the Skopje side there is a great interest in the condition and protection of the lake in contrast to the Greek side where there is indifference, dirt and stench. The goal of the research was to record the views of the respondents regarding the current state of the lake and whether they consider that they benefit from it. The implementation of the research started from the construction of the respective questionnaire. The sample size was selected at 339 units (inhabitants), while the method followed was that of random sampling, at random locations in the study area. The results showed that most respondents believe that Doirani is in a miserable stateand that their quality of life and financial situation is significantly affected by it.

Keywords. Wetland - Ecosystem Services – Questionnaire – Degradation - Aesthetic Value - Protection

Évaluation de la valeur environnementale et sociale du lac Doirani

Résumé. *Le Doirani est un lac transfrontalier entre la Grèce et la République de Macédoine du Nord et fait partie de Kilkis. L'importance de cette zone humide a conduit à sa protection par la législation européenne et nationale. Ces dernières années, l'équilibre hydrique du lac a été perturbé, ce qui a entraîné le déclin de la faune et de l'avifaune. En ce qui concerne la valeur esthétique du lac, alors que du côté de Skopje, il existe un grand intérêt pour l'état et la protection du lac, au côté grec règne l'indifférence, la saleté et la puanteur. La question centrale de la recherche était de recueillir les points de vue des personnes interrogées concernant l'état actuel du lac et si elles considèrent qu'elles en bénéficient. La mise en œuvre de la recherche a commencé par la construction du questionnaire respectif. La taille de l'échantillon a été sélectionnée à 339 unités (habitants), tandis que la méthode suivie était celle de l'échantillonnage aléatoire, à des emplacements aléatoires dans la zone d'étude. Les résultats ont montré que la plupart des répondants pensent que Doirani est dans un état misérable et que leur qualité de vie et leur situation financière en sont affectées de manière significative.*

Mots-clés. *Zones humides - Services écosystémiques – Questionnaire – Dégradation-Valeur esthétique-Protection*

I - Introduction

The distinct geomorphology with the special diversity, the intense relief, and the many different climatic types are key factors in the existence of a large variety of fauna, flora and ecosystems in Greece. The effective management to the situations that pose a threat to the rich natural environment of Greece is considered imperative, with the loss of biodiversity being today one of the most important environmental challenges (WWF Greece, 2012). Regarding the protected areas in Greece, apart from the national legislation, a significant part of the country is included in the European Ecological Network Natura 2000. Furthermore, Greece has signed International

Conventions for the protection of the natural environment. Country's participation in international organizations, such as UNESCO and the Council of Europe comes with obligations (www.ekby.gr).

Lake Doirani, which belongs in Natura 2000, is a source of life for both the natural environment and man. A wide variety of functions performed in this specific wetland, regard the storage of water, the support of the food webs, the enrichment of the underground aquifers and the modification of the flood phenomena. Also, in this wetland there are high values such as great variety of plant species, amphibians, reptiles, insects and birds, the irrigation, as lake water is used to ensure the quantitative and qualitative yield of crops, the scientific and the educational. Doirani is rather attractive for research and training due to the variety of natural features, the diversity of the species and the beauty of the waterfowl that it features. Finally, the recreational value is observed in it as it offers opportunities such as the enjoyment of the natural landscape, the photography, the observation of birds and plants as well as the amateur fishing (Gerakis and Tsiouris, 2010). In recent years, the water balance of the lake has been disturbed (Bonacci et al., 2014). From 1952 onwards, there has been a significant and continuous drop in water levels, which is due to both human activities and environmental change (Katsavouni and Petkovski, 2004). The aim of this study was to investigate if the inhabitants of the areas around the lake benefit from its current situation and what actions do they consider important to be done so that the Greek side of the lake is highlighted and utilized in the same way as on the Skopje side.

II - Materials and Methods

The implementation of the research started from the construction of the respective questionnaire. The questionnaire consisted of two distinct parts. The first part included 22 questions, some of which included additional sub-questions. The total number of questions of the first part (together with the sub-questions) were 33. The second part contained a total of 9 questions related to demographic characteristics of the respondents. The questionnaires were completed through personal interviews in the settlements around the basin of Doirani. The on-site survey took place between December 2019 and January 2020. The reference population of the present study was determined by the total population of the surrounding areas of Lake Doirani. The sample size was selected at 339 units (inhabitants). The chosen method was random sampling and it regards conducting various researches at random locations in the study area. Furthermore, in order to carry out the research, the consent of the respondents was required according to the General Data Protection Regulation (GDPR). All statistical analyses were carried out with the SPSS® statistical software v. 25.0 (SPSS Inc., Chicago, IL, USA).

III - Results and discussions

Approximately 70% of the visitors visit lake Doirani for its outstanding natural environment. The minority of them states that the primary reasons for visiting regard activities like fishing, outdoor dining and photography. Similar research was conducted concerning lake Pamvotis in Ioannina, Greece. The majority of the sample answered that sport and recreational activities mainly attract tourists (Lazoglou and Vagiona, 2018). Furthermore, survey participants were asked to answer if they visited lake Doirani more frequently 10 years ago, before its inclusion in NATURA 2000. The majority, approximately 60% of the respondents, answered in the affirmative.Those who stated that they do not visit the lake today, cited a percentage of more than 80% as the main reason for their attitude the lack of infrastructure. Using a series of questions, the perspectives and perceptions of the respondents about the current state of the lake were recorded. About 4 in 5 respondents (80%) believe that Doirani is in a terrible condition. The respective respondents share the same belief about lake Pamvotis (Lazoglou and Vagiona, 2018).). Respondents were asked as well to address the problems and cause that led to the current

poor condition of lake Doirani. The most common problem is the lack of cleanliness (29.5%) and in minor percentages the abandonment (14.8%), the alteration of the natural landscape (13.7%) and inaccessibility (11.6%) (Table 1).

Table 1. The most important problems of Doirani lake today.

Problems	Percentage (%)
Cleanliness	29.5
Abandonment	14.8
Alteration of natural landscape	13.7
Inaccessible	11.6
Non-utilization	10.4
Indifference	9.2
Lack of infrastructure	5.4
Other reasons	4.6
Water level overflow	1.6
Low water level	0.2
Neglect of a museum	0.1
Total	100.0

Respondents were also asked to express their point of view on the impact of the lake regarding the financial status of the area's households and the quality of life. The majority of respondents (86%) believe that their financial situation is affected by the current state of the lake. Respectively, 78% of the sample assumes that the current situation has negative consequences on their lives (Stergiou, 2020). Finally, respondents were asked to identify which actions need to be taken in order to restore and ameliorate Doirani, following a priority order. Most of the respondents state that in order to restore the lake it is necessary at first place for tourists to have access to its environment so that they can explore it. They assume as well that the establishment of recreation areas, visitor information spaces and cleanliness might be beneficial for the lake's ecosystem (Table 2). Only 8.9% of the respondents consider that the key to restoration is the conservation of fauna and fish fauna.

Table 2. The most important actions for the restoration of Doirani.

Actions	Percentage (%)
Ability to access and tour the lake	27.3
Creating recreation areas	23
Creating visitor information spaces	21.6
Cleanliness	19.1
Conservation of fauna and fish fauna	8.9

IV - Conclusions

Conservation of protected areas is one of the most important environmental challenges today. However, effective site management requires financial resources. It is therefore imperative to demonstrate, at various levels of decision-making, the social feasibility of this environmental policy. In this regard, the application of economic assessment methods of the environment can be particularly useful. According to the results obtained from this research it is understood that the need to implement a lake rehabilitation plan is imperative.

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SESSION II

Pastoralism in Algeria: transformation, challenges and prospects

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Abstract. Pastoralism plays a significant socio-economic role in Algeria. However, extensive livestock systems, which are of high nature value, are facing many challenges and their decline might have social, economic and environmental consequences. In this context, the present review contributes to a better understanding of the current situation in which pastoralism in Algeria is evolving and the major developments over the last decades. It draws upon secondary data from the scholarly literature as well as grey one (e.g. reports). The analyzed literature suggests that the pastoral regions in Algeria are subject to a number of social, economic and technical transformations. These transformations occur as a result of the breakdown of traditional balances between social groups and natural resources. The socioeconomic factors induced by demographic growth as well as climate change have also profoundly modified the Algerian pastoral systems (cf. decreased mobility, greater dependence on feed supplements). This study reveals livestock systems and practices instability as well as an increase of competition over pastoral resources use. The results also highlight that in the face of those transformations, pastoral societies are becoming economically fragile, pushing pastoralists towards livelihoods diversification to improve their chances of maintaining their farms in economically and climatically difficult conditions.

Keywords. Pastoralism – Algeria - livestock production - semi-arid areas - pastoral communities - sustainability.

Le pastoralisme en Algérie : transformation, défis et perspectives.

Résumé. *Le pastoralisme joue un rôle socio-économique important en Algérie. Cependant, les systèmes d'élevage extensifs, qui ont une grande valeur naturelle, font face à de nombreux défis, et leur déclin pourrait avoir des conséquences sociales, économiques et environnementales. Dans ce contexte, la présente revue contribue à une meilleure compréhension de la situation actuelle dans laquelle évolue le pastoralisme en Algérie et des développements majeurs des dernières décennies. Elle s'appuie sur des données secondaires tirées de la littérature savante ainsi que sur des données grises (p. ex., rapports). La littérature analysée suggère que les régions pastorales en Algérie sont soumises à un certain nombre de transformations sociales, économiques et techniques. Ces transformations résultent de la rupture des équilibres traditionnels entre les groupes sociaux et les ressources naturelles. Les facteurs socio-économiques induits par la croissance démographique ainsi que le changement climatique ont également profondément modifié les systèmes pastoraux algériens (cf. mobilité réduite, plus grande dépendance aux compléments alimentaires). Cette étude révèle l'instabilité des systèmes et des pratiques d'élevage ainsi que l'augmentation de la concurrence sur l'utilisation des ressources pastorales. Les résultats soulignent également que, face à ces transformations, les sociétés pastorales deviennent économiquement fragiles, poussant les pasteurs vers la diversification des moyens de subsistance afin d'améliorer leurs chances de maintenir leurs exploitations dans des conditions économiques et climatiques difficiles.*

Mots clés. *Pastoralisme – Algérie – production animale – régions semi-arides - communautés pastorales - durabilité*

I - Introduction

Mediterranean pastoralism is a cultural fact, heir to a long tradition. Despite the stereotypes that stick to its image, it is anchored in the modernity to which pastoral societies have always been able to adapt and survive. Pastoralism is about men, women, and families, life choices and career paths related to animal husbandry (cattle, sheep, goats, equines, camelids); stories and human relationships that are not reducible to the technico-economic performances of farms. Pastoralism is also a relationship with nature and territory, a set of knowledge and know-how, and a cultural heritage (material and intangible) to be protected as modes of production of quality goods, environmental services and lifestyles, but also emblematic landscapes shaped by populations that coexist or have coexisted on territories to which they have given an identity (Ben Hounet and Guinand, 2016).

In Algeria, in the recent decades, the steppe region has undergone a profound evolution. Its human population has tripled from 4 million in 1977 to 12 million in 2009 (ONS, 2011), increasing the pressure of agricultural (livestock and crops) and non-agricultural uses of rangelands. Moreover, the number of animals present on these rangelands also increased from 6 million in 1968 to 20 million in 2014 (Yabrir et al., 2015), which would have contributed to the decline in spontaneous forage availability in the steppe (Le Houérou, 1995; Daoudi et al., 2013; Hammouda et al., 2013). Successive land reforms have allowed a significant expansion of crops, towns and villages to the detriment of pastures and transhumance corridors. The massive use of concentrates in the feeding of animals, as well as the association of crop growing with pastoralism (cf. agro-pastoralism), allowed some breeders to guarantee the feeding of their animals without regularly making large displacements, to be content with collective and private pastures available in their region of origin (Aïdoud et al. 2006; Ghozlane et al., 2009). This set of changes that the steppe has undergone in recent decades has greatly reduced large herd movements, and is constantly changing the habits of the locals (Abbad & Genin, 2004).

The purpose of this article is to present the context, the results and the conclusions of researches, articles and official reports on pastoral livestock farming carried out by different institutions in the Algerian rangelands, throughout the past decades, in order to identify in broad strokes, the common practices and the possibilities of improvement towards more sustainable pastoral production systems. The paper addresses transformations in pastoralism and pasture management relating to society and culture, economics, environment, and policy and governance.

II - Methods

The article draws upon a review of some relevant documents (journal articles, book chapters, conference articles, official national reports and theses) available on the internet or indexed in the libraries of Algerian universities. Two inclusion criteria were considered for the selection of the documents: geographical coverage (viz. regional or national Algerian study) and thematic focus (viz. pastoralism). Following the scrutiny of titles, abstracts and full-texts, 44 documents were included in this narrative review.

3.7 Society and culture

Pastoral and agro-pastoral systems are extremely important for the local population of the Algerian steppes. They play a major role in the food security, and social and economic stability of the local population. However, the processes of changes in lifestyle, livestock management, and biophysical environments, linked in part to climate change, have led to dynamics that determined the degradation of natural resources. This situation has had the effect of altering ancestral know-how, known for generating income for the population (Ben Hounet & Guinand, 2016).

The sedentarization process of nomadic and transhumant breeders, the increasing use of complementation (in particular barley and bran) for animal feeding (thus breaking with pastoral feeding practices based solely on grazing) and the individual appropriation of rangelands are the main highlights of the Steppic territories in the last few years (Moulai, 2008). These transformations have resulted in intense degradation of the natural plant resources of the rangelands, the basis of agropastoral production systems in Algeria. This regressive dynamics of steppe alteration has been confirmed by numerous ecological and agro-pastoral diagnostics that have shown the intensity of degradation of the vegetation cover (Le Houérou, 1995; Nedjraoui, 2003; Tarhouni et al, 2007). Although the agro-pastoral and pastoral populations have been able to cope with the extreme variability of the rains, this adaptation, often individual, has unfortunately led to the monetisation of grazed forage resources (natural range, pasture and cultivated land) (Aidoud et al., 2006). Rights holders who do not own livestock, rent their natural rangelands as well as their cultivated areas to farmers (Mouhouse, 2005). The entire Steppic territory is shared among the members of the different pastoral and agro-pastoral communities. The purchase of feed supplements for livestock became systematic (grain or commercial feed) even in years when rains have been abundant (Kanoun, 2012).

Almost all women in the pastoral communities, have animal husbandry roles and activities regardless of the mode of husbandry. In particular, they are involved in feeding young animals, monitoring animals near the place of residence, etc. Their level of involvement differs from one system to another, but in all cases, they do not have the right to intervene in the management of rangelands or even livestock. In these patriarchal societies, women are excluded from rangeland management. Even if the wife owns land, the exploitation and management is carried out by a male member of her family (father, brother, husband, son) (Ben Hounet & Guinand., 2016; Cialdella, 2005). Indeed, in these traditional societies, women have limited decision-making power when it comes to dealing with the outside world, although they contribute to the rural economy through the creation of local agricultural and para-agricultural wealth and market values, and that they remain the guarantors of the sustainability of indigenous tangible and intangible cultural know-how. Several agricultural and craft activities are carried out by women. These activities contribute to improving the livelihoods of rural households. According to Ferroukhi & Benterki (2003), rural households derive their income from multiple sources within the economy (self-production, agricultural production, crafts, asset leasing). Women constitute with their human potential, the main force of production, they play a driving role in the strategies of survival of families and management of pastoral and natural resources. However, women are rarely involved in important decision-making regarding the management of the livestock and its by-products (Ben Hounet & Guinand, 2016).

3.8 Economics

Animal husbandry and its productions are major issues for the people of the steppic areas in Algeria as well as for the national economy. In fact, the livestock sector contributes with 51%

of agricultural GDP, and the percentage is probably higher if other livestock intermediate values are assessed more adequately (Akhilu, 2002). This sector is also a supplier of raw materials essential to traditional economic activities that valorizes milk, wool and dromedary hair.

One of the weaknesses of the economic literature on pastoralism in Algeria is the discretion of research on the determination of the real weight of pastoralism in the agricultural GDP and in the national wealth produced. Despite the strong intuition of the contribution of the pastoral sector in the national economy, there is very little scientific contribution focused on a global approach to this activity in Algeria, and the existing one is relatively old. This orientation requires, among other things, the updating of studies on the economic viability of pastoralism. This would have the advantage of quantifying economic arguments in order to stimulate, simulate and facilitate decision-making oriented towards the economic development of pastoralism. This could, for example, results in the determination for the Algerian State, of the overall cost they would have to bear in supporting the pastoral economy in relation to economic, social and environmental benefits (Ferroukhi & Benterki, 2003; Bedrani, 2008).

Milk and meat production are the main objectives of livestock farming in the steppic regions of Algeria. Apart from the self-consumed portion of production, the surplus is generally destined for marketing. However, we tend to see a preference among pastoralists for the production of meat, at free prices, than milk, whose prices are controlled (Sraïri et al., 2007). Generally speaking, the pastoral milk production in Algeria faces two major constraints: price competition and supply instability (Yakhlef, 1989). To increase the effectiveness of the marketing of pastoral products, it is not enough to focus on strategies to support and control supply. It would also be advisable to develop strategies to strengthen the competitiveness of pastoral livestock products, targeting the needs of the sector and, above all, respecting the intrinsic characteristics of this activity. This could, for example, take the form of support for securing the environment and improving infrastructure and marketing standards (Bencharif, 2001).

3.9 Environment

In order to be sustainable, livestock systems must be consistent with ecological and social issues as well as economic imperatives. Development options should favour production systems that are best able to meet all of these challenges (Davies et al., 2010). The efficiency of pastoral systems in valuing arid and semi-arid areas is now recognized, but not by all stakeholders, and their ability to respond to the three challenges is insufficiently scientifically justified. There is therefore a major challenge to demonstrate that these extensive livestock systems, simple in principle but complex in their implementation since they develop in difficult environments, preserve a fragile environment while securing rural societies (Derry & Boone, 2010).

For a long time stigmatized as an environmentally degrading element with the development of concepts of “overgrazing”, “desertification” and “land degradation”, pastoralism benefits from a return to grace through the recognition of its contribution to the development of its environment. By re-characterizing the environment of pastoralists in arid areas of uncertain, variable, ecosystem imbalance, etc., the major contributions of Ellis & Swift (1988), Westoby et al. (1989), Behnke et al. (1993), Scoones (1999), Ellis (1999) and Perrier (1999), have helped to rethink the ecology of the rangelands and to seek to determine the respective shares of climatic factors and pastoral activity in the degradation of pastoral environments.

In Algeria, and in other African countries, where the environment is considered to be

permanently in an unbalanced state, both climate and herbivore predation on vegetation and water resources are variables that are part of the system. Through this approach, many scholars have put forward an explanation of the repeated failures of breeding projects, which have focused on finding balanced solutions based on the idea of "carrying capacity". Their contributions have enabled pastoralism to be rehabilitated, believing that it is not sufficiently influential in the sustainable degradation of such an environment. Conversely, it even appears that the mobility strategies implemented by pastoralists are likely to counteract environmental risks (Morton & Meadows, 2000; Briske et al., 2008).

Pastoral systems, which accommodate a large part of the population, are also areas particularly exposed to the risk of desertification. This situation results from the impoverishment of the soil and the decrease of water resources (Tabet-aoul, 2008). In the Algerian High Steppe Plains, climatic disturbances, and more particularly lower rainfall, are an important cause of the fragility of these environments. Natural forage availability is becoming more and more random. Studies by the Long-Term Ecological Monitoring and Observation Network (ROSELT) in the southern Algerian steppes showed a loss of pastoral production equivalent to 236 feed units (UF)/ha for a decrease in annual rainfall of 104 mm/year (Bneder, 2018). Halfa grass is disappearing, although this plant accounted for 80% of the vegetation cover of the pre-existing system, this disappearance being of course even faster in the grazed plots. In addition, inadequate cropping practices result in annual ploughed areas subject to wind erosion being estimated at nearly 1.2 million ha (CREAD, 2018). The recurrence of drought cycles, which have become longer and longer, accentuates this desertification. The development by remote sensing of a map of sensitivity to desertification has shown that already more than 570,000 ha of land in steppic areas are completely desertified without the possibility of biological ascent and that nearly 6 million ha are very threatened by the effects of wind erosion (Nedjraoui & Bedrani, 2008).

As a result, farm households are likely to see their sources of income decline. At the level of the population as a whole, prices of the main agricultural products could rise significantly, threatening the country's food security. Domestic prices for animal products (meat and dairy) could also see substantial increases due to reduced pasture productivity (Bessaoud, 2016).

3.10 Policy and governance

The second pillar of the Algerian agricultural policy, which covers the concept of "rural renewal", is aimed at households living in rural areas, or nearly 40% of the Algerian population (11 million rural residents). According to the Ministry of Agriculture, Integrated Rural Development Proximity Projects (PPDRI) have been implemented around four axes: the modernization or/and rehabilitation of villages, the diversification of economic activities and the improvement of living conditions in rural areas, the protection and enhancement of natural resources (steppe, oasis, mountains), and the protection and enhancement of the tangible and intangible heritage of rural territories (Ferroukhi & Bentourki, 2003).

Bessaoud et al. (2019) also note that the State, aware of the risks incurred both by pastoral activity and by people in steppic areas, has taken into charge this aspect by implementing technical and institutional programs and measures. These include: the strategy to combat desertification and drought, the development of the map of sensitivity to desertification and degradation of steppe rangelands, the establishment of the High Commissioner for Steppe Development (HCDS) and its provision of material and human resources to monitor risks and to act in the framework of the development of steppic areas (e.g. agricultural development with a ban on cereal ploughing, creation of water points for livestock, drilling for irrigation, epidemiological monitoring, development of sheep, bovine and cameline sectors, support and capacity building for pastoralists, etc.).

Nonetheless, few questions arise, on the one hand, whether those proceedings will represent the ultimate solution to the multiple risks and problems faced by the rural and pastoral communities, and, on the other hand, will they be thoroughly implemented in every region of the country to ensure maximum efficiency.

IV - Conclusion

What is important to note from this study is that the steppe region in particular and the Algerian rangelands in general have undergone strong changes marked by an increase in the number of livestock and the rural population. Pastoral resources have declined due to the extension of cultivation, failures of agricultural policies and climate change (droughts). This has made pastoral communities much more fragile and vulnerable. In this context, farmers have adopted a set of strategies (complementation, mobility, irrigation, etc.). Pastoralists with land seem to be more resistant to decapitalization. Therefore, the development of agro-pastoral activities in the Algerian steppe and rangelands is, today, a necessity, in order to protect their natural resources, improve incomes, guarantee food security and provide enough jobs to a growing population. Underestimating, or neglecting, these development possibilities may not only lead the particular vegetation of the steppe to shrink, its soils to degrade and its agro-pastoral population to become impoverished, but also to see its livestock farming gradually evolve towards a kind of farming that is subject to price fluctuations of different imported grains, and seeing the particular quality of the livestock products, especially sought by consumers, to deteriorate.

Finally, and because the Algerian pastoral systems are evolving amidst very high fluctuation in both climatic and economic conditions, we highlight the urgent need for broader, more in-depth long-term studies, that cover all the aspects of pastoralism, in order to clarify and complete the different analyses and diagnoses available. It is also necessary that the different actors (e.g. researchers, breeders/pastoralists, officials and policy-makers) join their efforts to promote a strategy to exploit reasonably and sustainably all accessible resources, whether renewable or not, such as water, arable lands and pastures.

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Patterns of transhumant livestock system on Mount Zireia, Peloponnese, Greece

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Abstract. The transhumant livestock system in Greece, as well as in the Mediterranean basin, is deeply rooted in time, having developed a set of cultural characteristics, the carriers of which continue to be the transhumant farmers. There are more than 3,050 transhumant flocks in Greece, whose major part belongs to Sarakatsans, an ethnic group. These flocks moved on foot in the past, but now most of these movements are carried out with trucks. This study aimed to investigate the dynamic overtime of a) transhumant animals and b) transhumant routes in Mount Zireia in Peloponnese in Southern Greece. The data were taken from personal communications, publications, and data from the Payment and Control Agency for Guidance and Guarantee Community Aid (PCAGGCA). According to the results, a substantial number of transhumant sheep and goats exist in the study area. The traditional routes on foot have stopped, and the animals are currently being moved with trucks, responding to modern socio-economic developments the shared international custom. These changes in the transhumant livestock system probably due to a general trend of transhumant farmers to adopt innovations and modern standards, restrictions in land uses, changes in their living standards.

Keywords. Transhumant routes - cultural heritage - ecosystem services – sheep.

Modèles de système d'élevage transhumant sur le mont Zireia, Péloponnèse, Grèce

Résumé. *Le système d'élevage transhumant en Grèce, ainsi que dans le basin méditerranéen, est profondément ancré dans le temps, ayant formé un ensemble de caractéristiques culturelles, dont les porteurs restent quelques petits groupes d'éleveurs mobiles. Il y a plus de 3,050 troupeaux transhumants en Grèce, dont la majeure partie appartient aux Sarakatsans, une communauté ethnique. Ces troupeaux se déplaçaient à pied dans le passé, mais maintenant la plupart de ces déplacements sont effectués avec des camions. Cette étude visait à étudier la dynamique au fil du temps des a) animaux transhumants et b) des routes transhumantes dans le mont Zireia dans le Péloponnèse dans le sud de la Grèce. Les données ont été extraites de communications personnelles, de publications et de données de l'Agence de Paiement et de Contrôle pour l'Orientation et la Garantie des Aides Communautaires (PCAGGCA). Selon les résultats, un nombre important d'ovins et de caprins transhumants existe dans la zone d'étude. Les itinéraires traditionnels à pied ont cessé et les animaux sont actuellement déplacés avec des camions, répondant aux développements socio-économiques modernes et à la coutume internationale commune. Ces changements dans le système d'élevage transhumant sont probablement à cause d'une tendance générale des éleveurs transhumants à adopter des innovations et des normes modernes, des restrictions dans l'utilisation des terres et des changements dans leur niveau de vie.*

Mots-clés. *Routes de transhumance - patrimoine culturel – services écosystémiques - ovins.*

I - Introduction

The term "transhumant livestock farming" indicates the annual movement of herds, especially sheep and goats, between summer and winter rangelands, regardless of the transportation means and distance they cover (Manzano-Baena and Casas, 2010; Bhasin 2017a). This paper focuses on transhumant sheep and goats, although in the past, movements also concerned

other animals belonging to the livestock family. Today except for small ruminants, there is a significant number of transhumance farms exclusively with cattle in Greece (PCAGGCA, 2020). Nevertheless, this kind of animal, the practice of movement is at the core of the cultural and social constitution of the mountainous livestock communities in Greece and has greatly contributed to the landscape of the regions historically developed (Sidiropoulou *et al*., 2015; Ragkos *et al*., 2020). The historical evolution of transhumant sheep and goats has put itself within the modern semi-intensive systems of the European Union, which are based primarily on grazing and less on feeding indoor. From this perspective, the process of the system is subject to problems that differ significantly from those faced by transhumant farmers of the past decades, but without changing the essence of their goals.

Sheep and goats transhumance can be found in many Mediterranean and Balkan regions, including Greece, as they are suitable for the particular conditions of mountainous rangelands (Ligda *et al*., 2012; Vallerand, 2014; Nori and Farinella, 2020). Movements in Greece have the form of a social organization in which they migrated independent family groups. Several ethnic groups such as Sarakatsans, Vlachs, and Koupatsaroi are associated with this activity. According to data from the Payment and Control Agency for Guidance and Guarantee Community Aid (PCAGGCA, 2020), there are more than 3,050 transhumant flocks in Greece, and a major part of them belongs to Sarakatsans. Sarakatsans are closest to the traditional historical movement and are located spatially throughout mainland Greece, while they were organized into closed autonomous societies, called "Tseligato".

According to Nitsiakos (1997), "Tseligato" was a form of productive cooperation between a number of domestic groups, generally linked by ties of kinship or marriage, under the leadership of a strong breeder. These social structures had a distinct identity, social cohesion, and efficient use of resources while seeing the exercise of all types of professions (grocery stores, cheese, bakeries, etc.), factors that combine them secured autonomy (Ragkos *et al*., 2016). According to Syrakis's (1925) data, 13,700 families moved along with their flocks, of which 5,956 were families of Sarakatsans. Later around 1950 -1960, Sarakatsans were mainly moved to Thessaly and Sterea Greece, Central and East Macedonia, Epirus, Peloponnese, and Thrace (Chatzimichali, 2007),

All flocks moved on foot in the past, but now most of these movements are carried out with trucks, and only local (small distance) are moved on foot. The aim of this study was to investigate the dynamic overtime of a) transhumant livestock and b) transhumant routes in Mount Zireia in Peloponnese in Southern Greece.

II - Materials and Methods

The study area was Mount (Mt) Zireia (Kyllini), located in the Peloponnese peninsula, South Greece, famous for its association with the god Hermes. Mount Zireia is located west of Korinthos city. The study area covers ca. 39761.57 ha in an altitudinal zone ranging from 310 m to 2374 m a.s.l.

The data for this investigation were collected from personal communications, and the respondents were all over 70 years old, for the past (1950-1960) and related publications (Chatzimichali, 2007), while for today (2020) from the Payment and Control Agency for Guidance and Guarantee Community Aid (PCAGGCA, 2020).

III - Results and Discussion

The patterns of transhumant sheep and goats in Mt Zireia are presented in Table 1. Although a remarkable number of transhumant sheep and goats exist in the study area for the last 60 years, their number presented a significant decrease of about 64%. In Mt Zireia around 1960, they moved 103 Tseligkata, 245 herders' families with 38,230 sheep and goats (Chatzimichali, 2007). According to the data from PCAGGCA (2020), they moved only 54 families with 13,717

animals, and the Tseligkato system has become almost extinct in the area as it happens in most areas in Greece (Kavvadias, 1991; Sidiropoulou *et al*., 2005). The abandonment of transhumance is obvious in mountainous local communities Kastania, Kyllini, and Trikala where the higher decrease of more than 80% was presented. It is interesting that in the study area, transhumant animals presented in 4 new communities in the last years. According to personal communications with residents of these local communities, there was also transhumance in the past, but it was not known as Chatzimichali did not record them.

Table 1. Transhumant sheep and goats per local community on Mt Zireia in 1960 and 2020

Local community	Animals	
	1960	**2020**
Gkoura	5530	2047
Drosopigi	2670	1302
Karya	200	1545
Kastania	2500	346
Kyllini	3300	454
Manna	1700	1012
Trikala	20680	3964
Feneos	1650	709
Steno		*543*
Saradapyxo		*464*
Arxaia Feneos		*275*
Kato Tarso		*1056*

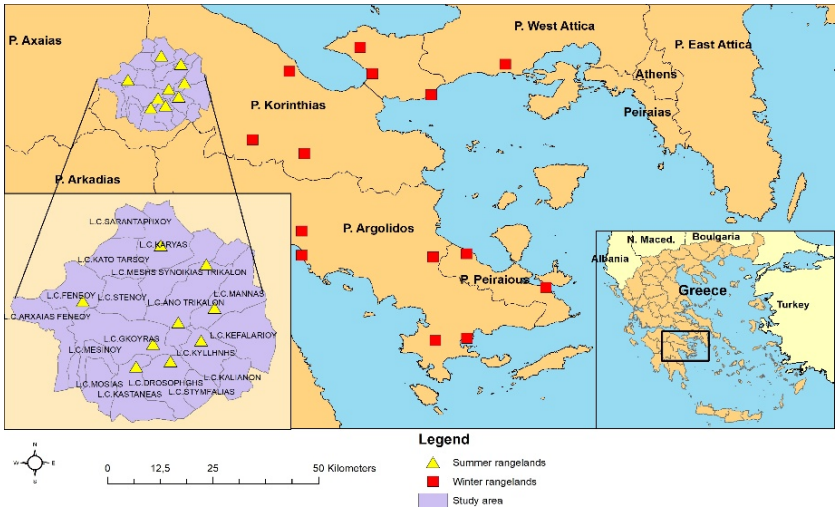

Figure 1. Grazing rangelands by transhumant sheep and goats during summer (mountainous) and winter (lowlands) in 1960

In the past, all flocks and families were moved on foot (Figure 1) from different regions from the Peloponnese peninsula or West Attica, lasted 3-7 days and nights, and followed the same route each year (Chatzimichali, 2007). These movements have stopped due to several reasons, and the main traditional transhumance routes practice that responds to modern socio-economic developments and is a common global custom. In the last decades, all these movements are

performed with trucks and have modified the time spent for the transitions of the herds (Apolloni *et al*., 2018). The changes in the transhumant livestock system probably due to a general trend of transhumant herders to adopt innovations and modern standards, restrictions in land uses, changes in their living standards. As in other countries, there is a need to develop a monitoring system of both transhumant activity and environmental changes (Pérez León *et a*l., 2020).

IV - Conclusions

These preliminary results indicated a remarkable decrease of transhumant animals in mountainous rangeland on Mt Zireia and the abandonment of traditional foot movements. These changes probably had significantly affected the landscape and the ecosystem services provided of this mountainous area. In many cases, abandonment of the transhumant livestock system was related not only to a loss of cultural heritage but also closely linked to the significant effects on the ecosystem structure and function. It is necessary to investigate tracking migratory routes and the effect of their dynamics especially on landscape and the ecosystem services provided.

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SESSION III

Economic performance of dairy goat farming in Greece. Preliminary results

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Abstract. The aim of this study is to outline the main technical and economic indicators of dairy goat sector in Greece. Through face-to-face interviews with farmers detailed accounting data were collected from 96 goat farms located in Northern Greece and a comparative analysis was carried out using milk yield/doe and farm size as classification criteria. Analysis showed that the farm indicators vary considerably, both in terms of milk yield and farm size. Milk production/doe is 155.17 kg for average farm, while in small size farms is considerably higher compared to medium and large size farms. The average farm uses 18.59 hours of labor/doe, of which 29.7% is hired labor. Small size farm uses more labor/doe, followed by medium and large size farm. Milk yield and farm size are both associated with the composition of the labor used, confirming that hired labor is more important in high milk yield and large size farms. Low milk yield farm pays less rent for land/doe than high milk yield farm, while farm size is negatively associated to land rent. High differences exist both among milk yield groups and among farm size groups regarding the composition of labor cost. Milk yield and farm size are also negatively related to the variable cost, fixed capital cost, and total production cost. In general goat farms exhibit losses, although the economic performance of the farms is improved as the milk yield and the size of the farm are increasing. The findings of this study could be useful for a more rational management towards increasing the productivity and enhancing the competitiveness of goat farming.

Keywords. Dairy goat farming - milk yield and farm size classification - farm technical and economic indicators - Greece

Performances économiques de l'élevage de chèvres laitières en Grèce. Résultats préliminaires

Résumé. *L'objectif de cette étude est de décrire les principaux indicateurs techniques et économiques du secteur de l'élevage de chèvres laitières en Grèce. Par le biais des entretiens personnels avec des éleveurs, des données comptables détaillées ont été recueillie auprès de 96 exploitations caprines situées dans le nord de la Grèce. Une analyse comparative a été réalisée en utilisant le rendement laitier/chèvre et la taille de l'exploitation comme critères de leur classification. L'analyse a montré que les indicateurs des exploitations diffèrent considérablement, tant en termes de taille de l'exploitation et de rendement laitier. La production du lait/chèvre est de 155,17 kg pour l'exploitation moyenne. Parmis les fermes de petite taille, la production est considérablement plus élevée par rapport aux fermes moyennes et de grande taille. L'exploitation moyenne utilise 18,59 heures de main-d'œuvre par unité de production, dont 29,7 % de main-d'œuvre rémunéré. Les exploitations de petite taille utilisent davantage de main-d'œuvre par unité de production, suivies par des exploitations moyennes et de grande taille. Le rendement laitier et la taille de l'exploitation sont en relation directe à la composition de la main-d'œuvre utilisée, ce qui confirme que la main-d'œuvre salariée est plus importante aux exploitations à haut rendement laitier et de grande taille. Les exploitations à faible rendement laitier paient moins de loyer pour la terre/chèvre que les exploitations à haut rendement laitier, tandis que la taille de l'exploitation est négativement corrélée avec le loyer de la terre. Il est montré que la composition du coût de la main-d'œuvre differe significativement quand les groupes de rendement laitier soient comparer aux groupes de la taille de l'exploitation. Le rendement laitier et la taille de l'exploitation sont également liés négativement au coût variable, au coût du capital fixe et au coût total de production. En général, les exploitations caprines présentent des pertes, bien que ses performances économiques s'améliorent à mesure que le rendement laitier et la taille de l'exploitation*

augmentent. Les résultats de cette étude pourraient être utiles pour une gestion plus rationnelle en vue d'augmenter la productivité et d'améliorer la compétitivité de l'élevage caprin.

Mots-clés. *Élevage de chèvres laitières - classement des rendements laitiers et taille de l'exploitation - indicateurs techniques et économiques des exploitations - Grèce.*

I - Introduction

Goat farming is a dynamic livestock sector in Greece, contributing to the employment of rural population in disadvantaged and remote areas of the country and providing income to thousands of farmers (Voltsou, 2005; Miliadou D., 2010; Arsenos et al., 2014; Laliotis, 2018). Goat farms are mostly situated in LFAs featuring animals of local breeds and mainly of low milk yields, under the extensive or semi-extensive production system. Most of the farms are characterized by poor infrastructure and depend on grazing in specific regions of the country which are not suitable for other production activities (Zygogiannis and Katsaounis, 2009; Gelasakis et al., 2017; Vouraki, 2019; Theodoridis et al., 2019). In lowland areas, goat breeds of high productivity are reared, under intensive or semi-intensive systems by modern farms that depend heavily on concentrates and forage mainly produced on-farm (Vouraki, 2019, Theodoridis et al., 2019).

Greece has the largest dairy goat population in the EU(27), rearing 30.34% of the total number of goats, and producing 355,760 tons of milk and 26,480 tons of goat meat (FAO, 2021; ELSTAT, 2020). The sector accounts for 14.51% and 43.18% of the total goat milk and meat production in the EU(27), respectively (FAO, 2021).

Despite the changes that have emerged in the Greek goat sector during the last decades, the sector is still facing severe structural weaknesses, mainly due to the small farm size, the lack of modern facilities, and the lack of vocational training of goat farmers (Vouraki, 2019; Katsaounis and Zygogiannis, 2009; Gelasakis et al., 2017; Amarantidis, 2014; Ragkos et al., 2017). Sector's prospects and sustainability in the globalized market are directly linked to the rational management of the available inputs and the improvement of farm productivity and competitiveness of the sector (Liontakis, 2015). The characteristics of foreign trade in goat products in recent years outline the export potential that the Greek goat sector can acquire, expanding in the European markets and beyond. Thus, the viability of the Greek goat sector and the promotion of its socio-economic importance and its export character, constitute the description of the technical and economic profile of the sector significant.

The aim of this study it to analyze the economic performance of the Greek goat sector and to present the main technical and economic indicators of the typical goat farm in the sector. These characteristics are also described for groups of farms which are categorized in terms of milk yield and animals reared, providing insight regarding the efficient management of goat farms and, consequently, the strategies which are required to be adopted by goat farms in the modern entrepreneurial environment.

II - Materials and Methods

Through a farm management survey of 96 goat farms, which carried out in 2018, detailed accounting data were collected. The surveyed goat farms operate under various farming systems, which embody the prevailing characteristics of goat farming in the country and are located in the area of Macedonia and Thrace in Northern Greece (Figure 1). The goat farming in this area accounts for 26.16% of the total goat population of the country (ELSTAT, 2019 data) and of 30.62% of the total quantity of goat milk (ELSTAT, 2018).

Basic cost accounting methods were used, and the main technical and economic indicators were estimated for the average goat farm in the sector (Kitsopanidis, 2006), as well as for groups of farms which were categorized using as classification criteria “milk yield” per doe and “farm size” (number of does (adult female animals in the farm)). Two “milk yield” groups were formulated, “Low milk yield farms: ≤140 kg/doe” and “High milk yield farms:>140 kg/doe” and three farm size groups, “Small size farms: ≤199 does”, “Medium size farms:200 to 399 does”, and “Large size farms: ≥ 400 does”.

Furthermore, the Wilcoxon rank sum nonparametric test (Mann-Whitney U-test) was applied to evaluate “milk yield” depended differences, and the Kruskal-Wallis nonparametric test was applied to evaluate “farm size” depended differences, on the mean values of milk yield (kg/doe/farm) and on the mean the number of does/farm (Zolman, 1993). All analyses were conducted using the statistical software program SPSS for Windows (v. 25.0). Significance was declared at P≤0.05, unless otherwise noted.

III - Results and Discussion

Table 1 presents the main technical characteristics of the goat farms, for the average farm in the sample as well as for the milk yield and farm size groups of farms.

Table 1. Technical indicators of goat farms, in terms of “farm size” and “milk yield”.

Technical indicators	Average farm	“Milk yield” group		“Farm size” group		
		“Low milk yield: ≤140 kg/doe”	“High milk yield: >140 kg/doe”	“Small size farms: ≤199 does”	“Medium size farms: 200 to 399 does”	“Large size farms: ≥400 does”
Number of farms	96	52	44	23	42	31
Milk production (kg/doe)	155.17	107.30	216.94	224.85	144.34	149.97
Milk yield (kg/doe/farm)	175.13	104.98	258.02	253,82	149,45	151,52
(Mean±SD)	±124.5	±21.05[a]	±144.01[b]	±181,48[a]	±99,75[b]	±71,35[b]
Number of does/farm	333.82	347.25	317.95	134.39	274.71	561.87
(Mean(±SD)	±238.03	±263.13[a]	±206.34[a]	±40.403[a]	±50.84[b]	±292.50[c]
Total labor (hours/doe)	18.59	18.28	18.99	27.57	20.01	16.05
Family labor (hours/doe)	13.07	14.16	11.66	21.41	16.51	9.31
Hired labor (hours/doe)	5.52	4.12	7.33	6.16	3.5	6.75

a, b, c: Mean values in the same row and for the same classification variable, with a superscript in common do not significantly differ (P>0.05) [Mann-Whitney and Kruskal-Wallis npar tests].

The results show that the milk production per doe for the average farm in the sample is 155.17 kg, while for the small size farms is 224.85 kg, for the medium size farm is 144.34 kg and for the large size farm is 149.97 kg. Moreover, for the low and high milk yield group is 107.30 kg and 216.94 kg, respectively. Meanwhile, the mean (Mean±SD) milk yield in the sample (kg/doe/farm) is 175.13±124.3 kg, while in the small size farms is 253,82±181,48[a] kg and

significantly higher than in medium size (149,45±99,75[b] kg) and large size farms (151,52±71,35[b] kg). Likewise, in low milk yield farms the mean milk yield is 104,98±21.05[a] kg and significantly lower compared to that in the high milk yield farms (258.02±144.01[b] kg).

The average goat farm in the sample, breeds 334 does, while the low milk yield farms breed 347 and the high milk yield farms breed 318 does. Although the farm size in the milk yield groups seems to be negatively related to milk yield per doe, with the number of does being lower in groups of high milk yield farms, the statistical evaluation shows no significant difference between the two groups (P>0.05), maybe due to high variability observed among individual goat farms.

In high milk yield farms, the average farm uses more labor/doe compared to the low yield milk farms. Moreover, regarding the farm size groups, the small size farms use more labor/doe, followed by the medium and finally by the large size farms. In more detail, the average farm uses 18.59 hours of labor/doe, of which 70,3% is allocated to family members and 29.7% is hired labor. The low milk yield farms use on average 22.5% of hired labor, while for the high milk yield group this percentage increases to 38.6%. The small size farms use 22.35% hired labor, while for the medium and large size farms the share of hired labor is 17.49% and 42.05%, respectively.

In general, the milk yield and the farm size are both associated with the composition of the labor used in the farm, confirming that hired labor is more important in high milk yield farms and large size farms.

Technical indicators of Greek goat farming have been reported by several researchers, in the past. Tsiouni (2018) surveyed 120 goat farms and estimated the average number of goats at 242 does and the average milk yield at 173.03 kg/doe/farm, not far from our results. She also reported a total labor of 14.45 hours/doe/year. Kaimakamis (2017) in a sample of 492 sheep/goat farms, of which 76 goat farms, estimated the average milk yield at 182.33 kg/doe/farm, while Galanopoulos et al. (2011) studied a sample of 106 sheep/goat farms, of which 31 goat farms, and estimated the average milk yield at 137 kg/doe/farm. Moreover, Miliadou (2010) used a sample of 130 organic goat farms and estimated the average number of goats at 278 and the average milk yield at 92.80 kg/doe/farm, also reporting a total of 16.04 hours/doe/year.

Chatzitheodoridis et al. (2007), in a technical-economic analysis of 75 sheep-goat farms in a typical Greek island, declared that total labor (hours/animal) is positively affected by farm size, reporting 12.83 hours/doe/year for farms with >301 animals and 34.84 hours for farms with ≤50 animals. De Rancourt et al. (2006) calculated the milk yield at 120 kg/doe/farm, while Kitsopanidis (2002) have classified Greek goat farms in 3 sizes (<150, 150-500 and >500 does), reporting a milk yield of 134 kg/doe/farm for the first class, a milk yield of 292 kg/doe/farm for the second class and a milk yield of 606 kg/doe/farm for the third class.

The main economic characteristics of the goat farms are presented in Table 2, both for the average farm in the sample as well as for the milk yield and farm size groups of farms.

Regarding the economic characteristics of goat farms, the analysis of the empirical data showed that the low milk yield farms pay less rent per doe (6.71€/doe) than the high milk yield farms (7.84€/doe). At the same time, farm size is negatively related to land rent, with the large size farms to depend less on home-grown feed to reduce the feeding cost (4.77€/doe), followed by the medium (8.54€/doe) and finally by the small size farms (15.91€/doe).

Table 2. Economic indicators of goat farms, in terms of "farm size" and "milk yield".

Economic indicators	Average farm	"Milk yield" group		"Farm size" group		
		"Low milk yield: ≤140 kg/doe"	"High milk yield: >140 kg/doe"	"Small size farms: ≤199 does"	"Medium size farms: 200 to 399 does"	"Large size farms: ≥400 does"
Number of farms	96	52	44	23	42	31
Land rental (€/doe)	7.20	6.71	7.84	15.91	8.54	4.77
Total labor cost (€/doe)	52.96	51.52	54.82	90.61	58.21	42.81
Family labor cost (€/doe)	39.21	42.49	34.97	64.22	49.54	27.92
Hired labor cost (€/doe)	13.76	9.04	19.85	26.38	8.66	14.89
Variable capital cost (€/doe)	90.95	76.05	110.20	161.84	87.84	80.44
Feed cost (€/doe)	69.40	58.68	83.25	120.74	67.49	61.56
Miscellaneous costs (€/doe)	21.55	17.37	26.95	41.1	20.35	18.87
Fixed capital cost (€/doe)	33.01	28.54	38.79	65.38	32.86	27.37
Production cost (€/doe)	184.13	162.82	211.65	333.74	187.45	155.39
Gross revenue (€/doe)	161.73	126.42	207.30	279.33	146.98	150.62
Gross margin (€/doe)	70.77	50.37	97,10	117.50	59.14	70.18
Profit or loss (€/doe)	-22.41	-36,40	-4,35	-54.41	-40.47	-4.76

For the average sample farm, the labor cost is €52.96 per doe, with substantial differences among farm size groups, but no high difference among milk yield groups. However, high differences exist both among the low milk yield and high milk yield farms as well as among farm size groups of farms regarding the composition of the labor cost. Expenses for hired labor are much higher in the high milk yield farms compared to low milk yield farms. In more detail, the share of hired labor cost in the low milk yield farms is 17.55%, while for the high milk yield farms is 36.21%. This is also evident for the farm size groups, as the small size farms spend on average €26.38/doe for hired labor (28.8% of the total labor cost/doe), while the medium size farms spend on average €8.66/doe (14.88%) and the large size farms €14.89/doe (34.78%).

For the average farm in the sample, the variable cost (including feeding cost and other expenses) is €90.95/doe, while the feeding cost is €69.40/doe. The milk yield/doe and the farm size are associated with the composition of the variable cost, with the observed differences mainly attributed to the feeding cost. For the low milk yield farm, the feeding cost is €58.68/doe (77.16% of the total variable cost) and 29.5% lower than in the high milk yield farms (€83.25). Moreover, the small size farms spend almost double on purchased and/or on-farm produced feed, compared to the large size farm farms.

Milk yield and farm size appear to be related with the fixed capital cost and total production cost/doe. For the average farm the fixed capital cost is €33.01/doe and production cost €184.13/doe, while in the low milk yield farms are less than in the high milk yield farms. On the other hand, the fixed capital cost and the total production cost are negatively related to farm size, with the small size farms paying more than double compared to the large size farms.

Similarly, gross revenue and gross margin per doe vary considerably among milk yield groups as well as among farm size groups. For the average farm, the gross revenue is €161.73/doe, while for the low and the high milk yield farms it is €126.42/doe and €207.30/doe, respectively.

Moreover, gross revenue of the small, medium and large size farms is €279.33/doe, €146.98/doe and €150.62/doe, respectively.

Furthermore, the gross margin for the average farm is estimated at €70.77/doe, while the high milk yields average farm achieves considerably higher values of gross margin compared to the low milk yield farm. On the contrary, the gross margin in the small size farms is €47.32/doe higher than in the large size farms. The goat farms exhibit loss, in general, but high milk yield farms and large size farms exhibiting better results.

Tsiouni (2018), reported estimations of economic indicators in Greek goat farming, e.g., a labor cost of €43,88/doe, a variable cost of €88,80/doe, a feeding cost of €76,25/doe, a fixed capital cost of €29,50/doe, a production cost of €118,51/doe and a gross revenue of €156,36/doe. Kaimakamis (2017), also reported a labor cost of €50,18/doe, a variable cost of €102,36/doe, a fixed cost of €88,81/doe, a production cost of €191,17/doe, a gross revenue of €241,08/doe, a gross margin of €138,72/doe and a profit of €49,91/doe. Miliadou (2010), reported a variable cost of €92,54/doe, a feeding cost of €37,87/doe, a fixed cost of €29,50/doe, a production cost of €122,94/doe, a gross revenue of €159,30/doe and a profit of €36,36/doe. Moreover, Chatzitheodoridis et al. (2007) declared that small to medium size farms exhibit loss of €33.29/animal, but large and very large size farms achieve a profit of €15.42 and €17.91/animal, respectively.

IV - Conclusions

The analysis of the technical and economic indicators of goat farms reveals considerable differences among milk yield groups as well as among farm size groups of farms. Farm size is negatively related to rent, with the small size farm spend almost triple for land rent compared to the large size farm. Moreover, small size farms exhibit significantly higher amount of milk production/doe compared to medium and large size farms.

Milk yield and farm size are both associated with the composition of the labor used, and consequently with the composition of labor cost, confirming that hired labor is more important in high milk yield and large size farms. The milk yield and the farm size have also a considerable effect on the composition of the variable cost, with the observed differences mainly attributed to the feeding cost. The small size farms spend almost twice as much on purchased and/or on-farm produced feed compared to the large size farms, while for the low milk yield farm, the feeding cost is lower than in high milk yield farms. Milk yield and farm size appear to be related to the fixed capital cost and total production cost/doe, with the low milk yield farm and the large size farm spending less, compared to other groups of milk yield and farm size, respectively. Gross revenues and gross margin per doe are improved as the milk yield increases, however, they are deteriorating as the number of animals reared increases.

Overall, the evaluation of the estimates reveals that the high milk yield farms are based more on hired labor, spend more for land rental and variable cost and invest more in fixed assets per doe, but achieve higher economic results in terms of gross revenue, gross margin and profit/loss per doe. On the other hand, the large size farms are based more on hired labor, spend less for rent and variable cost and particularly for feed and invest less in fixed assets per doe, but achieve higher economic results in terms of gross margin and profit/loss per doe, utilizing scale economies. In conclusion, the high milk yield farms and the large size farms seem to operate under higher management standards, thus achieving higher economic performance. The findings of this study could be useful for a more rational management towards increasing the productivity and enhancing the competitiveness of goat farming.

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Comparative technical and economic analysis of a local sheep breed in Greece and North Macedonia

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Abstract. The development of the sheep sector resulted in the transition from traditional extensive systems to intensive, where local breeds have been gradually replaced by imported improved ones or extensive crossbreeding has taken place. This has been the case in Greece as well as North Macedonia, where cross-breeding between local breeds has also been extensive. This study examines the economic performance of the production systems of the local "Pelagonia" sheep breed - which can be found in the cross-border area of the two countries but is actually witnessing declining populations. The results of a descriptive technical and economic analysis demonstrated that the extensive Pelagonia production systems are more profitable than the intensive - despite lower milk yields– mainly due to significant savings in feeding costs. In addition, it showed that the economic results of the Greek extensive group were better than those of the average Pelagonia farm in North Macedonia. However, a different outcome is yielded when subsidies are not taken into account, as the economic results of the average Pelagonia farm in North Macedonia were more satisfactory than those of the Greek extensive group, indicating that the Greek Pelagonia farms highly rely on income support. The results of the technical and economic analysis are an essential step toward the definition of the framework within which Pelagonia sheep farms will be incorporated towards the emergence of sustainable production systems in both countries.

Keywords. Pelagonia sheep breed - Pasture - Technical and economic indicators - Livestock production systems.

Analyse technico-économique comparative d'une race ovine locale en Grèce et en Macédoine du Nord

Résumé. *Le développement de la production ovine a entraîné le passage des systèmes extensifs traditionnels vers des formes intensives, où les races locales ont été progressivement remplacées par des races importées ou des croisements ont eu lieu. Cela a été le cas en Grèce ainsi qu'en Macédoine du Nord, où les croisements entre races locales ont également été étendus. Cette étude examine les performances économiques des systèmes de production de la race ovine locale « Pelagonia » - qui se trouve dans la zone transfrontalière des deux pays mais connaît en réalité un déclin des populations. Les résultats d'une analyse technico-économique descriptive ont démontré que les systèmes de production extensifs de Pelagonia sont plus rentables que les systèmes intensifs - malgré la production de lait soit plus faible - principalement en raison d'importantes économies sur les coûts d'alimentation. En outre, il a montré que les résultats économiques du groupe extensif grec étaient meilleurs que ceux de la ferme Pelagonia moyenne en Macédoine du Nord. Cependant, un résultat différent est conclu quand les subventions ne sont pas prises en compte, car les résultats économiques de la Macédoine du Nord étaient plus satisfaisants que ceux du groupe extensif grec, indiquant que les fermes Pelagonia grecques dépendent fortement des subventions. Les résultats de l'analyse technico-économique sont une étape essentielle vers la définition du cadre dans lequel les élevages ovins Pelagonia seront intégrés vers des systèmes de production durables dans les deux pays.*

Mots-clés. *Race ovine Pelagonia - Pâturage - Indicateurs techniques et économiques - Systèmes de production animale.*

I - Introduction

In recent years, the development of the Greek sheep sector has been based on a transition from traditional extensive systems to intensive ones (Ragkos *et al.*, 2017). Most of the farms adopted a new capital-intensive business model (e.g. novel technologies in farm management, larger buildings), which also brought the introduction of imported sheep breeds (e.g. Lacaune, Friesland, Assaf, Awassi etc.) with high milk production capacity (Ragkos *et al*., 2015). This trend combined with the absence of integrated breeding programs and the unplanned crossbreeding resulted in the gradual replacement of Local Sheep Breeds (LSB) by imported ones (Ragkos *et al.*, 2017). Their low milk yields - compared to the imported improved ones - constitute the main reason that led to the reduction of their populations and to the underestimation of their Total Economic Value. In particular, apart from their important functional traits (e.g. resistance to diseases and adaptability to specific local conditions), LSB are able to formulate multifunctional production systems in marginal areas, as they produce a wide range of services (e.g. climate change mitigation, protection of cultural heritage, maintenance of rural livelihoods) jointly with the provision of food (milk, meat, dairy products etc.) (Ragkos *et al*., 2017).

According to the Ministry of Rural Development and Food (2018), there are 18 recognized LSB in Greece, many of which are nowadays threatened with extinction - to a greater or lower extent – or are already extinct. Among the breeds that are vulnerable to extinction is also the “Pelagonia” sheep breed, known also in Greece as Florina-Pelagonia or Florina breed. The current population of this breed in Greece is estimated at 1,800 heads, which are reared in ten farms, two of which are experimental farms (University of Western Macedonia and Research Institute of Animal Science in Giannitsa - Zaralis & Theodoridis, 2021). Pelagonia sheep have been reared for centuries in the area of Western Macedonia. On the other hand, in the Pelagonia region of North Macedonia, there are currently reared 5,409 sheep of the autochthonous Pramenka breed - a sheep very similar to Florina breed - most of which (4,547) are reared in the Municipality of Resen (Dodovski & Sdraveski, 2021).

Based on its productive characteristics, “Pelagonia” is a "dual-purpose" breed due to carcass quality and fattening ability of lambs (Christodoulou *et al*., 2007; Papas 1996), as well as the milk quality and the ability to increase milk production under certain conditions (Alexandridis *et al.*, 1987). Furthermore, its adaptability to grazing along with its capability of long-distance walking render it suitable for extensive grazing (Triantafillidis *et al*., 1998). Nevertheless, it has been observed that this breed is reared also in semi- intensive conditions (less grazing and more provision of forage and concentrates). The objective of this study is to analyze the economic performance of the Pelagonia sheep production systems in Greece and North Macedonia. The analysis is based on technical and economic data from a sample of fifteen sheep farms from Greece and North Macedonia, which were classified according to the level of intensification.

II - Materials and methods

The farm accounting data for the analysis were collected from farmers of the study area (Pelagonia area in North Macedonia and Western Macedonia in Greece), through a farm management survey using a carefully designed questionnaire. Data included a description of the flock; cropland (cultivated crops, total cultivated area, land market value, etc.) and pasture area used (natural or artificial – total acreage and rent); product yields and prices; subsidies/compensations; description of labour (family and hired); variable capital for purchased feedstuff, crop production and other supplies; fixed capital (buildings, machinery, etc.). Moreover, in order to highlight potential differences due to intensification, Greek farms were categorized as semi-extensive (SEG) and semi-intensive (SIG) according to grazing. Farms in

North Macedonia were not grouped, as all of them implemented a similar pasture-based system.

After the collection of the data, a comparative descriptive technical-economic analysis was employed to investigate the economic performance and profitability of the three groups. This analysis included the calculation of technical and economic indicators, the presentation of the structure of farm expenses per production factor (land, labour, and capital) as well as the calculation of the following basic financial results.

- Gross revenue = (Milk production * Milk price) + (Meat production * Meat price) + (Other products * Price) + Income support
- Net profit/Loss = Gross revenue—Production expenses
- Gross margin = Gross revenue—Variable expenses
- Return to labor = (Labor wage + Net profit/Loss)/Total labor (hours)
- Farm income = Land rent + Labor wage + Interest + Net profit/Loss

III - Results and discussion

Table 1 presents basic technical and economic indicators for the 'average' representative farm of each group. The average size of SEG and SIG was 270 and 350 lactating ewes respectively, while the size of the average Macedonian farm (aMF) was higher (598 lactating ewes). Note that the large size of aMF in this study constitutes an exception and not the rule, as according to Dodovski & Sdraveski (2021) the size of the sheep farms in North Macedonia - especially in Pelagonia region – ranged between 20 to 200 heads, and rarely exceeded 300.

The sampled farms in both countries exhibited similar characteristics in terms of production orientation (dairy farms) and cultivated land, however, grazing differed between these three groups. Milk yield decreased as grazing increased. Indeed, the average milk yield per ewe was higher for SIG by 55.9 kg and 7.6kg compared to SEG and aMF respectively. Regarding lamb meat production, also the SIG achieved a higher yield per ewe (2.4 kg higher) compared to SEG, but a lower yield by 2.2 kg per ewe in comparison with aMF. However, in terms of ewe/ram meat the SIG achieved a lower yield from both SEG and aMF.

Besides, Table 1 illustrates that the aggregate prices of milk were considerably higher in the SEG and SIG compared to those in aMF by 0.17€/kg and 0.19€/kg. However, it was interesting to note that farmers in North Macedonia received direct payments coupled to milk production of 0.073€ per kg. Therefore, by including coupled payments, milk price in North Macedonia was 0.65€ per kg, which was still lower compared to the Greek. Contrary to milk price, the lamb meat price (live weight) was higher in aMF compared to SEG and SIG by 0.24€ and 0.14€ per kg.

Moreover, even though aMF implemented a pasture-based production system similar to SEG, labor requirements were lower for the former, and almost equal to those of SIG, which may indicate more efficient farm management. However, when it comes to the structure of labor, both SEG and aMF relied on family and hired labor in contrast with the SIG that relied only upon family members.

The cost structure of the sample farms per group, reported in Table 2, indicates that SIG operated under higher costs per ewe compared to SEG and aMF. This was due to capital cost savings of 90.4€ /ewe for SEG and of 75.9€ /ewe for aMF mainly due to less purchased feedstuff. For SIG, as expected, capital expenses accounted for 71.1% of the total production costs, while for SEG labor was the most important cost driver (47.0% of total costs). However, it was notable that despite the grazing of animals the percentage of capital expenses in aMF were

high (75.8% of the total), while the labour costs were low (23.1% of the total), approaching those of SIG. As for the implicit (unpaid) expenses for family labor, they were calculated for an implicit hourly wage of 3.5€ /h in the case of the Greek groups and of 3.0€/h implicit hourly wage for aMF.

Table 1. Technical and economic indicators of the sampled "Pelagonia" farms: average

	Greek farms		Macedonian farms
	Semi-extensive (SEG)	**Semi-intensive (SIG)**	**(aMF)**
Average size	270	350	598
Crop production (ha/ewe)	0.007	0.006	0.010
Pasture area (ha/ewe)	0.020	0*****	communal pasture areas
Milk yield (kg/ewe)	74.1	130.0	122.4
Lamb meat yield (live weight - kg/ewe)	15.2	17.6	19.8
Ewe/ram meat yield (live weight - kg/ewe)	6.7	3.1	6.7
Mean milk price (€/kg)	0.75	0.77	0.58
Mean lamb meat price (live weight - €/kg)	2.00	2.10	2.24
Labour requirements (h/ewe)	20.7	15.0	15.5
Family (h/ewe)	13.0	15.0	6.3
Hired (h/ewe)	7.8	0.0	9.2

*****Sheep do not graze but spend a part of the day in common lands outside the barn.

Table 2. Production costs of the sampled "Pelagonia" farms

	Greek farms				Macedonian farms	
	Semi-extensive (SEG)		**Semi-intensive (SIG)**		**(aMF)**	
	€/ewe	%	€/ewe	%	€/ewe	%
Land	20.7	13.9%	15.4	7.4%	1.1	1.1%
Own	7.8		15.4		0.1	
Rented	13.0		0.0		0.9	
Labour	70.0	47.0%	45.0	21.5%	22.2	23.1%
Family	38.9		45.0		19.0	
Hired	31.1		0.0		3.2	
Capital	58.3	39.1%	148.7	71.1%	72.8	75.8%
Variable	43.2	29.0%	119.3	57.0%	47.4	49.3%
Purchased feedstuff	12.5		91.3		28.0	
Other	3.0		8.0		11.8	
Crop production	27.8		20.0		7.6	
Fixed	15.1	10.1%	29.4	14.1%	25.4	26.5%
Total	149.0	100.0%	209.1	100.0%	96.1	100.0%

As can be seen in Table 3, milk was the main product for all groups, accounting for 27.8%,

54.4% and 43.7% of total gross output, for SEG, SIG and aMF respectively, followed by meat. Moreover, SEG and SIG seemed to rely to a large extent on subsidies, which accounted for 55.3% and 23.8% of the total farm revenues, while in the case of aMF this percentage stood only for 5.8%. The lower milk price in North Macedonia along with the reduced subsidies were the main reasons for the reduced gross output compared to SEG and SIG. Note that the Single Farm Payment was not included in subsidies.

Table 4 summarizes two sets of financial results of farms across the groups — the first set including income support, while the second excluding them. Greek farms relied highly on subsidies, as when income support was not included, both Greek groups operated with net losses, while aMF operated with net profit. Indeed, when income support was not included in the analysis, aMF was by far more profitable than the Greek groups – despite the fact that its total gross output is lower than the latter (51.1€ and 35.5€ less gross output per ewe than SEG and SIG, respectively) – due to lower total expenses. In particular, the expenses of aMF were lower by 52.9€ and 113.0€ per ewe compared to SEG and SIG, mainly due to the low land and labour costs. However, the outcome was different when income support was taken into consideration. In that case, aMF still performed better than SIG, but the same conclusion could not be drawn in comparison with SEG, as the latter was more profitable according to the gross margin (€/ewe), farm income (€/ewe) and return to labor (€/h) indicators, while the aMF operated with higher net profit.

Furthermore, another important finding was that grazing contributed toward a more sustainable production system, increasing the competitiveness and the viability of the farms, due to significant cost savings. Indeed, in the case of the aMF, all financial results were positive while in SEG, only Net profit was negative (net loss) when income support was excluded, but even in this case the loss was lower compared to SIG. This coincides with Ragkos *et al*. (2016) who pointed out that sheep farmers in Greece shifted to grazing and became more extensive in order to mitigate the negative effects of the financial crisis and to reduce their production costs. However, Papadopoulou *et al.* (2021) reported that grazing in the feeding strategy of a farm does not always lead to higher financial results. On the contrary, unbalanced feeding patterns could lead to excessive expenses and higher labour requirements for flock supervision. This observation highlights the importance of a rationally designed feeding plan for all farms, regardless of their level of intensification.

Table 3. Gross output of the sampled Greek Pelagonia farms: average

	Greek farms				**Macedonian farms (aMF)**	
	Semi-extensive (SEG)		**Semi-intensive (SIG)**			
	€/ewe	%	€/ewe	%	€/ewe	%
Milk	55.6	27.8	100.1	54.4	64.9	43.7%
Meat	33.6	16.9	40.0	21.8	60.7	40.9%
Cheese/Wool	0.0	0.0	0.0	0.0	14.2	9.6%
Subsidies (without single farm payment)	110.3	55.3	43.8	23.8	8.6	5.8%
TOTAL	199.5	100.0	183.9	100.0	148.4	100.0%

Table 4. Financial results of the sampled Greek Pelagonia farms: average

	Greek farms				Macedonian farms (aMF)	
	Semi-extensive (SEG)		Semi-intensive (SIG)			
	With Subsidies	Without Subsidies	With Subsidies	Without Subsidies	With Subsidies	Without Subsidies
Total expenses (€/ewe)	149.0	149.0	209.1	209.1	96.1	96.1
Net profit/loss (€/ewe)	50.5	-59.8	-25.2	-69.0	52.3	43.7
Return to labor (€/h)	5.8	0.5	1.3	-1.6	4.8	4.2
Gross margin (€/ewe)	156.2	45.9	64.7	20.9	101.0	92.4
Farm income (€/ewe)	147.4	37.1	43.5	-0.3	84.9	76.3

IV - Conclusions

This study presented a technical-economic analysis of the Pelagonia sheep breed production systems based in Greece and North Macedonia. The findings of this study may help Pelagonia farmers - existing or future - to organize their farms more rationally and make the correct decisions towards the choice of a production system that not only will facilitate the conservation of the breed but will ensure or increase economic returns, thereby encouraging farm entrepreneurship in marginal areas of Greece and North Macedonia. However, the basic limitation of this study is the fact that information about the quantity and quality characteristics of the pastures that each farm grazes has not been considered. Therefore, in order to secure an in-depth analysis, it would be interesting to get insight into this issue in the future combined with more information of the effects of land access patterns. Apart from that, it would also be interesting to shed light on the ways that farm products (milk and meat) are valorized (e.g. in the production of local dairy products), that would increase financial performance.

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The sheep meat sector: strategies of actors in the steppe region of Tiaret in Algeria

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Abstract: The development of sheep farming has always been a priority for Algeria to meet the population's needs for animal proteins. The objective of this article is to examine beyond the sheep meat producers the functioning of the sector in the region of Tiaret. The morphology and geographical position of the latter give it an agro-pastoral character. Horse dealers (collectors, 22 respondents) and butchers (31 respondents) are considered to be the main players in the sheep meat marketing circuits in the region. They act as mediators between producers and consumers. This study has enabled us to observe that actors in the region are generally better informed about supply, demand and price levels thanks to an efficient information network and a permanent presence in the market. They are characterized by their practices which are particularly aimed at maximizing the margin, followed by transactions which consist in buying when prices are low and selling under advantageous conditions. The times of sale where the prices are higher are the religious periods of Aid El-adha (sacrifice) and Ramadhan.

Keywords. marketing- market- horse dealer-butcher- steppe

Résumé

Le développement de l'élevage ovin a toujours été une priorité pour l'Algérie pour répondre aux besoins de la population en protéines animales. L'objectif de cet article est d'examiner au-delà des producteurs de viande ovine le fonctionnement de la filière dans la région de Tiaret. La morphologie et la position géographique de cette dernière lui confèrent un caractère agro-pastoral. En effet, les marchands de chevaux (collecteurs, 22 répondants) et les bouchers (31 répondants) sont considérés comme les principaux acteurs des circuits de commercialisation de la viande ovine dans la région. Ils jouent le rôle de médiateurs entre les producteurs et les consommateurs. Cette étude nous a permis de constater que les acteurs de la région sont généralement mieux informés sur l'offre, la demande et les niveaux de prix grâce à un réseau d'information efficace et une présence permanente sur le marché. Ils se caractérisent par leurs pratiques visant notamment à maximiser la marge, suivant leurs stratégies qui consistent en la pratique de transactions qui consistent à acheter lorsque les prix sont bas et à vendre à des conditions avantageuses. Les périodes de vente où les prix sont plus élevés sont les périodes religieuses d'Aid El-adha (sacrifice) et de Ramadhan.

Mots-clés. *marketing-marché- maquignon-boucher- steppe.*

I - Introduction

The development of sheep farming has always been a priority for Algeria to meet the needs of the population in animal protein, particularly for the northern regions of the country, which are considered to be major consumers of red meats (Sadoud, 2011). There has been an expansion of the sheep herd, which rose from 21 million to 25 million head between 2010 and 2014, ie a growth of 25%. They are divided mainly between four main local breeds, namely "Ouled Djelleal", "Hamra", "Rumbi" and "D'men". The rest of the production comes from three breeds which are secondary to say the least. These are the "Barbère" and the "Terguia" or "Sidaho", a variant of the sheep breed, bred in the south of the country (Djaout et al., 2017). The meat consumption model encountered in southern Mediterranean countries is based on sheep and

poultry meat (FAO, 2014). Generally, meat is consumed where it is produced, this is the case of the region of our study which is Tiaret. This region is considered one of the major sheep meat producing regions, ranking third after the Djelfa and El Baid regions. It accounts for 4.55% of the national herd, i.e. a production of 302,572 quintals of meat (MADRP, 2017). The Algerian steppe, known as an area of nomadism and sheep farming par excellence, is currently changing its face. This change has resulted in the emergence of new production systems tending to the sedentarization of sheep farmers. The sheep population of the Tiaret region is made up of the local “Rumbi” breed (DSA, 2016), considered the heaviest Algerian sheep breed, with weights of around 90 kg for the ram. It is located exclusively in the Tiaret region and represents 11% of the national herd (Moula et al., 2013). The animals have spiral and massive horns, have a strong wear-resistant dentition which allows them to make the best use of the woody vegetation and to delay the cull age to 9 years (Soltani, 2011). It is a particularly rustic and productive breed (Chellig, 1992), generally rectangular in shape, characteristic of meat breeds (Cerquiera et al., 2011; Laoun et al., 2015). The objective of this article is to contribute to a knowledge of the strategies of the sheep actors (collectors and butchers) in the steppe conditions of the region.

II - Materials and methods

2.1. Presentation of the Tiaret region

The Tiaret region was the chosen site of investigation. It is located at 1150 meters above sea level, its climate is characterized by a harsh winter with frequent snowfall and a hot and dry summer. Its morphology and its geographical position give it an agro-pastoral character (fig. 1).The Tiaret region is a typical region which conceals natural and human characteristics making it possible to be an agricultural pole practicing sheep farming with the particularity of being an economic and agricultural source in the production of red meats of high nutritional quality. It is considered to be one of the major producing regions for sheep meat.
Due to its strategic position is a dominant door and a passage for the ends in the southern expanses which conceals important natural potentialities and in particular 1,609,900 Ha of agricultural land, 142,966 Ha of steppe areas and a forest area of 142,422 Ha. The relief, which is heterogeneous, is materialized by a mounting zone in the North of the high plains in the Center; semi-arid spaces in the South (68.44%).

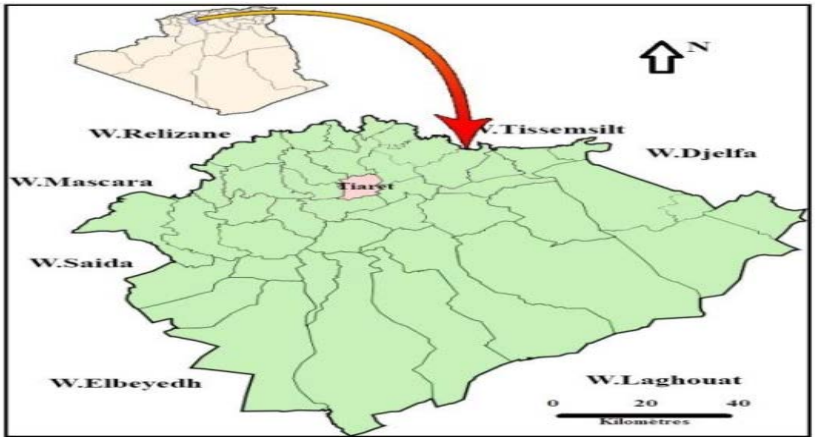

Fig.1. Geographic location map of the Tiaret region (department), Source: Boulenouar, 2016

2.2. Survey methodology

The methodology is based on a survey of 22 collectors spread across the region of Tiaret and operating in two main and most important markets in the region, which are Sougueur and Hamadia, ensuring the supply. butchers from the region and even from other regions Algerian. Their animal purchases, the progress of the purchase operation, their activities per week, their customers, their relationships with actors and funding were detailed in this survey. Thus, a survey was carried out among 31 butchers spread over the Tiaret region. Their sources of meat supply and the constraints encountered, their selection criteria, the place of purchase, the weight of the animal at the time of purchase, financing, the practice of cutting, the expectations of their customers and their relationships with stakeholders were detailed in the framework of this survey. The data collected were subjected to statistical analysis using Excel in order to characterize the horse-trading and butchery activities in the region.

III - Results

3.1. Collectors

There are several dozen of them working in the Tiaret region. According to the law, they must register in the commercial register and are subject to turnover tax, but not all are registered. They act as the link between the market and the butchers. They buy live animals (wholesale) and also sell live animals (retail). Most of them come from the region where they work; they frequent two weekly markets located in the various Sougueur and Hamadia communes of the Tiaret region. We were able to interview 22 horse dealers, which enabled us to better understand their role, their working method and their organization. They are mainly present in the region, where they form an important link in the chain of intermediaries. They source their livestock from these markets, are old and known for their regular supply to butchers slaughterers at the slaughterhouses in the region, as well as other horse-dealers from other regions of Algeria. The transaction between the horse dealer and the butcher is made according to the weight of the carcass and the price of the kilo of meat on the market without taking into account the value of the offal which goes to the butchers. Some horse dealers are only paid after the sale of all the carcasses by the butchers. They all specialize in the sheep business. The dealer is usually the one who is best informed about the supply, the demand expressed by the butchers and the price level thanks to an efficient information network and a permanent presence in the market. He also has significant financial resources, allowing him immediate payment from the breeder and accepting deferred payment from the butcher, which allows him to secure a clientele. 54% of our sample carries out the activity at the level of the Sougueur market, i.e. 12 horse-dealers and the rest practices the activity at the level of the Hamadia market, in addition to other horse-dealers who practice and who are from the regions of Algiers, Sétif, Djelfa, Tissemsilt and Ain d'Ain Defla. 72% of them are married and the rest are single. Thus, 72.70% of them are horse dealers over 42 years old and who are permanent intermediaries practicing sheep activity, while 22.7% are between 35 and 41 years old, of which 4.5 % are occasional intermediaries who do not know this profession of sheep activity. Indeed, the average age of these intermediaries is 45 years. However, 68.20% have their own means of transport which is trucks and vans for transporting animals, while the rest, or 7 horse-dealers do not have. Indeed, 90.90% buy animals from livestock markets and sell locally to the same market to avoid feed and transport costs. The rest, or 9.10%, buy from the farms, given the confidence they have in the farmers to avoid diseases. The majority of respondents, 72.70%, said that price estimation is done by prospecting by touring the entire market. On the other hand 27.30% of them declare that the knowledge of the price is done according to the experience in the trade, because it is the seniority in the trade the exercise of the activity that makes it easy to know the price. . Thus, 68.20% negotiate with the breeder above all the price, according to his financial capacities. While the rest, or 31.80%, mainly negotiate the weight of the animal to control the price of the live and that of the carcass with the aim of maximizing the margin. We

found that 63.60% of our sample make purchases and sales on the same day, while 36.40% do not sell the purchased animals on the same day and prefer to transport them to the place of residence and which are generally intended to butchers. Indeed, 54.5% of horse dealers believe that the sales period where the price remains higher is that of Aid El-adha and the month of Ramadhan, where there are strong requests during these religious periods. While 45.5% of them believe that the price increases during the pilgrimage and 13.60% during the marriage periods. Indeed, the category of sheep requested during these last two periods is the ewe. While during the first two periods it is the rams and antenais that are the most in demand.

During the purchase and sale of animals, 63.60% believe that the problems they encounter are due to price fluctuations, which are seen as an obstacle, while for 31.40% it is due to the risk of diseases and what does not control the purchase can lead to poor sales of the sick animal. On the other hand, 4.5% of horse dealers have a risk of death of the animal when buying, which leads to a loss of money (Fig.2).

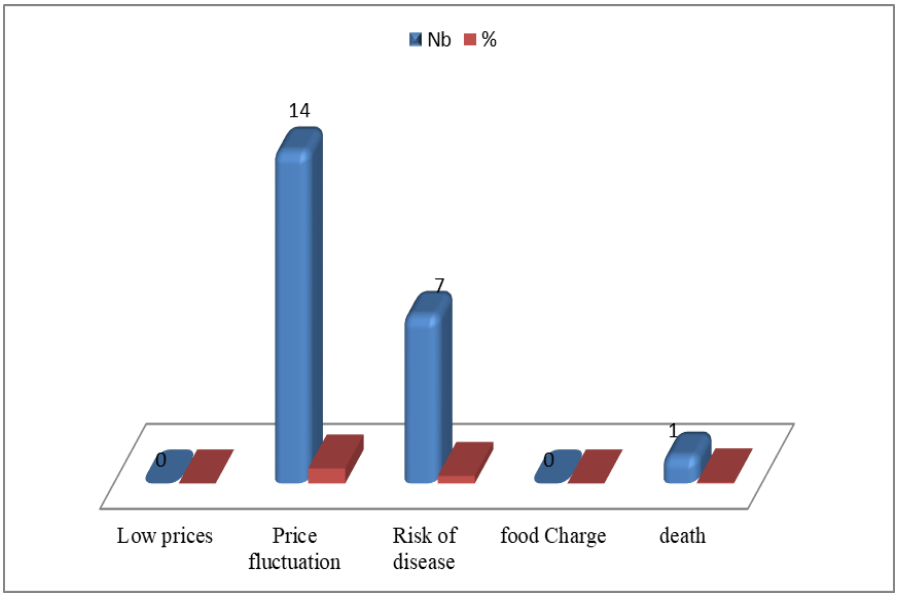

Fig. 2. Problems encountered by horse traders when buying and selling animals

Half of our samples, i.e. 50% declare that the problem encountered in the market lies in the difficulty of evaluating the quality of the sheep, due to the lack of experience of some of them and he asks a veterinarian to not. not be deceived by the seller and this to decide on the purchase or not of the animal. Thus, the difficulty of estimating the live weight of the animal when it comes to sale to the butcher. On the other hand, 4.5% of respondents encounter problems of lack of know-how, respectively, due to lack of experience and the cost of transport which falls to the horse dealer (Fig. 3).

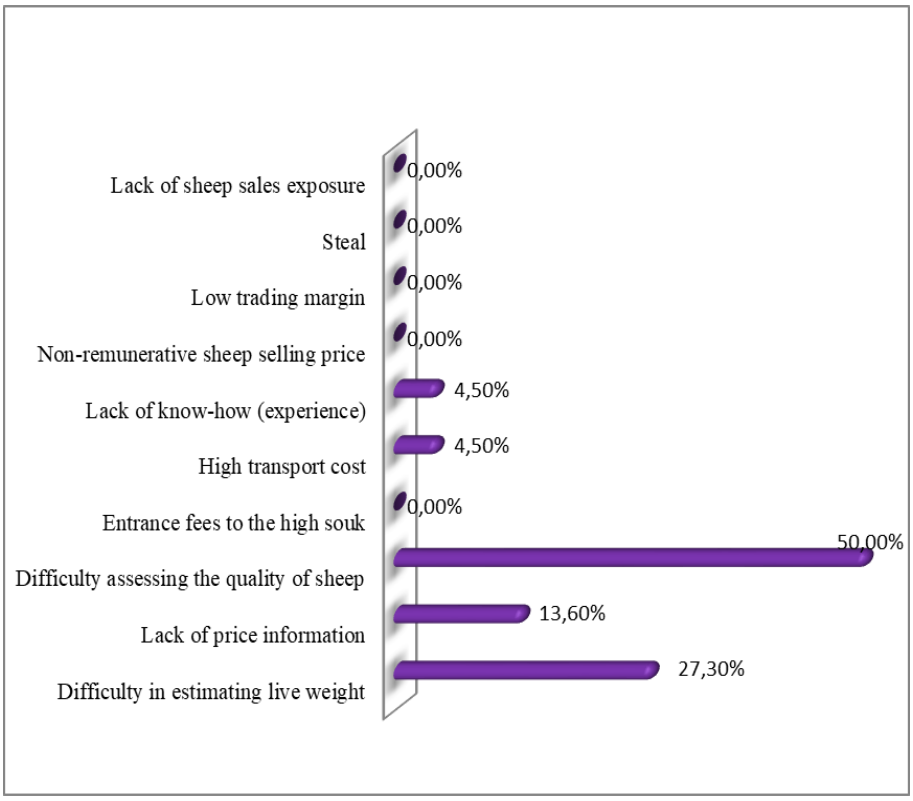

Fig. 3. Problems encountered by horse traders in markets in the Tiaret region

3.2. Butchers

Butchers represent the last link before consumption. We have sought to understand through our surveys how they organize themselves in the region and how their activity is carried out. How do they source their meat and what are their criteria for choosing? What are their customers' expectations and how do they meet them? What relations do they maintain with the actors? Butcher shops (retail stores) are the most developed channel and cover the most space across the country. It is, in fact, a multitude of points of sale or butcher's shops. The majority of them source their supplies from horse dealers according to customer demand, with the exception of a few butchers who said they buy from breeders. These butchers market the meat at retail and control almost the entire meat circuit. It is they who intervene on the last link in the chain of the quick, given the absence of ankles in the region. The butcher therefore simultaneously plays the role of backstop and butcher: he buys the live animal from horse-dealers, slaughters, cuts and sells its meat. The majority of butchers own their own store. The average age of these butchers is 45, varying between a maximum of 55 and a minimum of 38. However, 66.7% of them have a tenure of ten years or more, while the rest are less than five years old. The latter began to learn the trade from their childhood, in contact with their parents. Indeed, 32.6% of them have a primary level, 22.6% no level, 16% respectively have a secondary and university level. While the rest or 4% are graduates. More than half specialize in sheep, while the rest, or 45%, sell other types e.g. beef, poultry and camel. All butchers have shops with a display where lamb carcasses are displayed. Quarters and pieces of meat (shoulders, legs) hang from metal hooks outside the store or above the stall. The carcasses are cut on large logs of wood. We found that

for the category of lamb, 45% of butchers buy on average 9 to 17 sheep / month, 26% between 18 and 26 sheep heads, 19.4% from 27 sheep and more and 9.7%, less of 9 heads. Regarding that of antenais, 29% of respondents each buy 10 to 14 heads / month and less than 5 heads / month. Thus, 22.6% buy from 5 to 9 heads and the rest, or 19.4% buy 15 sheep and more. We observed 61.3% get their supplies from the livestock markets from horse-dealers, while the rest, i.e. 38.7%, get their supplies from the breeding sites, directly from the breeders to avoid the problems of diseases and therefore loss of margins.

IV- Discussion

In the markets, the collectors and the butchers confront the breeders. Both, to meet their own objectives, develop strategies according to their financial means, transport and fattening. A balance of power is established between these stakeholders and conditions their gains and / or losses. This balance of power depends on their social status, their power of action in space and time and the financial resources mobilized during the exchange. The collectors determine the volume to be offered for exchange based on forecasts made on the price situation in the markets. For butchers, the purchase of animals is appropriate in the event of low prices (Zoubeidi and Chehat, 2011).

The flows in the market reflect the price of food and the strategies of collectors and butchers that derive from it. The collectors negotiate the selling prices with insistence, due to their dominance and presence in these markets. It is now accepted that it is necessary to upgrade and restore the competitiveness of the players by renewing their technologies, acquiring know-how which poses a management problem for them and introducing management tools. efficient management in order to build significant competitive advantages (Djermoun 2011).

The sheep meat market does not yet see the entry of foreign investment. Indeed, the cost of handling contributes to the low economic profitability.

V - Conclusion

In the Tiaret region as in the rest of Algeria, the dynamics of animal flows were observed from the number of collectors and butchers involved in the marketing of meats, which testifies to the large share of the market held. by these actors. They were characterized by their practices which are particular aimed at maximizing the margin, following their strategies which consisted of the practice of transactions and to buy when prices are low and sell under advantageous conditions. The regularity of transactions and the sustainability of flows were based on exchange networks based on mutual knowledge of the traders and tacit agreements. For the proper functioning of these cattle markets, it is recommended to improve transaction conditions through the development and equipment of markets, such as loading and unloading docks, scales and organization of the movement of animals and operators. The results obtained also testify to the existence of a lack of transparency which operates at the level of the souk and mainly concerns information on prices as well as the weight of animals.n this context, the concentration of capital in these agents does not occur and these artisanal units function normally without growth, nor regular investments. Its nature varies according to multi-year and seasonal production cycles.

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Session IV

Key constraints and opportunities for pastoral development projects engineering and rangeland governance in South Tunisia

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Abstract. Pastoral development projects engineering in Tunisia has encountered several problems due to the complexity of rangeland resources, territories, societies, and institutional settings. The aim of this paper is to depict some of the current constraints and opportunities faced by three pastoral investment project management units (PMU) in South Tunisia, while characterizing the wider impact of these projects on rangeland governance. We assessed three pastoral development projects in South Tunisia to appreciate their compliance with principle of enhanced development projects engineering including: i) relevance and coherence of the project; ii) effectiveness; iii) efficiency of implementation; and iv) impact orientation and sustainability. The data was gathered using an online questionnaire and focus group discussions with leaders of the three project PMUs. Results emerging from this research show that it is highly important to include infrastructure investments of the projects into a broader perspective of pastoral economic and territorial development. It is further important for pastoral development projects to invest in building enhanced social capital, networks and norms. The impact of the later investments will not be immediate but contributes to building long term resilience and sustainability.

Key words: Inclusive rangeland management, pastoral development, projects engineering, project management units, Southern Tunisia.

Résumé. *L'ingénierie des projets de développement pastoral en Tunisie a rencontré plusieurs problèmes dus à la complexité des ressources des parcours, des territoires, des sociétés et des cadres institutionnels. L'objectif de cet article est de dépeindre certaines des contraintes et opportunités actuelles auxquelles font face trois unités de gestion de projet (UGP) d'investissement pastoral dans le sud de la Tunisie, tout en caractérisant l'impact plus large de ces projets sur la gouvernance des parcours. Nous avons évalué trois projets de développement pastoral dans le Sud de la Tunisie afin d'apprécier leur conformité avec les principes améliorés de l'ingénierie des projets de développement, notamment : i) la pertinence et la cohérence du projet ; ii) l'efficacité ; iii) l'efficience de la mise en œuvre ; et iv) l'orientation et la durabilité de l'impact. Les données ont été recueillies à l'aide d'un questionnaire en ligne et de discussions de groupe avec les responsables des trois UGP du projet. Les résultats de cette recherche montrent qu'il est très important d'inclure les investissements en infrastructures des projets dans une perspective plus large de développement économique et territorial pastoral. Il est également important que les projets de développement pastoral investissent dans le renforcement du capital social, des réseaux et des normes. L'impact de ces derniers investissements ne sera pas immédiat mais contribuera à la construction d'une résilience et d'une durabilité des acquis du projet à long terme.*

Mots clés *: Gestion inclusive des parcours, développement pastoral, ingénierie de projet, unités de gestion de projet, sud de la Tunisie.*

I - Introduction

Governance refers to all the measures, rules, decision-making, information and monitoring bodies that ensure the proper functioning and control of a State, an institution or an organization that it is public or private, regional, national or international (FAO, 2007). Governance is further defined as "…the process of reconciling the priorities and competing interests of different groups". Governance involves formal and informal institutions and arrangements among

stakeholders". It considers the rules (laws and other norms), institutions and processes that determine interaction among and between actors (Herrera et al., 2014). Governing the commons refers to the capability of "community, group of communities or group of people to own, manage and/or use collectively natural resources in support of their food security, livelihoods, and well-being" (Davies et al., 2016). The concept of resource governance is thus highly intricated into larger social, institutional and economics systems, at different levels, with strong relationships and articulations between both resource and territorial concepts (Frija et al., 2019).

Tunisia is predominated by the semi-arid and arid climate on three quarters of its territory. Arid and desert regions occupy about 77.6% of the total area of the country (16,400,000 ha). Rangelands occupy 4.3 million ha, mostly in the arid zones (DGF & Banque Mondiale, 2015). About 14% of the country's population is living in forests or rangelands, most of these households are poor and depend on silvopastoral activities. Forests and rangelands provide 30 to 40% of the income of rural households, 15-25% of food needs for livestock, and 14% of household energy needs. They generate profits of around 1 billion TD per year, representing 14% of agricultural GDP and 1.3% of the country's GDP in 2012 (DGF & Banque Mondiale, 2015). Talking about rural development planning, programs and investments in these arid areas refers necessarily to socioeconomic activities based on arid farming and livestock grazing on common rangeland areas. Rural development programs in the pastoral areas need also to consider rangeland resources in the heart of their objectives and actions.

The Tunisian experience on rangeland and pastoral development during the four last decades shows that pastoral development projects engineering has encountered several problems due to the complexity of rangeland resources, territories, societies, and institutional settings. The performance of these projects has often been explained by the hostility of biophysical conditions, by the scarcity and vulnerability of natural resources and by socio-economic constraints. However, limited attention has been paid to aspects related to projects' engineering and management. Pastoral investment projects in Tunisia are usually divided into different components (each of them is further subdivided into different investment activities). These activities can be of different type ranging from investments in infrastructure to facilitate farmers' access to markets, investments in capacity building, investments in enabling environment for stimulating income generation activities, etc. Furthermore, pastoral investment projects in South Tunisia are also contributing to the restoration of large rangeland areas through different approaches (resting, seedling, reforestation, etc.). This is helping to generate more evidence about the positive impact of such restoration operations on rangeland biomass and incentivize the pastoral communities to further collaborate among themselves and with other actors for collective action and rangeland preservation. Despite their deep correlation, both concepts of rangeland governance and pastoral development investments are currently undertaken by research and development programs in a separate and fragmented way.

Within this framework, the aim of this paper is to depict some of the current constraints and opportunities faced by three pastoral investment project management units (PMU) in South Tunisia, while characterizing the way these projects are considering rangeland governance in their investments. We analyzed three pastoral development projects which are all funded by “International Fund of Agricultural Development” (IFAD) to enhance the pastoral development in South Tunisia (Tataouine, Medenine, and Kebili). The method was based on assessing the projects against four critical principles of development projects engineering including: i) relevance and coherence of the project; ii) effectiveness; iii) efficiency of the projects implementation; and iv) impact orientation and sustainability. The data was gathered using an online questionnaire and focus group discussions (reflecting in detail about the previous criteria and indicators) with leaders of the three project PMUs. The questionnaire included a mix of close ended and open questions to capture the opinions of different PMU leaders about current design, management and monitoring aspects related to pastoral development projects implementation in south Tunisia.

The remaining of this conference paper is divided into 4 sections. The next section is providing an overview of the evolution of pastoral policies and programs (large investment programs) in

the country, and the main achievement. Based on that, we present the paper methodology and results in the third and fourth sections. A last section concludes.

II - Overview of pastoral development programs in Tunisia

Since independence, 4 main periods have marked the evolution of Tunisian policy and experience in terms of rangeland and pastoral development. These are as follows (Abaab et al., 2020):

The period 1956-1970 did not consider the development of rangelands as a specific orientation but was integrated into the overall development policies of watersheds management to reduce water erosion. In this period, policies for the delimitation of the forest/rangeland area and clearance of pending tenure issues were implemented. This aimed at delimiting and clarifying the land tenure status to facilitate access to land for settlers and the sedentarisation and control of pastoral populations.

The period 1971-1989 consisted of the deployment of the policy of clearing collective land and the acceleration of its privatization process, upon their submission to the forestry regime (1974), and the promulgation of the forestry code in 1988. Early pastoral development projects were implemented in that period. These include the "Oglet Merteba" project in Menzel Habib (Governorate of Gabes) which is a pioneering example of rangeland rehabilitation and the fight against desertification in drylands. This project revealed the importance of the socio-economic factors and land tenure systems in the successful implementation of rangeland rehabilitation projects. This experience drew the attention of the public administration on the multidimensional and integrated dimensions of pastoral development which are needed to avoid contradictory actions such as the encouragement of olive plantations at the expense of rangelands. Early awareness about possible conflicts and harmonies between such pastoral territorial development and rangeland management started to arise in this period.

The period 1990-2011 was marked by a deliberate political priority for the development of rangelands and forests materialized by the implementation of two national programs and major pastoral development projects such as PRODESUD1 in the large area of rangelands of the governorate of Tataouine in the south of the country. The most important achievements of these development programs concerns (i) the development of the National Strategy for Reforestation, Water and Soil Conservation (CES) and the fight against desertification; (ii) the financing of forestry and rangeland projects with the support of donors; (iii) the development in 2007 of the national forest program (NFP); (iv) the formulation of an early national rangelands strategy; (v) the development of a national forest protection plan against fires; (vi) carrying out the first national forest and pastoral inventory (IFPN). Thus, the ten-year strategy 1990-2001 was implemented by the Forest Department (which was also mandated to manage rangelands). The second national development strategy for the forestry and pastoral sector (2002-2011) which was further implemented by the Forest department, consolidated the achievements of the first phase by integrating the interventions of other related technical public agencies such as the livestock department, the agency for territorial development of South Tunisia, the soil and water conservation administration, etc. We thus started to see integrated actions and programs, which are partly devoted to rangelands restoration, especially through integrated technical solutions. Both strategies resulted in 423,500 ha of improved rangelands (Abaab et al., 2020).

The post-revolution period (2011) has experienced profound changes where the forest and rangeland areas have suffered from serious infringements which deeply threatened their sustainability given the weakness of the executive state authorities. There was a consensus at that period about the emergency of investing in social, institutional and economic empowerment of local pastoral communities as key factors for the sustainability of resources and of the development programs. New pastoral investments projects have been designed and implemented with a strong focus on participation of local population in the community

[1] "Agropastoral Development and Local Initiatives Promotion Programme for the South-East", phase I (2004-2011)

development programs. Additional focus was lately made on integrating and developing value chains and income generating activities through these projects. Two of the most important projects are PRODESUD (phase II – 2012-2019), and the PRODEFIL[2] (2014-2023). More focus was made on territorial economic development of the pastoral areas through these projects. They also considered targeted investments in empowering rangeland farmers associations and building rangeland infrastructure for pastors. A focus was further made on agro-pastoral diversification (greenhouse vegetables, sheep fattening, etc.) and a cross value chain approach.

III - Conceptual framework and methodology

Pastoral investment projects are usually divided into different components (investments in infrastructure to facilitate farmers' access to markets, investments in capacity building, investments in enabling environment for stimulating income generation activities, capacity building, etc.). The structure of the investment portfolio of the pastoral development projects will re-define the way pastoral communities interact with their common resources and the focus they devote to access, usages, and management of these resources. The analytical framework of this paper is divided into two sequences: 1) identify gaps, constraints and opportunities in terms of pastoral development projects (against enhanced principles of development projects engineering) currently ongoing in Tunisia; and 2) look at how these projects are directly (or indirectly) investing in enhancing rangeland governance and provide, accordingly, recommendations for better inclusion of rangeland protection (and governance).

The methodology of the paper consists of cross comparing three of the largest pastoral development projects in Tunisia (PRODESUD II – Component of Tataouine, PRODESUD II – Component of Kebili, and PRODEFIL). Each of these projects is implemented in a different social and biophysical context and is lead by a different project management unit. This means that these projects have some common characteristics but are also facing different specific challenges in terms of territorial dynamics and needs. The earlier PRODESUD projects started using an approach of participative co-design of development actions and institutional empowerment of farmers associations. The PRODEFIL rather adopted an inclusive cross value chain development approach since its early conceptualization and design phase. These orientations are also partly induced by ongoing donors, approaches and external technical assistance. More description of the structural differences across these three projects will follow in the coming section. In this paper, we used a set of “project engineering indicators” related to the different phases of design phase, implementation, and monitoring, to compare these projects and thus derive gaps in terms of pastoral projects engineering. Figure 1 presents an illustration of the 4 project engineering principles used in this regard. A questionnaire was built based on these pillars and filled up by the leaders of the projects management units (PMU) to explore the gaps, constraints and opportunities faced by these projects. These aspects were also discussed in an open focus group discussion which gathered the leaders and co-leaders of each of these projects. Principles involved in figure 1 include i) relevance and coherence of the project (where the relevance assess the links between the objectives of the project activities and the identified needs); The coherence (is reflected through the existence of coherent linkages between the different components of the investment project); ii) effectiveness (as reflected by the relationship between the activity objectives and the results obtained); iii) efficiency (the relationship between the resources allocated to the activity and respective results) ; and iv) impact orientation and sustainability.

[2] *Le Projet de développement agro-pastoral et des filières associées dans le Gouvernorat de Médenine*

Figure 1. Basic principles for effective engineering of investment projects (Source: Own elaboration, 2021).

IV - Results: main recommendations for enhanced pastoral projects' engineering and rangeland governance

4.1 Characteristics of the considered pastoral development projects

The presentations of the three investment projects revealed many structural differences, yet some similarities ranging from the approaches used for projects implementation to the components and types of investment portfolios undertaken. While the three projects promoted and adopted a participatory and partnership approach centered on local community, the action plans and the institutional settings highlighted major differences across them. One of these major differences is the inclusion and the focus on value chains adopted by PRODEFIL project in Medenine governorate. There were also structural differences related to operational modalities used by these projects to align with national priorities and SDGs. In fact, while PRODEFIL is explicitly committed to deliver for SDG national commitments, the PRODESUD-K remains, for example, less explicit within these regards which means lower potential to map it to higher level national objectives. This fact combined with lower ownership and embeddedness of this project PMU into regional public administrations accentuate this feeling and further limit the project delivery in terms of development impact.

Table 1. Overall characteristics, objectives and cost structure of the selected pastoral development projects.

	PRODESUD-T	PRODESUD-K	PRODEFIL
Objectives	▪ Participative management of rangelands and water ▪ Livestock integration and valorization of territorial assets and services ▪ Gender and youth integration in economic and resources decisions	▪ Improve the productivity of rangelands ▪ Diversification of income activities and employment generation (especially for women and youth) ▪ Devotion of local development and resources management to local population	▪ Improve the overall welfare and livelihoods of local population, ▪ Improve the productivity of rangelands, agricultural systems and associated value chains. ▪ Capacity building and community-based organizations empowerment. ▪ Creation of income and employment opportunities.
Target beneficiaries	66,000 inhabitants; 9,000 households; 6,500 pastoralists.	600 households	15,000 livestock keepers; 19,000 farms; which refers to around 75,000 inhabitants (including 52% women)
Cost and duration	116 Mio TND – 15 years.	23 Mio TND – 7 years	73.9 Mio TND – 6 years
Investment structure	37.9% (of the budget) for system productivity and resilience; 39.6% for infrastructure investments; 6% to support income generating activities; 7.7 institutional and capacity building.	84.2% for systems productivity (including infrastructure investments) 5.35% for promoting income generating activities and other local economic initiatives; 6% institutional and capacity building	32% for systems productivity and resilience; 52.4% for value chain development (including targeted collective infrastructure); 15.6% for institutional and capacity building.
Affiliation and hierarchy of PMU	Embedded (but partly disconnected) into the regional agricultural administration (CRDA). Lack of human resources.	Affiliated to the CRDA but dealing with local administration as the project is focusing on Douz sub-district of Kebili. Lack of human and logistic resources	Strong hierarchy but lack of human resources. Embedded into CRDA of Medenine. Benefited from strong technical assistance to the PMU (EU grant)
Strongest achievements	Large rangeland areas restored (Rested) and change in communities' mindset towards higher acceptance of restoration. Creation, promotion and empowerment of large number of GDAs Wide intervention in terms of pastoral infrastructure (Wells, roads, etc.)	Large rangeland areas restored (Rested) Wide intervention in terms of pastoral infrastructure (Wells, roads, etc.) Improvement of vegetation cover.	High number of SME, SMSA and other forms if income generation for women and youth. Wide intervention in terms of pastoral infrastructure (Wells, roads, etc.) Experimentation of the cross associated value chains with territorial approach (Imada/versus UST)

Source: own elaboration based on focus groups discussions, 2020

Table 1 highlights the most important structural differences across projects, especially in the way the PMUs are embedded into the regional agricultural administrations (also called CRDA in Tunisia). This level of embeddedness would define the level of support the PMU receives from their "mother institutions" to support their various operations. This can be qualified as an important criterion when dealing with other non-agricultural regional administrations for implementing some of the investment activities. Low level of embeddedness is particularly observed for the case of PRODESUD-K as this project is rather focusing on a sub-district and thus dealing with local (rather than regional) agricultural administrations.
The PRODEFIL project has a larger share of its budget devoted to promoting associated value chains, SME's (Small and Medium Enterprises) promotion and income generation investments. This helped the project to even target their collective infrastructure investments to support the good structuring of the local livestock (and other) and local resources valorization value chains. The achievements of this project in terms of number of SME and SMSA (Société Mutuelle de Service Agricole, cooperative) created are beyond the target. It is also important to refer here to the fact that a sub-directorate dealing with value chains development (partly embedded/hosted at the CRDA) was also supporting the project. A similar lesson can be drawn from the PRODESUD-T project where most of the infrastructure investments were undertaken in the framework of the larger component of rangeland restoration (resting), where the success and achievements were very satisfying. A first remark is that investments in infrastructure are usually the largest components of these projects and are related to the overall development-oriented of these projects.

4.2 Constraints and opportunities for enhanced engineering of the pastoral investment projects

The studied projects revealed some good opportunities and highlighted other constraints facing the PMUs responsible for the implementation of different projects' components. From a development engineering perspective, these opportunities and constraints are linked to the four main performance components previously listed. The first principle regarding the relevance of the projects can be discussed from many perspectives (relevance to whom, at which stage of the project implementation, etc.). In fact, all projects started with a participatory demand assessment analysis carried out at the beginning of the project to reflect about the various needs of different stakeholders. Results of the survey reveal that projects design (components and activities portfolio) was based on these assessments, and further affected by the management approach suggested by the donor (IFAD). It is also suggested that objectives and results of the projects are aligned to the real needs of the local population. However, there is sometimes a lack of coherence across the different projects' activities for some projects (such as PRODESUD-K).

Table 2. Main projects engineering constraints and opportunities for the three pastoral development projects.

Project name	Project engineering Constraints	Project engineering opportunities
PRODESUD II – Tataouine	▪ Land tenure system is highly problematic for the success of some investments. ▪ Difficulty to design activities which satisfies all beneficiaries which do sometimes have conflictual interests. ▪ Lack of activities which aims at enhancing the enabling institutional environment (policy dialogues etc.) ▪ Lack of advanced monitoring and evaluation systems which provides feedback for adjusting the project interventions.	▪ Long term collaboration through the different project phases enhanced mutual trust and the acceptance of project approaches. ▪ Strong technical partnership with other technical partners which helped achieving high areas of restored rangelands. ▪ The project generated evidence about benefits for rangeland restoration (resting) which further enhanced communities' acceptance and ownership of these investments
PRODESUD II – Kebili	▪ Moderate engagement of national partners in terms of mandate, influence, capacities, etc. ▪ Lack of coherence of some of the project components/activities. ▪ Lack of appropriate indicators to monitor the progress of the project. ▪ Lack of resources (human) and technical backstopping for implementation of a wide range of investments. ▪ Only a low share of investment is devoted to income generating activities and to farmers' subsidy against rangeland fencing. ▪ The scale of intervention is large compared to the resources available (probably need to rethink/fit the geographical scale).	▪ Benefited from strong support from GDAs and local societies. ▪ Strong impact of capacity development investments for GDA despite their limited number.
PRODEFIL– Medenine	▪ The high number of beneficiaries through the VC, lack of time to change the mindset of different VC actors reduced the success of achieving structural changes for key VCs relevant to the region. ▪ Some communication problems with some GDAs and local community in some areas (mainly in Bengardane) have led to misunderstanding and then slowing down of the implementation rate of project actions and blocking others such as the resting technique. ▪ The delay of value chain infrastructure investments	▪ Elaboration and data collection for gender sensitive monitoring indicators is feasible and extremely helpful for project evaluation and decision making. ▪ Strong achievements in terms of rangeland governance and income generating activities. ▪ Project design enhanced the closeness of the project to the community of the area of intervention. ▪ Project design flexibility (the project was able to take appropriate arrangements (investment or other) according to specific needs / situations.

Common to All	▪ The available financial and human resources are not well embedded and sufficient to achieve projects objectives. ▪ Lack of gender analysis prior to the starting of the project. ▪ Moderate use (and transformation) of project outputs (so far) by the project partners ▪ Projects implementation didn't lead to a change in national (and partners) priorities by inducing a favorable enabling environment capitalizing on the different success. ▪ The project relies on arrangements with GDA and LMCs which is not sufficiently representative of the interests of the whole population. ▪ The legal financial restrictions influenced the delivery of activities in a timely manner	▪ Strong involvement of national partners in the different steps of project design, implementation and evaluation, which stress the participative aspect of the projects. ▪ Strong impact of investments in institutional and capacity development (especially GDAs) ▪ Impact on the communication process between different stakeholders (or at least an initiation of the process)

Source: own elaboration based on focus groups discussions, 2020

it has been revealed from this comparative analysis that some common constraints for the good engineering of pastoral development projects do exist across the three studied projects and may threaten the sustainability of the projects' investments. An overall summary structuring the findings in table 2 according to the projects engineering principles previously stated is as follows:

- There is a strong need to better define the appropriate governance organization and hierarchy of PMUs and strengthen their position (embeddedness) within their mother administrations. This will support the legitimacy of the whole investment portfolio and strengthen the project ownership and impact.
- It is highly important to include infrastructure investments into a broader perspective of pastoral development, depending on the specific objectives and main focus of the projects. This will enhance the effectiveness and achievement.
- The analysis reflects about the importance of adequacy between means and resources (especially human and physical capitals) allocated and projects objectives, which may enhance the overall projects effectiveness.
- In the same line, there is a need for enhanced administrative settings and handholding of the project's PMUs (through trainings, technical assistance, etc.).
- The same highlights are also relevant to enhance projects efficiency as this is also related to the available means and resources in relation to achieved results.
- In terms of pertinence and adequacy, it is important for pastoral projects to effectively investigate the real needs of local populations through in-depth participatory development diagnostics, which should be implemented prior to the development of the log frames of these investments. Pastoral development projects should be fully integrated within the territory development strategies (e.g., territorial planning and regional and local development plans).
- Finally, pastoral investment projects can further enhance their impact orientation and sustainability by being inclusive and investing in building enhanced social capital, networks and norms. The impact of such investments will not be immediate but will certainly contribute to building long term resilience and project sustainability.

4.3 Projects investments in rangeland governance

Pastoral development projects are designed for communities living and using rangelands. Project outcomes in terms of enhanced rangeland management, governance, and sustainability are thus primary. While all projects' activities have been designed and implemented to fit the pastoral community's needs, some activities had however stronger direct and indirect impact on rangelands. There can be listed as below:

- Subsidies in terms of additional feed resources against resting their collective rangelands. This has strongly contributed to change the mindset of pastoralists, especially during rainy years where the biomass production of rangelands increased tremendously, and early signs of ecological recovery appeared.
- Targeted investments in rural infrastructure which can help guiding the mobility of pastoral farmers and reducing its transportation costs.
- Investments in enhancing the technical skills of partners assisting with the implementation of rangeland resting. This was a key element of success.
- Investments in enhancing/upgrading the capacities of pastoral farmers associations, which in some cases highly contributed to the success of local restoration programs implemented by these associations.
- Investments in pastoral plantations and reseeding of some rangeland areas (not significant for the three projects).
- Income generating activities are positive drivers of local development but not enough for reducing significant pressure on rangelands.

The positive impact of many of these investments on rangeland governance was confirmed by studies undertaken by the IRA-ICARDA team about the importance of upgrading GDAs who are key institutions for rangeland governance (Frija et al. 2021; Fetoui et al., 2020). Particularly, enhancing the internal organization of GDAs, their capacity to raise funds and implement collective projects, and the social acceptance of the GDA president are key drivers of farmers' participation to rangeland restoration. The results also confirm the importance of responding to the need of local populations in terms of economic diversification through wider alternatives of income generation activities, employment, and enterprising (Frija et al. 2021).

V - Conclusions

The analysis of pastoral development/investment projects engineering in South Tunisia revealed many interesting lessons which can be taken into consideration for future national debates. While there are common lessons and similarity across the three considered projects, contextuality and specificities of each of these projects remains to be considered. Results emerging from this research show that it is highly important to include infrastructure investments into a broader perspective of pastoral socioecological and territorial development, depending on the specific objectives and the purpose expected from these projects. These suggest that opportunities exist to enhance the effectiveness and achievement initially planned by the projects. In terms of pertinence and adequacy, it is important for pastoral projects to effectively investigate the real needs of local populations through in-depth participatory development diagnostics and consultations, which recommended to be implemented prior to the development of the log frames of these investments. It is imperative that pastoral development projects should be fully integrated within the territory development strategies (e.g., territorial planning and regional and local development plans). Finally, pastoral investment projects can further enhance their impact orientation and sustainability by being more inclusive and becoming increasingly apparent that investing in building enhanced social capital, networks and norms. The impact of such investments will not be immediate but will certainly make an effective contribution to long term sustainability and led to a new socio-ecological impact strategy.

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Les pâturages collectifs dans l'œil du législateur tunisien

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Résumé. La présente communication analyse le cadre institutionnel et juridique des parcours collectifs en Tunisie concentrés actuellement dans le sud du pays et dont la superficie totale couvre 1,5 millions d'ha. Cette analyse s'appuie en grande partie sur un passage en revue des dispositions juridiques adoptées jusqu'à présent au sujet de la gouvernance et de la sécurisation foncière de ces espaces pastoraux. Parmi ces dispositions, la récente modification du statut juridique des terres collectives opérée par la loi n°2016-69 du 10/08/2016. Le travail évoque également la nécessité d'une réflexion approfondie autour des composantes du tissu institutionnel interférant dans la gouvernance de ces parcours.

Mots-clés. cadre institutionnel et juridique, gouvernance, tenure foncière, parcours collectifs, Tunisie.

Collective rangelands as perceived by Tunisian law

Abstract. *This paper analyses the institutional and legal framework of collective rangelands located in southern Tunisia and whose total area covers 1.5 million ha. Such an analysis, which will be guided in large part by a review of legal provisions adopted so far concerning management and land tenure security issues of collective rangelands including those recently set out by the law n°2016-69 dated 10/08/2016, reveals the need for an in-depth reflection about the institutional framework for the management of these pastures.*

Keywords. *institutional framework, legal framework, land tenure, collective rangelands, Tunisia.*

I - Introduction

Inédite, la loi du 10/8/2016 envisage la privatisation totale des terres collectives du centre sud tunisien à l'horizon de l'année 2022, à l'exception des terres à vocation pastorale qui garderont leur statut collectif et continueront d'être gérées collectivement.

Est-ce une reconnaissance de l'importance socio-économique et environnementale de ces pâturages qui n'ont cessé de se replier au cours de ces dernières décennies vers la région du sud, ou est-ce tout simplement une « manœuvre juridique » pour stimuler davantage le rythme de leur partage et contribuer au développement des régions concernées et classées?

Quoi qu'il en soit, et en admettant que le « verdict » prononcé par cette loi de 2016 se tiendra valide dans les années à venir, il sera utile dans le cadre de cette communication de procéder à une analyse rétrospective du cadre institutionnel et juridique régissant les parcours collectifs en Tunisie. La rétrospective proposée sera entamée par une lecture sommaire de l'évolution contemporaine des terres collectives, avant de passer par la suite à la discussion de la portée et surtout des limites des prescriptions juridiques et institutionnelles prévues dans les textes de lois en vigueur en vue d'assurer la bonne gouvernance et de la sécurisation foncière de ces espaces pastoraux plus que jamais fragilisées par le surpâturage, l'extension des cultures arboricoles et les longues périodes de sécheresse climatique.

II - L'histoire des parcours collectifs du centre sud tunisien racontée par des textes de lois

La lecture rétrospective des composantes du corpus législatif tunisien afférent aux terres collectives de la région du centre sud du pays permet de distinguer trois périodes historiques rassemblant chacune un nombre considérable des faits saillants.

3.11 L'époque précoloniale (XIe - XIXe siècles): des lois implicites qui imposent le respect

Depuis l'arrivé sur scène des premières tribus arabes au cours du XI[e] siècle et jusqu'au XIX[e] siècle, le nomadisme pastoral constituait le mode de peuplement dominant dans toute la région du centre et du sud de la Tunisie. Les vastes steppes exploitées à l'époque par les communautés d'éleveurs nomades appartenaient dans l'indivision à des tribus ou à des confédérations des tribus (Abaab, 1994). Au niveau de chaque tribu, un « *cheikh* » (chef de tribu) est désigné parmi les notables pour gérer certaines affaires internes, telle que la résolution des conflits sur le foncier et sur les points d'eau, et également pour défendre les intérêts de la tribu à l'extérieur. Les *cheikhs,* faisant partie d'une même confédération des tribus, se réunissaient à l'intérieur d'une assemblée, « *miaad* », qui assurait notamment la répartition des terres de labour et des pâturages ainsi que l'arbitrage des conflits survenant entre les différentes tribus autour de l'exploitation des ressources pastorales (AbdelKebir, 2003).

3.12 L'époque coloniale (1881-1956) : l'ère de toutes les fictions juridiques

Suite à son arrivée en 1881, la colonisation française s'est vite tournée vers la question de délimitation des terres tribales afin d'avoir la main mise sur tout le territoire de la Tunisie (Abaab, 1994). Cette délimitation s'articulait légalement sur la fiction juridique de « terres collectives » désignant les terres tribales de Centre-Sud du pays et introduite dans par un décret beylical du 14/1/1901.

Les travaux de délimitation initiés par le décret beylical précité donnaient lieu à un long débat opposant d'un côté, l'inspecteur des domaines l'époque (DECHAVIHNY) qui sollicitait l'administration coloniale à s'emparer des dites terres en déclarant leur domanialité, et de l'autre côté le président du tribunal mixte (DUMAS) réclamant d'attribuer le droit de propriété de ces terres aux tribus locales (Abaab, 1994). À l'issue d'une longue hésitation, parait-il, l'administration coloniale parvenait à une décision qui sera transcrite dans le décret beylical du 24/11/1918: « les tribus », une deuxième fiction juridique, bénéficieront sous la tutelle de l'Etat d'un droit de jouissance considérée comme un préalable à l'entame des opérations de partage de ces terres.

À ces deux premières fictions juridiques, les terres collectives et les tribus, venait d'être greffée une troisième par un décret beylical du 30/12/1935. Il s'agit de la « personnalité civile » attribuée à chacune de ces tribus et qui servira par la suite à la création des conseils de gestion qui vont prendre la relève des « *miaad* » en matière de gestion des terres tribales et d'arbitrage des conflits liés à leur exploitation (Abaab, 1994; Nasr et Bouhaouach, 1996).

3.13 L'époque postcoloniale (à partir de 1956) : la marche solennelle vers la privatisation des anciens parcours

Sous l'effet conjoint d'une demande sociale inédite à l'appropriation individuelle des actifs fonciers agricoles et d'une politique publique convoitant la modernisation des anciens régimes

fonciers jugées « archaïques » et contre productifs (Bourbouze et al, 2009), la Tunisie s'est engagée dès les premiers jours de son indépendance en 1956 dans une série des réformes foncières orientées essentiellement vers l'accélération du rythme du partage des terres collectives du centre sud du pays. Il s'agit en premier lieu de deux premiers textes de lois de 1957 et 1959[3], mais surtout la loi n°71-7 du 14/1/1971 venant modifier le régime foncier des terres collectives promulgué en 1964 et qui a nettement hissé la cadence des dites opérations de partage des anciens parcours collectifs (Bourbouze et al, 2009; Nasr et Bouhaouach, 1996).

A l'heure actuelle, le bilan de ces réformes foncières est nettement drastique. En effet, la superficie totale des terres collectives léguée par la colonisation française, estimée à 3 millions d'ha, est actuellement réduite à moitié (Nefzaoui et al, 2020). Quant aux superficies qui ont pu échapper jusqu'à présent à ce « fléau » de privatisation, elles devront passer encore une fois par l'épreuve épineuse annoncée par la loi n°2016-69 du 10/8/2016 allant même, cette fois, à prévenir l'intervention du tribunal immobilier pour achever les opérations de partage délaissées par les conseils de gestion au bout d'un délai de cinq ans de sa publication dans le journal officiel (à l'horizon de l'année 2022).

Par ailleurs, le dépouillement de ces mêmes lois fait apparaitre plusieurs autres dispositions allant à l'encontre de la logique du partage en faisant prévaloir la sauvegarde, voire parfois l'amélioration, des parcours collectifs.

III - Sauvegarder les parcours collectifs d'aujourd'hui

La régression progressive des normes et des instituions coutumières d'antan conjuguée à la fragilisation accrue de la situation des pasteurs et agropasteurs, induite en particulier par le partage massif des anciens parcours, nous amène à questionner la pertinence et surtout la validité des solutions juridiques et institutionnelles prescrites par les textes de lois en vigueur afin d'assurer la sécurisation foncière et la bonne gouvernance des parcours collectifs de nos jours qui sont concentrés actuellement dans le sud du pays.

4.4 Sécurisation foncière de terres de parcours : des règles confuses, superposées et non contraignantes

Au sens proposé par Le Roy (1996), *in* Lavigne Delville (2006), la sécurisation foncière correspond au « processus par lequel les droits sont affectés, validés et garantis en cas de contestation ». Appliquée sur les lois tunisiennes ayant trait aux terres collectives, cette grille de lecture permet de dégager essentiellement trois mécanismes légaux censés intervenir dans un processus pareil ciblant les terres de parcours. Il s'agit des dispositions juridiques relatives à la délimitation de ces pâturages, l'institution des principes légales protecteurs d'inaliénabilité, d'imprescriptibilité et d'insaisissabilité et la mise en place d'un dispositif juridique pour l'arbitrage des conflits fonciers.

A. La délimitation des parcours collectifs

Mystérieusement, c'est la loi n° 71-7 du 14/1/1971, à laquelle on doit le dopage des opérations de privatisation réalisées au cours des années soixante-dix et des années quatre-vingt, qui a assigné pour la première fois la tâche de la délimitation de terres dites « à vocation pastorale et destinées au pâturage» aux conseils de tutelle régionale. Mieux encore, la circulaire n°5 du 15/2/1971 du ministère de l'Agriculture relative aux modalités d'application de cette loi précise que les conseils de tutelle devront reconnaitre ces terres comme étant: « les terres non irriguées ou à vocation arboricole et qui sont au dessous de l'isohyète 180 mm, à l'exception des bas fond ». Cette disposition, qui n'a pas été abrogée par les textes ultérieurs, a été récemment consolidée par la dernière loi de 2016 qui vient urger les conseils de tutelle

[3] Il s'agit de la loi n°57-16 du 28/9/1957 et de la loi n°59-83 du 21/7/1959 qui ont adapté les anciens textes relatifs aux terres collectives au contexte du pays suite à l'indépendance.

régionale à finaliser la délimitation des terres de parcours dans le délai bref de deux ans à partir de la date de sa publication.

Néanmoins, ni l'une ni l'autre des deux dispositions susmentionnées n'a été respectée par les différents conseils de tutelle régionale qui semblent céder pleinement de ce fait à une pression sociale réclamant plus du partage. Faut-il encore signaler que le dépassement du délai de deux ans mentionné dans la loi de 2016 n'a suscité jusqu'à présent aucune initiative législative sollicitant au moins pour la prolongation de ce délai[4]

La seule réussite en la matière, jusqu'à nouvel ordre, consiste à la soumission d'une superficie totale de 600.000 ha au régime forestier en application des dispositions du code forestier afin de favoriser une gestion rationnelle de ces terres appuyées sur des plans d'aménagements pastoraux élaborés par les conseils de gestion en collaboration avec les services techniques compétentes du ministère de l'Agriculture. Toutefois, ladite soumission n'a débouché réellement que sur trop peu de plans d'aménagement. De l'autre côté, il faut signaler également que ce chiffre de 600.000 ha a été révisé plusieurs fois à la baisse sous la pression de plusieurs collectivités réclament un usage autre que le pâturage (Nefzaoui et al, 2020).

B. L'institution des principes protecteurs

Depuis la promulgation de la loi n°64-28 du 4/6/1964, les terres collectives sont identifiées comme étant des biens inaliénables, imprescriptibles et insaisissables, ce qui est en mesure de dissuader, au moins théoriquement, toute tentative d'occupation illicite. La seule dérogation prévue par l'article 15 de cette même loi porte sur les terres acquises ou mises en valeur et localisées exclusivement dans la région du sud-est, à condition que les demandes de régularisation à leur sujet parviennent à l'administration dans un délai maximal de trois ans.

Cette tentative de régularisation, que nous trouvons assez fondée puisqu'elle visait uniquement les terres collectives qui ont été exclues des travaux de délimitation antérieures (en vertu du décret beylical du 14/1/1901), a été retenue encore une fois par la réforme de 2016, mais sans donner aucune précision à propos des sites visés par la présente dérogation et surtout concernant les délais d'acceptation des demandes de régularisation, ce qui est en mesure de vider les dits principes protecteurs de tout leur sens.

C. La mise en place d'un dispositif d'arbitrage des conflits fonciers

La version actuelle du régime foncier des terres collectives a gardé pour l'essentiel le même, ou presque, dispositif juridique d'arbitrage des conflits fonciers conçu lors de l'époque coloniale. Ces sont les conseils de gestion qui assurent l'arbitrage des conflits survenant à l'intérieur d'une même collectivité, alors que l'arbitrage entre collectivités revient aux conseils de tutelle régionale, voire les conseils de tutelle interrégionale pour le cas particulier d'un litige survenu dans plus d'un gouvernorat. Par ailleurs, Une innovation assez intéressante de la récente modification de 2016, qui porte sur l'assouplissement des procédures contentieuses, consiste à fixer d'un délai contraignant de trois mois devant les conseils de gestion et les conseils de tutelle régionale pour se prononcer au sujet des demandes d'arbitrage.

4.5 Cadre institutionnel de la gouvernance des parcours collectifs : des acteurs divers, des enjeux multiformes

Le cadre institutionnel de la gouvernance des parcours collectifs en Tunisie regroupe un nombre considérable d'acteurs qui peuvent être répertoriés essentiellement selon leurs statuts et rôle: structures gouvernementales, administratives et/ou d'appui, organisations non gouvernementales, intervenants au niveau national, régional et local (Sghaier et al, 2020).

[4] La seule initiative juridique déposée à l'Assemblée des Représentants du Peuple jusqu'à la date du 15/6/2020 ne réclame que la prolongation du délai de cinq ans accordé par la loi n°2016-69 du 10/8/2016 aux conseils de gestion pour finaliser les opérations de privatisation.

Par principe de parcimonie et en guise d'une meilleure appréhension des interactions intervenant entre les acteurs que nous jugeons les plus influents sur la scène des parcours collectifs, nous ne retiendrons ici que les acteurs qui interviennent directement soit au niveau de l'exercice de gestion, à savoir les conseils de gestion et les groupements au développement agricole, soit au niveau de l'exercice de la tutelle administrative ou encore technique.

A. Les structures de gestion

a] Les conseils de gestion

À l'image de ses prédécesseurs, la dernière réforme de 2016 conserve la mission de gestion des parcours collectifs aux conseils de gestion. C'est ainsi que ces conseils, dont chacun est formé d'au moins six membres élus par les individus de la collectivité, ont la responsabilité de gérer les terres collectives aux noms des collectivités et réaménager les pâturages et entretenir les zones qui lui sont réservées.
Cependant, les constats des faits réalisés surtout par Ben Saad et al (2009) et Elloumi et al (2010) informent que ces conseils n'exercent aucun contrôle à l'accès de ces parcours, y compris ceux qui sont soumis au régime forestier, et n'ont apporté aucune solution pratique pour assurer l'exploitation durable des leurs ressources. Ben Saad et al (2009) avancent plusieurs raisons qui peuvent expliquer, en quelques sortes, l'inadaptation de ces structures à la tâche de gestion des parcours collectifs. Il s'agit notamment de la faible connectivité de ces conseils à leurs bases qui elle-même est imputable à la faible participation des ayants droit. Une autre raison consiste au manque des moyens financiers et même des locaux pour ces conseils, ce qui témoigne notamment de leur marginalisation par les autorités publiques qui semblent privilégier les nouvelles structures de gouvernance des parcours représentées par les groupements de développement agricole.

b] Les groupements de développement agricole (GDA)

L'introduction des GDA, crées en vertu de la loi n°99-43 du 10/5/1999 et dirigés par des comités élus par les adhérents, dans la gestion des parcours collectifs est attribuable à la promulgation de la loi n°2004-24 du 15/3/2004, mais surtout à l'arrivé sur scène depuis l'année 2003 du Programme de Développement Agropastoral et Promotion des Initiatives Locales du Sud Est (PRODESUD). En effet, la promulgation de ladite loi de 2004 a permis de redéployer les GDA, rattachés auparavant à la gestion des ressources hydrauliques, vers la gestion de toutes les ressources naturelles de leurs territoires, ce qui correspond dans notre cas aux parcours collectifs. De l'autre côté, PRODESUD (2003-2020), un projet programme qui s'étalait sur une bonne partie du sud tunisien (tout le gouvernorat de Tataouine et la délégation de Douz du gouvernorat de Kébili), trouvait dans ces GDA la formule la mieux appropriée pour traduire ses programmes de développement durable, intégrant entre autres le développement des grands parcours, en actions. C'est ainsi que les GDA, grâce au soutien de PRODESUD, ont réussi à convaincre plusieurs collectivités de reprendre la pratique ancestrale de « *gdel* » (mise en repos) qui correspondait auparavant à la meilleure illustration d'une gestion coordonnée de ces espaces pastoraux (Elloumi et al, 2010).

Force est de constater à ce stade l'objection souvent déclarée de la part des conseils de gestion de partager leur compétence, qui émane d'ailleurs des lois spécifiques aux terres collectives, avec les GDA (Elloumi et al, 2010). De même, la clôture de PRODESUD (depuis la fin de l'année 2020) pourra vraisemblablement mettre en question la durabilité du modèle de gestion instauré par les GDA, surtout en l'absence d'un soutien financier permanant en provenance des autorités publiques.

B*. Les structures de tutelle*

a] La tutelle administrative

Cette tutelle est attribuée depuis la dernière réforme de 2016 aux gouverneurs et aux conseils de tutelle régionale, alors qu'elle s'étalait auparavant aux conseils de tutelle locale (au niveau de chaque délégation), ainsi qu'au ministère de domaines de l'Etat, ce qui dénote une volonté marquée vers plus de simplification de cette tutelle.

Les conseils de tutelle régionale, et dont les membres sont désignés par les gouverneurs, interviennent dans ce cadre notamment pour orienter l'activité des conseils de gestion et contrôler leur gestion administrative et financière, délimiter les terres de parcours et arbitrer les conflits fonciers entre les collectivités. Quant aux gouverneurs, ils interviennent en particulier pour organiser et valider les élections des membres des conseils de gestion, et également pour exercer le contrôle du fonctionnement administratif et financier des GDA.

b] La tutelle technique

Pour l'instant, la seule forme prévue explicitement par la loi (le code forestier) concerne les parcours soumis au régime forestier qui demandent l'intervention du ministère de l'agriculture pour la mise au point des plans d'aménagement de ces parcours en concertation avec les conseils de gestion.

IV - Conclusion

En guise de conclusion, nous pouvons souligner qu'en dépit de l'expérience assez riche du pays dans le domaine du développement de territoires pastoraux, le législateur tunisien tarde encore à identifier les outils juridiques et surtout institutionnels pouvant offrir des garanties certaines à la bonne gouvernance et à la sécurisation foncière des parcours collectifs, ce qui évoque l'ultime nécessité d'une réflexion approfondie autour des composantes du tissu institutionnel interférent dans la gouvernance de ces parcours.

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Territorial Intelligence: A collective opportunity for sustainable pastoral development and good rangeland governance in South Tunisia

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Abstract. Pastoralism is still considered an important economic and cultural aspect of the life of the Tunisian communities practicing agropastoral faming in South Tunisia. Our research on fundamental rangeland governance aspects showed that questions on “how to sustain rangelands and enhance their governance” and “how to develop pastoral areas” are highly interlinked. A research was carried out explore these linkages based on the “territorial intelligence - TI” concept. We particularly aim to explore the opportunities to apply the TI (as reflected by more efficient pastoral development investments) as a wider framework to enhance rangeland governance through more efficient pastoral development actions and investments. A mixed methodology has been used combining both social network analysis and “prospective system” method. To this end, results show that the lack of communication between the main economic actors involved in the management of collective pastoral areas, the dominance of the local authorities on pastoral development program design, and the weak autonomy of community based organizations (CBO’s) are the main challenge factors which could enhance harmony between rangeland governance and pastoral development.

Keywords. Territorial intelligence, collaborative intelligence, rangeland, governance, social network analysis, Tunisia

Résumé. *Le pastoralisme est toujours considéré comme un aspect économique et culturel important de la vie des communautés tunisiennes pratiquant l'agropastoralisme dans le sud de la Tunisie. Notre recherche sur les aspects fondamentaux de la gouvernance des parcours, a montré que les questions sur "comment maintenir les parcours et améliorer leur gouvernance" et "comment développer les zones pastorales" sont fortement liées. Une recherche a été menée pour explorer ces liens sur la base du concept d'"intelligence territoriale - IT". Nous cherchons en particulier à explorer les possibilités d'appliquer l'IT (telle que reflétée par des investissements plus efficaces dans le développement pastoral) comme un cadre plus large pour améliorer la gouvernance des parcours à travers des actions et des investissements de développement pastoral plus efficaces. Une méthodologie mixte a été utilisée, combinant à la fois l'analyse des réseaux sociaux et la méthode du "système prospectif". A cette fin, les résultats montrent que le manque de communication entre les principaux acteurs économiques impliqués dans la gestion des zones pastorales collectives, la domination des autorités locales sur la conception des programmes de développement pastoral, et la faible autonomie des organisations communautaires de base (OCB) sont les principaux facteurs de défi qui pourraient améliorer l'harmonie entre la gouvernance des terres de parcours et le développement pastoral.*

Mots-clés. *Intelligence territoriale, intelligence collaborative, parcours, gouvernance, analyse des réseaux sociaux, Tunisie*

I - Introduction

Pastoralism is one of the main production systems in the world's arid areas (FAO 2001). Over the years, pastoralism has shifted from nomadism to transhumance to agro-pastoralism and intensive livestock farming. Pastoralism, i.e. the use of extensive pastures on rangelands for livestock production, is an important economic and cultural way of life for between 100 and 200 million people worldwide. Extensive pastoral production systems cover about 25% of the earth's surface (Blench 2000). Rangelands can be defined as lands on which native vegetation consists mainly of grasses, herbaceous plants, or shrubs that are grazed or have the potential to be grazed, and which are used as a natural ecosystem for livestock and grazing wildlife production (Allen et al. 2011). In Tunisia, rangelands cover 5.5 million hectares of the country's total area (Gamoun et al. 2018). Three quarters of these rangelands are located in regions where the bioclimatic stage is changing from semi-arid to desert. This geographical importance is of socio-economic, political, biological and ecological importance. It is reflected in its involvement in the country's agricultural and animal production, the historical and social value of these rangelands, and the ecological biodiversity of the plant species encountered.

This activity plays an important role in the circulation of key ecosystem goods and services in drylands. Rangeland areas remain however vulnerable to the effect of climate change and are often exposed to management and governance problems. Complex land tenure systems add complexity to the way rangelands are governed and managed. Collective governance combined with lack of strong local organizations and institutions leads to major governance problems and stakeholders conflicts. Communication, and strong relations between actors/communities are necessary for maintaining good management and governance of natural resources. For the case of Tunisia, the different institutional reforms undertaken in the last century led to the disappearance of traditional governance mechanisms, usually based on strong communication and social leadership. The newly created farmers' associations are still lacking good communication and management skills.

The concept of territorial intelligence (TI) is derived from the "Economic Intelligence" (EI) theory. It refers to territorial governance processes, mainly related to the actors' and stakeholders' interactions and the territorial development. TI provides a set of approaches and tools that facilitate understanding of the territory and assist for knowledge generation and management for territorial development purpose (Meyer 2004). The TI proposes a framework that serves to consolidate the links between actors, create and activate networks in order to encourage knowledge sharing, cooperation and collaboration between the different parties involved in the global process of sustainable development of these territories (Bozzano 2009).

The objective of this paper is to provide an early highlight on relevant aspects of TI which can serve to enhance the effectiveness of pastoral projects and investments in South Tunisia, while ensuring greater sustainability and enhanced governance of rangelands. Local and regional social networks will be analyzed to reflect on the level and intensity of interaction of actors involved in pastoral development and rangeland management.

II - Economic and Territorial Intelligence as a Strategy for Local Development

1.1 Economic and territorial intelligence

There are several definitions of Economic Intelligence. Each society, according to its history, its cultural past, its geographical location, its natural or industrial resources may have a different definition of economic intelligence (Said 2006; Coder 2013). In France, economic intelligence was born early 1990s following the work of the “Commissariat Général au Plan” with Henri Martre's report in 1994, which made it possible to clarify the concept and give it a first definition (DUFAU 2010). In this report, EI was defined as “all coordinated research, processing and distribution actions of information useful to economic actors”. Local and regional authorities and administrations also play an essential role in optimizing information flows. The operational flow of information between companies, local authorities and administrations is a key factor in competitiveness against foreign competition, both offensively and defensively. Nevertheless, local and regional authorities are supposed to provide significant financial support to collect, compile and make available these economic-oriented information (Martre et al. 1994).

The concept of TI consists in the application of the principles of EI during a public action, in the service of the economic and industrial development of a given territory. It is a decision-making tool for local communities who would like to plan for their local development. TI presents a structured framework for researchers, actors and the territorial community to acquire a better knowledge of the territory, but also to better control its development. The appropriation of information and communication technologies, and of information itself, is an essential step for actors to engage into a learning process that will enable them take effective and efficient decisions (Girardot 2011). The TI approach is based on 4 important levers, including development of job-creating projects, anticipation of economic changes, disruptions and risks, the promotion of the attractiveness of territories and the animation of territorial development and social networks (Paillot 2016).

1.2 Territorial intelligence and local development of territories

The emergence of the concept of sustainable development has changed the way problems are considered from a territorial perspective and made its management even more complex. It has become clear to those involved in the management of this physical and/or virtual space that mastering this complexity requires a better understanding of the territory and its natural endowments (resources). Thus, both qualitative and quantitative information will be relevant to consider. In Tunisia, there is growing demand for concepts and approaches of territorial development as results of new economic, social and environmental pressures (Meyer et al. 2018). TI methods and tools would provide the opportunity to confront the needs and demands of local stakeholders with operational solutions being available to meet these needs. In other words, the development of territories would mobilize all technical practices, devices and approaches for data collection and information processing and exchange, in a way that make the gap between the earlier needs and the respective available operational development tools, considered into the local development decisions (Haddad 2008; Slymen 2014).

1.3 Resource governance and territorial intelligence

Participatory territorial governance complements representative democracy on subjects of local interest. Its ethical principles: participation, cooperation, coordination, consultation, learning, co-construction, transparency, equity and sustainability, have been identified as evaluation criteria

(Ugarte 2006). TI would contributes to mainstreaming dimensions of sustainable development by involving and stimulating each stakeholder to act into a broader perspective of "well-being of each and every one" (Conseil de l'Europe 2005). This would only happen through intensive exchange of information about the available resources in a territory, threats and opportunities to their sustainability, and collective engagement for their preservation. Doing so will make resources management and conservation part of the decisions about broader territorial development and planning.

III - Materials and Methods

1.4 Conceptual framework

This study was carried out, by applying TI principles on pastoral development in the governorate of Medenine in southeast Tunisia. A "monitoring framework" has been set up for data collection followed by data processing and analysis. The diagnosis of the field of development-oriented actions was through the application of the "prospective system" analysis of territories. A social network analysis was further performed to characterize current levels of social inclusion and transparency. Social network analysis is used to measure and analyze the structural properties of the interdependent dyadic relationship networks of interorganizational relations between organizations as a whole - including relationships such as joint collaborations, resource sharing, information sharing or even membership in common organizations (e.g., trade associations) (Steketee et al. 2015). We conducted interviews guided by a questionnaire with key stakeholders, internal and external experts in addition to direct observations of these networks (Figure 1).

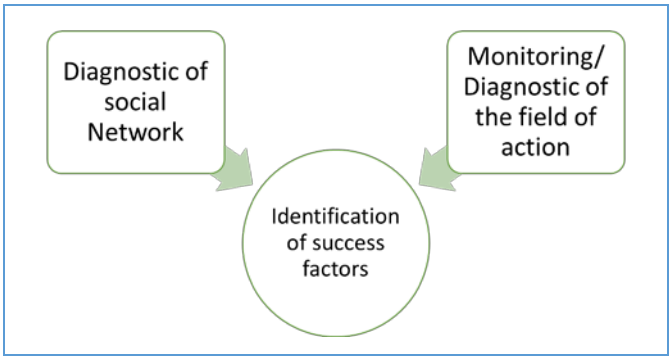

Figure 1: Methodological approach for the study of pastoral TI (Source: Own elaboration, 2021)

The method used to analyse the field of action was the Prospective System method developed by Pacini (Durance, PACINI, and MIRENOWICZ 2021), but enriched by elements of the Meta method developed by the Goux-Baudiment (Auroy and Pacini 2018).

1.5 Data collection

In this study, we combined qualitative data (sociometric questionnaire) and methods (interviews/observations/documentations, etc.) with quantitative analysis. Mixed methods make it possible to enrich the research design either upstream (enrichment of the questioning) or downstream (enrichment of the results) or at both levels (Aldebert and Rouzies 2014). The

study was also based on interviews and collection of archival data, documentation, scientific articles, previous studies (research results) and direct observations. The quantitative data collection method was in the form of a "Face to Face" interview assisted by a questionnaire, which aims at tracking the intensity of social relations and interactions. We have adopted the PAPI (Paper and Pencil interviewing) collection method. Direct data collection was done with PRODEFIL (Projet de développement agropastoral et des filières associées dans le Gouvernorat de Médenine) project members, managers, partners, and beneficiaries including farmers' cooperatives, associations, and land management councils.

1.6 Sampling procedure and statistical analysis for SNAs

The choice of actors included in our SNA was based on network or snowball sampling. This is a nonprobability sampling that consists in choosing several actors that are considered important and that correspond to the desired profile and asking them to list the other actors needed for the network. Obviously, the snowball method does not provide a complete representation of the network because it necessarily introduces biases. Snowball sampling is generally used when the study population is not easily accessible (Wagner et al. 2017; Atkinson and Flint 2001).

For our network analysis (SNA), we used the Gephi software, version 0.9.2. Gephi is an interactive visualization and exploration platform for all kinds of complex networks and systems, dynamic and hierarchical graphics. Works on Windows, Linux and Mac OS X, Gephi is an open source and free software. Gephi is a tool for people who need to explore and understand graphs. Like Photoshop but for data, the user interacts with the representation, manipulates structures, shapes and colors to reveal hidden properties.

IV - Results

The types of links and relationships between actors considered in our study area are rather cooperative (Boudedja 2013). The relationships between the actors are clearly non-hierarchical. Even in the case of administrations affiliations (subdivisions of the same administration), the nature of their operating status favors cooperative relationships rather than hierarchy. In most cases, these sub-divisions do have their administrative independence.

The analysis of the field of action consists of understanding key factors currently driving and guiding the development of pastoral territories in Medenine. We studied the territory from a prospective point of view by asking the following questions: What environmental and external factors, and what internal factors you consider as currently driving the development of pastoral territories in Southern Tunisia?

The assessment of rangeland system in the target area reveals that pastoral territories, like all other natural systems, are vulnerable to factors that can undermine their sustainable functioning, evolution, and development (Figure 2). The prospective system distinguishes two categories of factors: external factors, as part of global environment, and internal factors. Internal factors refer to factors that are produced by the system itself and external factors are those that come from the outside. Environmental factors are generally those factors where the intervention of actors is limited. The following figure presents the different studied internal and external dynamics of the studied pastoral system.

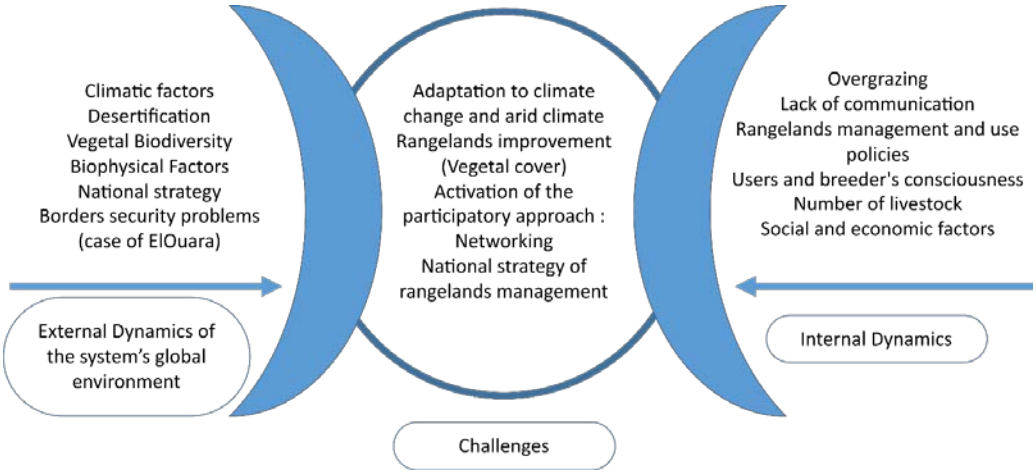

Figure 2: prospective system (source: own elaboration, 2021)

In arid regions, rangelands are facing several climatic and environmental challenges. These factors are mainly: climate change resulting from droughts, erosion, rainfall and desertification, which leads to the degradation of vegetation cover. External factors are not limited only to environmental factors. The national strategy and policy for collective land management and problems related to border areas, mainly the case of the pastoral territory of El Ouara in Ben Guerdane and the borders with Libya.

Environmental factors are divided into two main parts: biophysical factors, including plant biodiversity and soil resources, and climatic factors, which include precipitation, temperature, wind movement and ecosystem variability and the reaction of these elements to climate change (Ouled Belgacem et al. 2011)

In addition to the environmental (i.e. factors), a set of internal factors have been considered in the analysis. These factors summarize the socio-economic factors, in particular, the institutional structure of the actors involved in the territory, the appropriate management and exploitation method, the number of livestock, the point of view of users (herders and pastoralists), the accessibility and the situation of the infrastructure in these territories.

Mapping Social Networks for pastoral development

Based on the selected factors outlined in the previous section, the adapted sampling method was able to identify 22 main actors intervening in the management and the governance of rangelands. This list of actors is not exhaustive and are clustered in nine main categories. The identification mapping of these actors taking into consideration their categories, fields of activity and interventions in the target territory are outlined in figure 3.

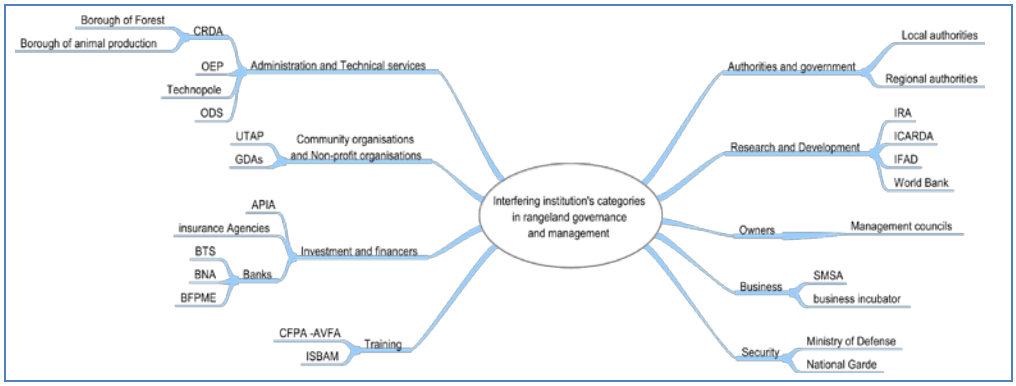

Figure 3: Map and list of actors identified by category (Source: Own elaboration based on focus groups discussions, 2021)

From this mapping exercise, it appears that links between the different actors are indeed existing and multiple. These links are in most cases informational in nature (information exchange). The clustering come up with 9 categories of actors. The size of each node is relative to the "betweenness centrality" indicator. Betweenness Centrality is an indicator to measure how many times an actor is on the shortest path between a pair of other actors (Ingold 2014). The actor is more central when he connects the other peers of the actors the most (Freeman 1978). The positioning of the actors in the graph is based on their degree of centrality. The most central actor is in the middle of the network. The more the actor/node is at the end, the less central the actor is.

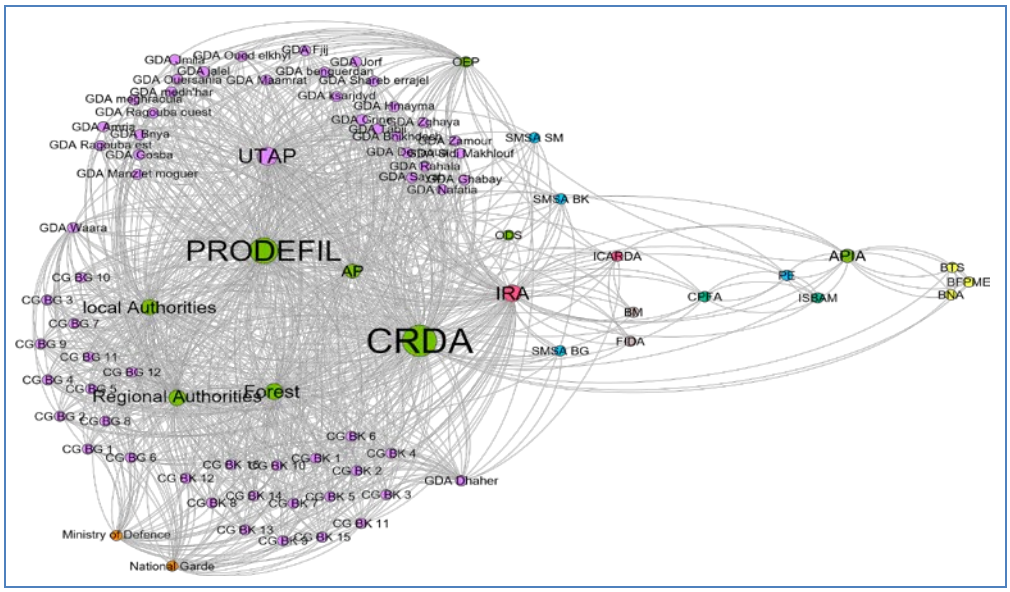

Figure 4: Social network analysis results (Source: Own elaboration, 2021)

The visual presentation of the network and the results of the different centrality indicators, show that the regional administration presented by the regional agriculture administration "Commisariat regional de développement agricole" (CRDA) and its divisions for animal

production AP and the forest administration (responsible for the rehabilitation of lands and the application of the forest regimen). Public actors always have the highest values. Local and regional authorities have a higher number of outgoing links than actors such as the Ministry of Defense presented by the army and the Ministry of Internal Affairs presented by the National Guard, which have presented a significant number of incoming links. The two GDAs responsible directly for the management and governance of collective rangelands in the governorate of Médenine, GDA Elouara and GDA Dhaher, presented different values from the other operating GDAs (29 GDAs). The PRODEFIL development project also presented a close value to that of CRDA. Other community organization stands out, the Tunisian Union of Agriculture and Fisheries (UTAP) also showed interesting results. The structure holds a central role between all farmers groups (GDAs5) and the regional administration and cooperation projects.

Community-based organizations (CBO's) have always been in a peripheral position. However, GDA Dhaher presented encouraging results (i.e., known for its activism). These results can be explained by the diversity of activities and services presented by the GDA. This GDA has successfully applied the resting technique of the collective rangelands, in partnership with the forest district and the PRODEFIL project. The GDA connects more with the land management councils (LMC) of Beni- khedache (CG6 BK1 to CG BKn). This can be interpreted by the good reputation of the GDA with the community and also the regional and local administration/authorities. Most of the other GDAs were created in the frame of the PRODEFIL project. These GDAs are characterized by a lack experience and vision. They are totally dependent on the activities managed by the project. Many of them are not aware of the choices of activities and development opportunities they can bring. The project has launched a program to support and strengthen these GDAs by organizing training sessions on administrative and financial management and specific missions (e. g. creation of a digital archive). The small number of GDAs created before the project were water management groups. The main activity was the management of water points in irrigated areas or public boreholes. This specificity of activity has created a distance between the GDAs and the other areas of intervention. Even after the change of their status to a more global and wider field (development group in general) and the arrival of PRODEFIL, these GDAs still focus on their initial activities. Supporting these organizations is also a bigger step towards smoother and sustainable development and better interaction between different actors to favorize the good management and governance of the rangelands.

The OEP is an organization that intervenes in the case of private rangelands. But it has shown remarkable interactions with the management of collective lands. This can be explained by the complexity of the agro-pastoral system in Tunisia and especially in the south. In arid and Saharan regions, livestock farming is an insurance and savings asset for farmers. Agricultural crops in these regions are subject to several difficult climatic and natural factors. The farmer therefore tries to prepare a second plan to overcome each year with a minimum of losses through this asset. This type of saving or management of the farmer's financial situation is mainly based on pastoralism. This strategy can only be effective if it is affordable with minimal costs and when it does not lead to more difficult situations when the farmer spends more to support the animals' feed and health. Farmers, therefore, use the natural resources of private and collective rangelands. The main role of the OEP is to organize and facilitate information and awareness days/campaigns on pastoral improvement at the regional level, but also to provide technical support on the plots of land for beneficiaries of the pastoral improvement program. In

[5] GDA : Groupement de dévelopment agricole

[6] CG : Conseil de gestion

practice, OEP's intervention is carried out through the multiple technical field visits of future members to determine the vocation of the plots and the types of development to be undertaken.

The land management (CGs) have a very limited centrality. These results are consistent with the results presented by Ben Saad et al. (2011). The authors emphasized the reduced role of collective land management councils. These structures are not suitable for managing collective land for distinct reasons (Ben Saad 2011). The LMCs are composed mainly and in a large number by farmers focusing on and not livestock farmers. It is true that most farmers in southern Tunisia have a number that varies of animals and adopt a mixed farming system, but this does not negate the fact that the opposite situation exists. There are farmers with a very large livestock population who use the totality of their private land for grazing. The cultivation of olive trees on these lands is a common practice and is used for the same insurance purpose. The objectives and motivations of these two groups of farmers to manage this land, are very different. A second factor underscores the inadequacy of these structures (the CG).

Despite the state's efforts to reduce the role of administrations in favour of local authorities, the results showed from this research illustrate the way on how the administration (and these technical services and the project) are the most central actors in the network. The Territorial Communities and local actors have maintained their marginal position. From the 1980s onwards, participatory approaches began to appear in agricultural and rural development programs. This approach aims to involve all stakeholders in the planning and implementation of its projects and development programs. It can be found in the design of development projects financed by International Fund for Agricultural Development (IFAD) and the European Union in the South East such as PRODESUD and PRODEFIL7. In Tunisia, the administration is the main decision-maker (Ministry). The adaptation of this participatory approach was intended to involve users, right land holders and local authorities in the planning of development activities. Although the application of this approach remains limited at the level of development programs, local actors encourage this initiative (PRODEFIL and PRODESUD cases). It is often regarded as a practical solution. Local authorities have stressed that the administration is still not aware of the differences and specific attractions and problems to each region and the involvement of local actors can facilitate the development and progress of activities. This lack of communication between the strategic actors of the natural rangelands contributes to the loss of the real contribution of development projects such as PRODEFIL. A project with such an investment figure is poorly assessed by the local population because of this weak coordination. The involvement of local stakeholders in a timely and informed manner could be the key to the success of this project.

V - Conclusion

The lack of communication between the main economic actors involved in the management of collective pastoral territories in the governorate of Médenine, located in south-eastern Tunisia, presents a main challenge and constraint to the development and good governance of the territory. The purpose of this study is to establish a better understanding of the existent network and the territories main attractions and threats.

First, we carried out a diagnosis of the field of action; the pastoral territories of the governorate. The governorate's rangelands present several internal and external factors that have led to the production of major challenges. Internal factors mainly include socio-economic factors and

[7] PRODEFIL : Projet de développement agropastoral et des filières associées dans le Gouvernorat de Médenine

factors related to land management. External factors include factors related to national and social security policies on the one hand, and environmental factors such as climatic, biological and ecological factors on the other. The main issues identified were the challenges of adaptation to climate change, the adjustment of management and exploitation methods to promote the conservation of these natural resources and the issues related to the network of actors and the lack of communication.

Secondly, a social network analysis (SNA) was carried out. The results showed that the regional and local administrations are the most central actor. Despite the state's desire to reduce the dominance of these administrative bodies, local authorities, community-based organisms retain their weak centrality and peripheral roles. The implementation of a capacity development plan for these organizations through training sessions is one other urgent step.

Finally, as this shows, the Governorate of Medenine is a unit in a more global and a wider territory regarding rangelands and agro-pastoral system. The rangelands in Medenine are not isolated from the other governorates where these pastoral territories extend. Our research focused only on this limited region. Therefore, a more comprehensive study of the South-East pastoral territory can be carried out to this extent. The list of actors presented in the study is not exhaustive. An in-depth study in which all actors are involved and where interviews must be conducted with each actor is needed. It can also provide an opportunity to analyze the nature of the links between actors and present a precise categorization of these links.

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Pastoralism and Sustainable Development

Proceedings of the international e-workshop organized in the framework of PACTORES project
Valenzano, Bari, 14-15 July 2021

Edited by:
R. Capone, F. Bottalico, H. El Bilali, G. Ottomano Palmisano, G. Cardone, A. Acquafredda

This issue of Options Méditerranéennes encompasses the Proceedings of the international e-Workshop Pastoralism and Sustainable Development. The two-day e-workshop took place on July 14-15, 2021, within the project PACTORES (Pastoral ACTORs, Ecosystem services and Society as key elements of agro-pastoral systems in the Mediterranean). The e-workshop served as a forum for the exchange of insights, ideas and good practices regarding the multifaceted nexus between pastoralism and sustainable development in the Mediterranean and beyond. The aim was to ensure the sustainability and perpetuity of pastoralism while improving the living conditions and livelihoods of pastoral communities in line with the ambition of the Sustainable Development Goals.

The workshop consisted of a keynote plenary session and four thematic sessions that addressed the connections between pastoralism and sustainable development: (1) environment, ecology and ecosystem services; (2) society and culture; (3) economy and finance; and (4) policy, institutions and governance. The keynote speeches addressed trends and challenges for sustainable development of sheep and goat systems as well as agro-ecology and agro-pastoral systems in Corsica (France) and the argan tree area in Morocco. The results of the e-workshop should inform evidence-based actions and policies for the sustainable development of pastoralism in the Mediterranean and beyond.

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