CIHEAM
Options Méditerranéennes

Diverse and resilient agro-pastoral systems: a common goal for the Mediterranean regions

Ates S., Casasús I., Louhaichi M.

in

Baumont R. (ed.), Carrère P. (ed.), Jouven M. (ed.), Lombardi G. (ed.), López-Francos A. (ed.), Martin B. (ed.), Peeters A. (ed.), Porqueddu C. (ed.).
Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

Zaragoza : CIHEAM / INRA / FAO / VetAgro Sup Clermont-Ferrand / Montpellier SupAgro
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 109

2014
pages 545-557

Article available on line / Article disponible en ligne à l'adresse :

---

http://om.ciheam.org/article.php?IDPDF=00007772

To cite this article / Pour citer cet article

Ates S., Casasús I., Louhaichi M. **Diverse and resilient agro-pastoral systems: a common goal for the Mediterranean regions.** In : Baumont R. (ed.), Carrère P. (ed.), Jouven M. (ed.), Lombardi G. (ed.), López-Francos A. (ed.), Martin B. (ed.), Peeters A. (ed.), Porqueddu C. (ed.). *Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands.* Zaragoza : CIHEAM / INRA / FAO / VetAgro Sup Clermont-Ferrand / Montpellier SupAgro, 2014. p. 545-557 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 109)

CIHEAM

http://www.ciheam.org/
http://om.ciheam.org/

CIHEAM

Diverse and resilient agro-pastoral systems: a common goal for the Mediterranean regions

S. Ates[1,*], I. Casasús[2] and M. Louhaichi[1]

[1]International Center for Agricultural Research in the Dry Areas (ICARDA), Amman (Jordan)
[2]Centro de Investigación y Tecnología Agroalimentaria, Gobierno de Aragón, Zaragoza (Spain)
*e-mail: s.ates@cgiar.org

Abstract. The potential of agriculture to maintain or even further intensify production to meet the food and fibre needs of increasing populations without degrading the capacity of the resource base is a major concern worldwide. This review briefly assesses options for the ecological intensification and increased resilience in agro-pastoral systems from the dual perspectives in the southern and the northern Mediterranean by providing examples of successful case studies. Despite the significant disparities in demographic, economic and agricultural land utilization patterns between countries in the north and south Mediterranean, improved animal and crop production is a shared priority with lesser concerns for preserving the natural resources in the southern part of the basin. While intensification may be a more achievable target in favourable areas of the northern Mediterranean, it is crucial to increase the resilience of resource poor agro-pastoral systems through sustainable management in the arid regions of the southern part. As the pressures on land and water resources increase, the major challenge today is how to achieve ecological intensification to be able to sustain the food security without compromising the environmental quality and natural resources that underpin crop and livestock production in the Mediterranean region. Fundamentally, ecological intensification is closely associated with increased efficiency and successful adjustment of seasonal herd management to available feed resources in agro-pastoral systems. Concomitantly, livestock can be used as a tool for the preservation of the natural resources, either by adapting management in conventional systems or through the design of new environmentally-targeted production systems. In addition, in mixed farming systems of the Mediterranean region, inclusion of locally available improved forage legumes in cropping rotations and the use of alternative fodder plants like shrubs and cactus in alley cropping system particularly in marginal areas to increase the availability of high quality feed resources are among the most viable options to achieve diverse and resilient agro-pastoral systems.

Keywords. Crop/livestock farming – Dryland forage legumes – Mediterranean agriculture – Rangelands – Sustainable intensification.

Des systèmes agro-pastoraux variés et résilients: un objectif commun pour les régions méditerranéennes

Résumé. *La possibilité de maintenir, voire d'intensifier, la production agricole sans dégrader les ressources naturelles, afin de répondre aux besoins alimentaires d'une population en constante augmentation, est une préoccupation mondiale majeure. Cette revue évalue brièvement, grâce à des études de cas réussies, différentes options permettant d'atteindre une intensification écologique et une augmentation de la résilience dans les systèmes agro-pastoraux avec une double perspective au sud et au nord de la Méditerranée. Malgré d'importantes disparités démographiques et économiques, ainsi que des différences dans les modes d'utilisation des terres agricoles entre les pays du nord et du sud de la Méditerranée, l'amélioration de la production agricole est une priorité partagée, avec toutefois des préoccupations plus faibles concernant la préservation des ressources naturelles dans la partie sud du bassin. Alors que l'intensification agricole peut être plus facilement atteignable dans les régions prospères du nord de la Méditerranée, il est crucial de renforcer la résilience des systèmes agropastoraux du sud à travers une gestion durable des régions arides. Étant donné l'augmentation des pressions qui pèsent sur les terres arables et l'eau, le principal défi actuel est de parvenir à une intensification écologique afin de maintenir la sécurité alimentaire sans compromettre la qualité de l'environnement et des ressources naturelles qui sont à la base de la production végétale et de l'élevage dans la région méditerranéenne. Fondamentalement, l'intensification écologique est étroitement associée à une efficacité accrue et à une adaptation réussie de la gestion saisonnière du troupeau par rapport aux ressources alimentaires disponibles dans les systèmes agro-pastoraux. De manière concomitante, le*

bétail peut être utilisé comme un outil pour la préservation des ressources naturelles, soit en adaptant la gestion dans les systèmes conventionnels, soit par la conception de nouveaux systèmes de production respectueux de l'environnement. En outre, dans les systèmes agricoles mixtes de la région méditerranéenne, l'intégration, dans les rotations culturales, de légumineuses fourragères améliorées et disponibles localement, et l'utilisation de plantes fourragères alternatives, comme les arbustes et les cactus, dans les systèmes de culture en couloirs pour accroître la disponibilité des ressources alimentaires de haute qualité, sont parmi les options les plus viables pour réussir à avoir des systèmes agro-pastoraux diversifiés et résilients.

Mots-clés. *Systèmes de culture/élevage – Légumineuses fourragères en région aride – Agriculture méditerranéenne – Pâturages – Intensification durable.*

I – Introduction

The Mediterranean region has unique agro-ecosystems with a prevalence of vegetation adapted for arid and semi-arid conditions (Kassam, 1991; Harlan, 1992). Ever since settled agriculture started with the establishment of diverse farming communities, agriculture has been in constant change in the Mediterranean region, albeit with diverging patterns in the northern and southern shores (Landau *et al*., 2000). In the northern part of Mediterranean, traditional crop-livestock farming that used to be extensively practiced over large areas has evolved into more intensive and highly productive crop based agriculture, but often while damaging natural resources (Pretty, 1995). As a result of the increased focus on cropping, the reduced number of livestock in turn caused abandonment of vast grasslands resulting in widespread bush encroachment (Landau *et al*., 2000; Bernués *et al*., 2011). Whereas in the southern part, the rapid increase in human and livestock populations has led to more intensive land use with an unrelenting exploitation of natural resources, particularly the rangelands (Hopfenberg and Pimentel, 2001; Le Houerou, 2000; Ates and Louhaichi, 2012). Socio-economic and political factors are distinctly different in both parts of the basin, and have also played a significant role in forming the structure of the existing agricultural practices (Aw Hassan *et al*., 2010).

The current agro-ecological, environmental and socioeconomic conditions pose a major challenge to increase production and to ensure food security without further degrading the capacity of the resource base. The scale and the type of the challenge may vary in different parts of the region depending upon the power of these prevailing conditions that determines the potential of agricultural production and its sustainability. Gloomy predictions on the impact of population increase, climate change and unsustainable resource management indicate that the constraints on land and feed supply will become increasingly evident in mixed crop-livestock and grazing systems in the region (World Bank, 2008). There is a general consensus that competition for grains between humans and livestock, diminishing capacity of rangelands and trade-offs between crop stubbles for animal feed, soil fertility and biofuels are likely to increase the pressure on livestock production in both high and low input systems (Ben Salem and Smith, 2008; Correal *et al*., 2006; Aw Hassan *et al*., 2010; Smith *et al*., 2013).

Given these worsening constraints on the agricultural resources and the unrelenting pressure on land use, substantial attention has been drawn to improving and sustaining the productivity of crop and animal production (Lal, 2002). In the context of the Mediterranean region, the concept of sustainability has to be considered as a function of whole production system and highly associated with appropriate management of rangelands and inclusion of forage legumes in rotation with cereal crops (Ryan *et al*., 2008; Aw Hassan *et al*., 2010; Ates *et al*., 2013). Forage based feeding can decrease the cost of animal production and reduce the pressure on degraded rangelands (Rihawi *et al*., 2010; Ates and Louhaichi, 2012). However, the area dedicated to forage production has generally been declining as the area of annual cropping of wheat and barley required

for human consumption and feed for livestock has increased, thereby downgrading the importance of forages at the expense of efficient livestock and sustainable crop productions (Ghassali *et al*., 1999; Ryan *et al*., 2008).

Despite the inherent fragility of Mediterranean ecosystems and deep-rooted challenges concerning the crop-livestock farming in the region, crop-livestock production can be improved and managed sustainably with appropriate practices (Stewart and Robinson, 1997; Ben Salem and Smith, 2008; Rihawi *et al*., 2010). This paper reports several examples of successful case studies in two sections that draw results together on the options for (i) ecological intensification of livestock production systems in the northern Mediterranean and (ii) increased sustainability and resilience in the southern Mediterranean.

II – Ecological intensification of livestock production systems in the northern Mediterranean

Ecological intensification of agricultural systems has been recently defined by Hochman (2013) as producing more food per unit resource use, while minimising the impact on the environment. In the case of livestock production systems, Dumont *et al*. (2013) suggested that for complying with both premises, sustainable systems should be based on: adopting management practices for improved animal health, decreasing both inputs and pollution, enhancing diversity within farming systems to strengthen their resilience and preserving biological diversity by adapting management practices. Notwithstanding, economic performance is the key to farm survival in the short term, and ultimately these practices will only be implemented if they are not detrimental to farmers' income, and especially if an economic benefit can be achieved (Swift *et al*., 2004), either directly or through stewardship payments. Recently, Firbank *et al*. (2013) demonstrated that such goals were achievable for British farms, which were able to increase both food production and ecosystem services, while receiving public payments through agri-environment schemes.

1. Matching livestock management to feed resources

Technically efficient and sustainable livestock systems need to match animal genotype and management to the available feed resources (Adams *et al*., 1996), in order to achieve the highest possible self-sufficiency, which is crucial for economic profitability and stability of farms (Ripoll-Bosch *et al*., in press). This may become even more important in the future if relations between inputs and productivity keep changing (along with resource availability and price), because it enables the system to cope with potential socio-economic and climate-induced hazards (Bernués *et al*., 2011). This can be achieved through adequate livestock feeding and reproductive management, ensuring that the available resources are enough to meet animal requirements throughout the production cycle.

The seasonality of forage availability is a common characteristic of most extensive systems, and consequently, livestock undergo a cycle of mobilization or accumulation of body reserves during the year. Knowledge of the factors affecting animal performance during the grazing season is needed to design the management calendar that best matches the animal needs to the availability of forage. This includes the choice of lambing/calving and weaning dates, and the provision of supplements when needed. For example, in cattle farming systems in dry Mediterranean mountain areas, Casasús *et al*. (2002) showed that cow gains on pasture were higher in autumn- than in spring-calving cows, which resulted in better reproductive performance (shorter postpartum anestrous interval (Sanz *et al*., 2004)) (Fig. 1). In addition, the use of forest pastures was optimally integrated into the autumn-calving system, with cows weaned at the end of the winter when they have low maintenance requirements and are better able to deliver nutrients obtained from spring pasture for the recovery of body reserves. This option can be further enhanced by the early weaning of calves born in late autumn (from 3 months of age), with no impairment of future calf per-

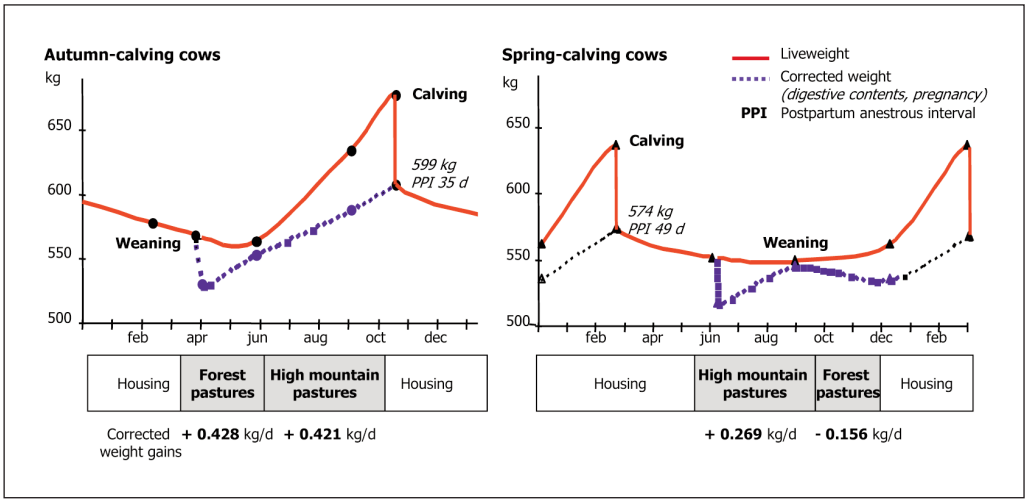

Fig. 1. Patterns of weight change through the annual cycle of autumn- and spring-calving cows in dry Mediterranean mountain areas [adapted from Casasús *et al*. (2002)].

formance (Blanco *et al.*, 2009). Spring-calving cows only used these pastures during the autumn, when pasture quality was low and only enough to maintain pregnancy and maternal weight.

Apart from enhancing production efficiency, optimizing economic performance of extensive livestock systems can also be achieved by increasing the added value of products. In fact, society is increasingly concerned about environmentally-friendly and ethical livestock production and product nutritional quality (Bernués *et al.*, 2012), and there is evidence that pasture or forage-based diets can improve environmental, ethical and human health outcomes, compared to feedlot systems (Entz *et al.*, 2002; French *et al.*, 2000). The choice of pathways to obtain these products will depend on aspects such as the available resources, their seasonal production, or the commercial product types preferred by consumers and retailers in a given area.

Several options have been tested for beef and lamb as alternatives to conventional, intensive finishing on concentrates (feedlots), comparing different forage resources that could be included in fattening diets. Lambs suckled on spring mountain pastures from birth to slaughter (3 months of age) had similar growth performance (Álvarez-Rodríguez *et al.*, 2007), better meat nutritional quality (Panea *et al.*, 2011) and lower production costs than their conventionally produced counterparts. Concerning beef production, heifer finishing diets based on maize silage reduced feeding costs per kg gain up to 13%, while weight gains, carcass and meat quality were similar to those of *ad libitum* concentrate-fed animals (Casasús *et al.*, 2012). Raising entire males on alfalfa pastures (+2 kg/d barley) yielded lower daily gains, similar carcasses but better economic margin (Blanco *et al.*, 2011) and meat nutritional quality (Blanco *et al.*, 2010) than conventional concentrate feeding. Different feeding systems have also been designed for the production of steers on mountain pastures (Blanco *et al.*, 2012), and the available results suggest that there is an opportunity to produce products of a superior quality from systems that include a high proportion of forages. There are even particular methods that allow retailers and consumers to trace animals raised in different production systems, based on the accumulation of pigments from forages in different animal samples (Blanco *et al.*, 2011). Both the distinctive quality and the good practices implemented in these ecologically intensified systems can set the grounds for the development of novel products led by consumer feed-back.

2. Using livestock as a tool for environmental management

The complex interactions between domestic animals and their habitat are not always synergetic, and there is increasing global concern about the detrimental effect that certain livestock production systems can have on the environment (Steinfeld *et al.*, 2006). But some practices can have positive impacts on environmental management and conservation. Such is the case for the northern Mediterranean agro pastoral farming systems, where the positive role of livestock in modulating the landscape is well recognized. However, these systems have gone through significant changes in recent decades, namely decreasing animal numbers and intensification of farming practices, with the concomitant abandonment of large extensively grazed areas (Bernués *et al.*, 2011). The latter is associated with pasture encroachment, and multiple implications on the ecologic values of these areas, such as the colonization of open spaces by a reduced number of competitive shrub species, loss of biodiversity and increased environmental risks.

In this context, adequately managed livestock grazing can control shrub encroachment, preserving the open structure of shrub and forest pastures in the Mediterranean (Landau *et al.*, 2000). However, its effectiveness may depend on the vegetation type and current succession status, as well as, on the actual pastoral management and on the socio-economic environment that surrounds livestock farming systems. In order to assess these factors, two similar studies analyzed the effect of livestock on the under-story vegetation in dry Mediterranean mountain forests under different conditions. Changes in herbaceous and shrub vegetation were studied in the presence or absence of livestock, firstly in a pine forest area grazed by cattle at a moderate stocking rate, steadily maintained for a long time. It was concluded that a moderate stocking rate succeeded in preventing shrub encroachment and the accumulation of low-quality, dead inflammable herbaceous vegetation, which were present in the grazing-excluded sites after 5 years (Casasús *et al.*, 2007). A second experiment was conducted in a natural park in the nearby, where the abandonment of extensive grazing of the natural pastures had been identified as a common pattern in many of the existing livestock farms (Riedel *et al.*, 2007). In this second study, sites grazed by sheep or cattle at very low stocking rates and excluded areas were compared. In contrast with the previous study, the observed stocking rates and management regimes were enough to maintain herbage resources but not to prevent shrub encroachment (Riedel *et al.*, 2013). Therefore, further reductions in grazing pressure should be avoided in these conditions, and specific supporting schemes were suggested to promote more intensive livestock utilization of these pastures.

Two study cases will be presented to illustrate how livestock can be used as a tool for landscape management, either by specifically designing new environmentally-targeted production systems, or by adapting management in conventional systems to attain these objectives.

Case 1: Based on studies suggesting that Mediterranean woodlands can sustain a viable beef herd throughout the year with moderate supplementation (Henkin *et al.*, 2005), a pilot study was conducted to check the feasibility of using beef cattle for environmental management in the aforementioned natural park. In a forest area without any pastoral use, a 25-cow Pirenaica beef herd was settled in a 464 ha range, and a management system adapted to natural pastures on offer through the year was designed (i.e. calving in October, weaning in March). The herd grazed forest pastures and dry grassland all year round, on cultivated crops in the winter and summer, and was offered forage supplementation in early lactation. A study of their diets and site preferences throughout the year indicated that the cattle devoted most of their grazing time to grasslands (49%), followed by forage crops (33%) and then browsing shrubs (18%). However, there were large seasonal differences in the selected diets, according both to nutritional requirements and the availability of the different forage resources. For example, fodder crops were highly grazed in the summer, while duration of grazing on browse was higher in the autumn and winter (up to 68% of the diet in January), when other resources were scarce (Casasús *et al.*, 2009). In the medium term, this consumption pattern prevented pasture shrub encroachment. The reproducibility of the

system was assessed, as cattle coped with the highly heterogeneous spatial and temporal pasture availability at the expense of large variations in body reserves throughout the year without impairing their technical performance. It was demonstrated that the system was able to provide an adequate economic output and an environmental goal at the same time.

Case 2: It is not uncommon for livestock farming systems to co-exist with other economic activities using, at least partly, the same resources, which may generate some synergies, but also competition. This is the case of some European mountain areas, where tourism and farming activities can interact (García-Martínez *et al.*, 2009), such as in ski stations containing alpine pastures used by livestock during the summer. A study conducted in the surroundings of a Pyrenean ski resort indicated that farming systems were similar to those of other neighbouring areas, except for some practices that reduced the farm workload in the winter to allow more time for tourism-related activities. Farmers were aware of the beneficial effect of the ski station on the valley and that, in turn, it profited from the ecosystem services provided by livestock grazing in summer (Casasús *et al.*, 2014). In an attempt to measure and enhance this mutual benefit, a study was conducted to analyze the spatial and temporal use of pasture by cattle in the ski station. The extent and intensity of grazing differed among vegetation types, due to their pastoral value and geographical location (Casasús *et al.*, 2013). Corrective measures were suggested where needed, involving either a different grazing management or the provision of infrastructures to ensure the most appropriate use of each vegetation type. The objective was to enable optimal livestock performance and avoid non-grazed stubble that would compromise the stability of the snowpack in the winter, strengthening the synergies between the tourism and agricultural activities.

III – Improving the sustainability and resilience of livestock production systems in the southern Mediterranean

In the region, rangelands represent the single largest land use type, covering over two-thirds of the total land area. Historically, the primary use of these rangelands was to provide forage for livestock and wildlife. In the southern part of the Mediterranean the majority of these grazing lands are either state or communally-owned. The significance of land ownership is important in the development of the policies and programs that are urgently needed to minimize the impacts of grazing land management and global climate change. Since the natural resources are in steady deterioration due to numerous anthropogenic and environmental factors, it is best to find alternative options which directly or indirectly minimize their decline and perhaps encourage their rehabilitation. Historically, in the south of the Mediterranean region, the effort to increase food and cash crops, arising from food security concerns, has caused conversion of large areas of rangelands to low input and low output crop production (Dixon *et al*., 2001; Nefzaoui, 2004). A viable strategy to reduce the pressure on the rangelands and overcome widespread feed shortages is to encourage fodder production through including forage legumes into rotations with cereal crops. Intensification of forage production will help farmers grow greater amounts of fodder for the livestock at lower costs and help meet the feed gap.

1. Agro-forestry for sustainable crop-livestock systems in drylands: alley cropping

Alley cropping, also known as intercropping, is an agroforestry system where rows of crops are cultivated alongside rows of trees or shrubs. Alley cropping with barley/saltbush (*Atriplex halimus*) is a common practice in the semi-arid southern Mediterranean region (Ben Salem, 2010). Diversifying the production systems has several benefits that are expressed on various space and time scales, from a short-term increase in crop yield and quality, to longer term agro-ecosystem sustainability, including societal and ecological benefits (Faravani *et al*., 2010).

Generally, forage species are chosen to meet deficiencies in the grazing system based on natural vegetation. The major deficiency in rangeland-based systems is usually the ability of the grazing land to provide either enough quantity or quality of feed to meet the productive needs of the grazing animal. Thus, the selection of species must be according to the objective of the intercropping systems, so that the different species occupy different niches in ecological time and space. In the south of the Mediterranean basin, several native and introduced species have been evaluated. Of particular benefit is the Mediterranean saltbush (*Atriplex halimus*) which alleviates feed shortages that occur during fall and during periods of drought. Alley cropping of barley and Mediterranean saltbush provides not only yield advantages for the barley, but also extra feed from the saltbush for the livestock (Ghassali *et al*., 2011). Alley cropping provides an opportunity to carry significant amounts of feed *in situ* into a period of deficit. However, the integration of these shrub species into existing agronomic practices and grazing systems may prove problematic as constraints such as social acceptance and the long period of establishment (requiring no grazing during the first two years) can significantly reduce the value of the extra dry matter produced leading to more moderate improvements in the system production.

2. Cactus as a multi-purpose species

Opuntia ficus-indica (L.) Mill. (OFI) is a xerophytic cactus species, widely cultivated in arid and semi-arid regions worldwide. OFI have developed phenological, physiological and structural adaptations for growth and survival in arid environments where severe water stress hinders the survival of other plant species. Among these adaptations, the asynchronous reproduction and Crassulacean Acid Metabolism (CAM) metabolism of cacti, which combined with structural adaptations such as succulence, allow them to continue the assimilation of carbon dioxide during long periods of drought reaching acceptable productivity levels even in years of severe drought. Their root characteristics which help avoid wind and water erosion, encourage their growth in degraded areas. The establishment of sustainable production systems based on cactus may contribute to the food security of communities in agriculturally marginalized areas and may led to reductions in soil degradation. Cacti are some of the best plants for the rehabilitation of degraded arid and semi-arid areas because they resist scarce and erratic rainfall and high temperatures and provide valuable animal feed (Nefzaoui *et al*., 2013). The reasons behind the diffusion of cacti include:

- simple cultivation practices required to grow the crop,
- rapid establishment soon after the introduction in a new area,
- ability to grow in harsh conditions characterized by high temperature, lack of water and infertile soils,
- generation of extra income from the much valued fruits, and
- use of cactus pads in human diets and as fodder for the livestock.

Cactus forage has high palatability and digestibility, and reduces the water requirements of animals. However, OFI pads have low crude protein (20 to 50 g/kg DM) and low crude fiber (80 to 150 g/kg DM) contents, and they have high water (800 to 900 g/kg fresh weight) and ash (150 to 250 g/kg DM) contents (Nefzaoui and Ben Salem, 2002). They are rich in readily available carbohydrates and vitamin A, but need to be supplemented with nitrogen. OFI is very useful and cost effective supplement for other poor quality diets, such as for raising sheep and goats on rangelands. The intake of straw from cereal crop residues increases significantly with the increase in cactus in the diet for sheep and goats (Nefzaoui *et al*., 1993). Water scarcity depresses feed intake, digestion, and weight gains of sheep and goats, and therefore, supplying livestock with water during summer and drought periods is crucial in hot arid regions. Therefore, the high water content of cactus is a solution for animal rearing in dry areas. In fact, animals given abundant supplies of cactus cladodes require little or no additional water (Nefzaoui and Ben Salem, 2002) and consume considerably less energy to reach water points.

3. Rangeland rehabilitation using "landscape depressions"

Landscape depressions are broad, often dry basins, or *wadis* (valleys) and gentle landscape lowlands that exhibit localized and unique edaphic and hydrologic properties and elevated vegetation productivity.

These lowlands have the potential to play an important role in the sustainable intensification and diversification of pastoral production and are a favourable environment for biodiversity conservation. This is primarily due to their specific ability to accumulate soil and nutrient deposits throughout the soil profile. These areas present an ideal habitat for production of food (eg. dual purpose cereals) and feed (eg. fodder shrubs) crops. Despite this potential, the current sustainable use of lowlands in the arid and semi-arid rangeland areas is still limited. This is mainly due to the continuous heavy grazing and aggressive agricultural activities (continuous barley cultivation without rotation) which resulted in excessive ecological degradation within these sensitive environments.

A recent study focusing on sustainable development of lowlands demonstrate that if these resources are managed properly (through rotational grazing and allowed to recover without being cultivated), they can provide a valuable source of feed for livestock, especially during the dry season when resources are often limited while preserving the natural resource base. When compared to the farmer practices (continuous grazing), versus improved grazing systems (i.e. rotational grazing), the results were astonishing. The productivity of the protected lowland sites in northern Syria averaged > 2 t/ha/y (Figure 2) and plants density was 28 folds higher in protected compared to the continuously grazed landscape areas (Figure 3). Plant diversity was also higher than that of the continuously grazed depressions (Figure 4) which were colonized and dominated by the invasive and unpalatable species *Peganum harmala* (Figure 2) (Louhaichi *et al*., 2012).

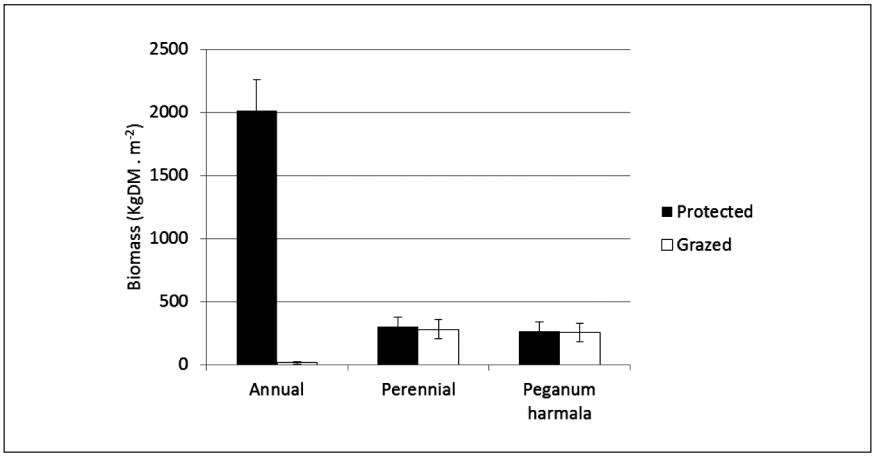

Fig. 2. Biomass production (g DM/m^2) in protected site (light or no grazing for two consecutive years) compared to continuously grazed site. Aleppo Steppe, Syria.

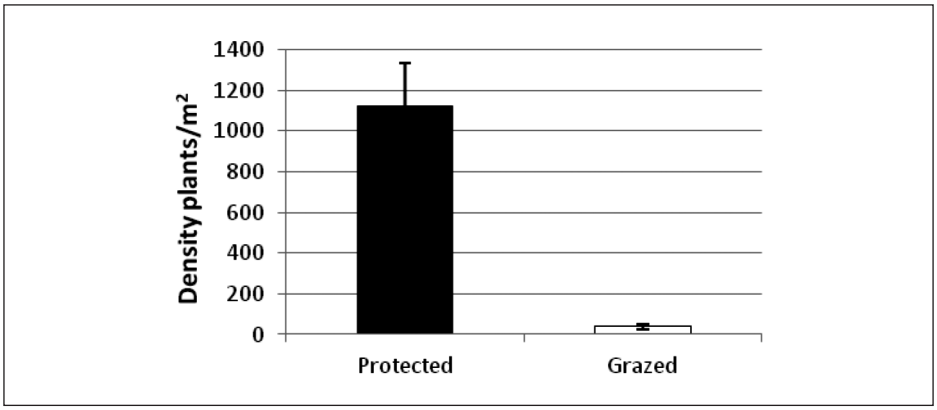

Fig. 3. Differences in density (number of plants m^2) in protected site (light or no grazing for two consecutive years) compared to continuously grazed site. Aleppo Steppe, Syria.

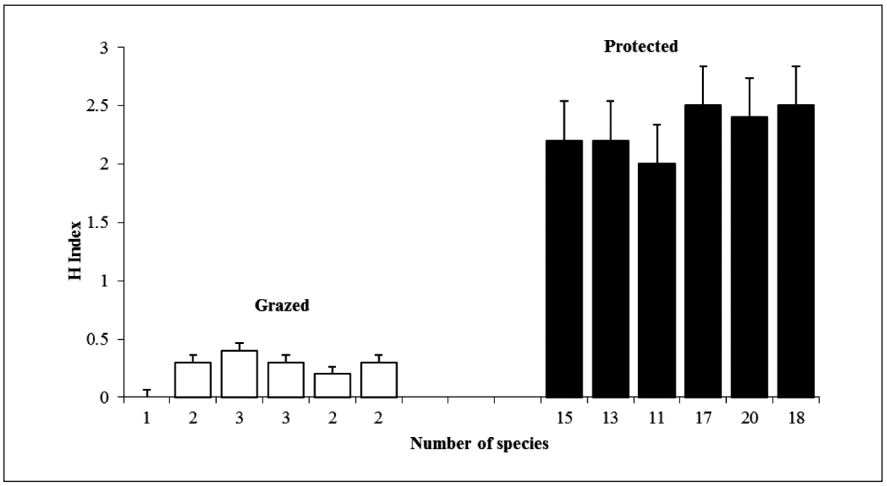

Fig. 4. Shannon diversity index (*H index*) for protected site (light or no grazing for two consecutive years) compared to continuously grazed site. Aleppo Steppe, Syria.

4. Reviving extensive grazing systems

In the Mediterranean area, the livelihood of pastoral and agro-pastoral people depends largely upon the rangelands which are the major feed source for their animals (Louhaichi and Tastad, 2010). Pastoralists, by definition, derive most of their livelihood from raising livestock on natural forages or crop residues, rather than on specifically cultivated and stored fodder or fenced pastures (Sanford, 1983). Pastoral communities have developed traditional knowledge of animal husbandry and natural resource management and this knowledge has allowed them to endure periodic severe droughts on their communally-managed rangelands. In fact, livestock mobility in search of better fodder and water used to be a common practice in the southern and eastern Mediterranean regions. This is mainly due to restrictions imposed by local government, conversion

of best rangeland areas to cropland (expansion of cultivation) and also the impact of globalisation on pastoral way of life. The degree of mobility depended on flock/ herd size, and the location of the family or village, as well as the amount of fodder produced in a given year.

The basic management problem for most pastoralists is that there is rarely enough grazing land and water at one location to support the pastoral community. Many factors have resulted in increased pressure on rangeland vegetation leading to widespread rangeland degradation: difficulties in accessing remote places, feeds subsidized by governments (eg. barley grain), barley cropping expanding onto rangelands, recurrent drought, failure to control stock numbers in the pastoral areas, and major shifts in attitudes of pastoralists reflected in increasing interest in educating their children and benefiting from social services provided in towns and villages. Although there are clearly social and ecological challenges for pastoral systems, there are also opportunities to increase productivity and sustainability, while reducing vulnerability to future changes in climate, land use, political and economic factors. Wright (2014) and Louhaichi (2014) highlighted key recommendations to sustain and promote the future of pastoralism in the world's drylands through adaptive measures including:

- Defending livestock corridors to maintain mobility.
- Building infrastructure such as roads, markets, and quarantine stations.
- Developing strategically placed water points for livestock watering to open up underutilized areas for grazing.
- Dissemination of near real-time information about the condition and abundance of forage resources and the availability of crop aftermath/fallow fields would facilitate the migration process and increase efficiencies.
- Developing systems for identification and traceability of livestock.
- Improving animal health care and veterinary services.

IV – Conclusions

Despite the current challenges facing agro-pastoral production systems and the changing climatic conditions of southern and northern Mediterranean regions, ecological intensification and increased resilience can be attained through appropriate and adaptive management practices. Forage legumes will continue to play significant role in sustainable crop-livestock production systems of the Mediterranean region. Introduction of shrubs and cactus as a multi-purpose species in alley cropping system in natural lowlands (wadis) in southern areas could help agro pastoralists better manage livestock feeding throughout the year, improve the natural resources and maximize their net income. More targeted rangeland rehabilitation activities, in particular the improvement of the "landscape depressions", may provide more rapid solutions for feed shortages. The adjustment of flock management to successfully match local environmental and feeding conditions with livestock requirements may improve the efficiency of agro-pastoral production systems. Livestock as a tool of managing the environment may help improving the productivity of fodder resources and their seasonal availabilities in northern Mediterranean areas.

Acknowledgments

The authors would like to thank FAO-CHIEAM Sub network, ICARDA, OFID, CITA, INIA and the CGIAR Research Program (CRP) dryland Systems for their support and funding. We also acknowledge Stephen Loss and Harun Cicek for revising the paper and Celine Aubert for the assistance in French translation.

References

Adams D.C., Clark R.T., Klopfenstein T.J. and Volesky,J.D., 1996. Matching the cow with forage resources. *Rangelands* 18, p. 57-62.

Álvarez-Rodríguez J., Sanz A., Delfa R., Revilla R. and Joy M., 2007. Performance and grazing behaviour of Churra Tensina sheep stocked under different management systems during lactation on Spanish mountain pastures. *Livestock Science* 107, p. 152-161.

Ates S. Feindel D., El Moneim A., Ryan J., 2013. Annual forage legumes in dryland agricultural systems of the West Asia and North Africa Regions: research achievements and future perspective. *Grass & Forage Science*, 69: 17-31.

Ates S., Louhaichi M., 2012. Reflections on agro-pastoralists in the WANA region: challenges and future priorities. In 14th Meeting of the FAO-CIHEAM Subnetwork on Mediterranean Pastures and Fodder Crops "New Approaches for Grassland Research in a Context of Climatic and Socio-Economic Changes". *Options Méditerranéennes,Series A: Mediterranean Seminars,* No: 102, p. 511-516.

Aw Hassan A., Shomo F. and Iniguez L., 2010. Trends in small ruminant meat production–consumption gaps in West Asia and North Africa Implications for intra-regional trade. *Outlook on Agriculture* 39, p. 41-47.

Ben Salem H., 2010. Nutritional management to improve sheep and goat performances in semiarid regions. R*evista Brasileira de Zootecnia* 39: 337-347.

Ben Salem H, Smith T., 2008. Feeding strategies to increase small ruminant production in dry environments. S*mall Ruminant Research* 77, p. 174-194

Ben Salem H., Nefzaoui A., Abdouli H. and Orskov E.R., 1996. Effect of increasing level of spineless cactus (*Opuntia ficus indica* var. inermis) on intake and digestion by sheep given straw based diets. *Animal Science,* 62: 293-299.

Bernués A., Ruiz R., Olaizola A., Villalba D. and Casasús I., 2011. Sustainability of pasture-based livestock farming systems in the European Mediterranean context: Synergies and trade-offs. *Livestock Science* 139, p. 44-57.

Bernués A., Ripoll G. and Panea B., 2012. Consumer segmentation based on convenience orientation and attitudes towards quality attributes of lamb meat. *Food Quality and Preference* 26, p. 211-220.

Blanco M., Villalba D., Ripoll G., Sauerwein H. and Casasús, I., 2009. Effects of early weaning and breed on calf performance and carcass and meat quality in fall-born bull calves. *Livestock Science* 120, p. 103-115.

Blanco M., Casasús I., Ripoll G., Panea B., Albertí P. and Joy M., 2010. Lucerne grazing compared with concentrate-feeding slightly modifies carcase and meat quality of young bulls. *Meat Science* 84, p. 545-552.

Blanco M., Joy M., Ripoll G., Sauerwein H. and Casasús I., 2011. Grazing lucerne as fattening management for young bulls: technical and economic performance and diet authentication. *Animal* 5, p. 113-122.

Blanco M., Joy M., Panea B., Albert P., Ripoll G., Carrasco S., Revilla R. and Casasús I., 2012. Effects of the forage content of the winter diet on the growth performance and carcass quality of steers finished on mountain pasture with a barley supplement. *Animal Production Science* 52, p. 823-831.

Casasús I., Sanz A., Villalba D., Ferrer R. and Revilla R., 2002. Factors affecting animal performance during the grazing season in a mountain cattle production system. *Journal of Animal Science* 80, p. 1638-1651.

Casasús I., Bernués A., Sanz A., Villalba D., Riedel J.L. and Revilla R., 2007. Vegetation dynamics in Mediterranean forest pastures as affected by beef cattle grazing. *Agriculture, Ecosystems & Environment* 121, p. 365-370.

Casasús I., Blanco M. and Revilla R., 2009. Activity patterns and diet selection of beef cows on mediterranean mountain forest pastures. In: (Eds), *15th Meeting of the FAO-CIHEAM Mountain Pastures Network "Integrated research for the sustainability of mountain pastures"*. Les Diablerets (Switzerland), p. 99-100.

Casasús I., Ripoll G. and Albertí P., 2012. Inclusión de silo de maíz en las dietas de cebo de terneras: rendimientos técnico-económicos y calidad de la canal y de la carne. *Información Técnica Económica Agraria* 108, p. 191-206.

Casasús I., Rodríguez-Sánchez J.A., Sanz A., Ferrer C., Reiné R. and Barrantes O., 2013. Use of pastures by cattle in a Pyrenean ski station: Diagnosis and recommendations for improved preservation of natural resources and snow condition. In: Lombardi G., M.E., Gorlier A., Lussig G., Lonati M., Pittarello M., Probo M. (Eds), *17th Meeting of the FAO-CIHEAM Mountain Pastures Network "Pastoralism and ecosystem conservation"*. Trivero (Italia), p. 103-107.

Casasús I., Rodríguez-Sánchez J.A. and Sanz A., 2014. Diagnóstico de situación y perspectivas de futuro de la ganadería en el entorno de una estación de esquí del Pirineo. *Información Técnica Económica Agraria* 110, p. 71-88.

Correal E., Robledo A., Rios S. & Rivera D., 2006. Mediterranean dryland mixed sheep-cereal systems. *Grassland Science in Europe* 11, p. 14-26.

Entz M.H., Baron V.S., Carr P.M., Meyer D.W., Smith Jr. S.R., and McCaughey W.P., 2002. Potential of forages to diversify cropping systems in the northern Great Plains. *Agronomy Journal* 94, p. 240-250.

Dixon J., Gulliver A. and Gibbon D., 2001. Dixon J., Gulliver A. and Gibbon D., 2001. Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO and World Bank, 412 p. in a Changing World. FAO and World Bank, 412 p.

Dumont B., Fortun-Lamothe L., Jouven M., Thomas M. and Tichit M., 2013. Prospects from agroecology and industrial ecology for animal production in the 21st century. *Animal* 7, p. 1028-1043.

Faravani M., Behshtii A. and Khanizadeh. H., 2010. Yield performance of black zira and saffron intercropping system in different plant densities and replacement series. *International Journal of Science and Nature* 1: 195-197.

Firbank L.G., Elliott J., Drake B., Cao Y. and Gooday, R., 2013. Evidence of sustainable intensification among British farms. *Agriculture Ecosystems & Environment* 173, p. 58-65.

French, P., Stanton, C., Lawless, F., O'Riordan, E.G., Monahan, F.J., Caffrey, P.J. and Moloney, A.P., 2000. Fatty acid composition, including conjugated linoleic acid, of intramuscular fat from steers offered grazed grass, grass silage, or concentrate-based diets. *Journal of Animal Science* 78, p. 2849-2855.

García-Martínez A., Olaizola A. and Bernués, A., 2009. Trajectories of evolution and drivers of change in European mountain cattle farming systems. *Animal* 3, p. 152-165.

Ghassali F., Cocks P.S., Osman A.E., Gintzburger G., Christiansen S., Semaan A. and Leybourne M., 1999. Rehabilitation of degraded grasslands in north Syria: use of farmer participatory research to encourage the sowing of annual pasture legumes. *Experimental Agriculture*, 35, p. 489-506.

Ghassali F., Osman A. E., Singh M., Norton B., Louhaichi M. and Tiedeman J., 2011. Potential use of Mediterranean saltbush (Atriplex halimus L.) in alley cropping in the low rainfall-cropping zone of northwest Syria. *Range Mgmt. & Agroforestry* 32(1): 1-8.

Faravani M., Behshtii A. and Khanizadeh. H., 2010. Yield performance of black zira and saffron intercropping system in different plant densities and replacement series. *International Journal of Science and Nature* 1: 195-197.

Harlan J.R., 1992. *'Crops and Man,* 2nd ed. p. 284. American Society of Agronomy. Crop Sci. Soc. Am., Madison, WI, USA.

Henkin Z., Gutman M., Aharon H., Perevolotsky A., Ungar E.D. and Seligman N.G., 2005. Suitability of Mediterranean oak woodland for beef herd husbandry. *Agriculture, Ecosystems and Environment* 109, p. 255-261.

Hochman Z., Carberry P.S., Robertson M.J., Gaydon D.S., Bell L.W. and McIntosh P.C., 2013. Prospects for ecological intensification of Australian agriculture. *European Journal of Agronomy* 44, p. 109-123.

Hopfenberg R., Pimentel D., 2001. Human population numbers as a function of food supplies. *Environment, Development and Sustainability* 3, p. 1-15.

Kassam A.H., 1991. Climate, soil and land resources in NAWA. *Plant and Soil*, 58, p. 1-29.

Lal R., 2002. Carbon sequestration in the dryland ecosystems of West Asia and North Africa. *Land Degradation and Development*, 13, p. 45-59.

Landau S., Perevolotsky A., Bonfil D., Barkai D., Silanikove N., 2000. Utilization of low quality resources by small ruminants in Mediterranean agro-pastoral systems: the case of browse and aftermath cereal stubble. *Livestock Production Science* 64, p. 39-49

Le Houerou H.N., 2000. Restoration and Rehabilitation of Arid and Semi-arid Mediterranean ecosystems in North Africa and West Asia: A review. In: *Arid Soil Research and Rehabilitatio*n, 14, p. 3-14.

Louhaichi M., 2014. Understanding livestock based livelihoods to reduce pastoral vulnerability in Rajasthan, India. In: Symposium of the The 67th Annual Meeting of the Society for Range Management entitled "Unsettled Futures for Subsistence Pastoralism: Adapting Livestock Systems in the Face of Changing Climate and Land Use". Orlando, FL.

Louhaichi M., Ghassali F. Salkini A.K. and Petersen S.L., 2012. Effect of sheep grazing on rangeland plant communities: Case study of landscape depressions within Syrian arid steppes. *Journal of Arid Environments* 79: 101-106.

Louhaichi M., Tastad A., 2010. The Syrian steppe: past trends, current status, and future priorities. *Rangelands* 32, p. 2-7.

Nefzaoui A., Louhaichi M., Ben Salem H. 2013. Cactus as a tool to mitigate drought and to combat desertification. Desert Technology 11th International Conference. 19-22 November 2013, San Antonio, TX, USA.

Nefzaoui A., 2004. Rangeland improvement and management options in the arid environment of Central and South Tunisia. In: Ben Salem H., Nefzaoui A. and Morand-Fehr P. (eds). Nutrition and feeding strategies of sheep and goats under harsh climates. In: O*ptions Méditerranéennes, Série A,* 59, p. 15-25.

Nefzaoui A. and Ben Salem H. 2002. Forage, fodder, and animal nutrition. Chapter 12. In: P.S. Nobel (ed.), *Cacti, biology and uses*. University of California Press, 280 p.

Panea B., Carrasco S., Ripoll G. and Joy M., 2011. Diversification of feeding systems for light lambs: sensory characteristics and chemical composition of meat. *Spanish Journal of Agricultural Research* 9, p. 74-85.

Pretty J.N., 1995. *Regenerating agriculture: policies and practice for sustainability and self-reliance*. Joseph Henry Press.

Rihawi S., Iniguez L., Knaus W.F., Zaklouta M., Wurzinger M., Soelkner J., *et al*., 2010. Fattening performance of lambs of different Awassi genotypes fed under cost-reducing diets and contrasting housing conditions. *Journal of Small Ruminant Research*, 94, p. 38-44.

Riedel J.L., Casasús I. and Bernués A., 2007. Sheep farming intensification and utilization of natural resources in a Mediterranean pastoral agro-ecosystem. *Livestock Science* 111, p. 153-163.

Riedel J.L., Bernués A. and Casasús I., 2013. Livestock grazing impacts on herbage and shrub dynamics in a Mediterranean Natural Park. *Rangeland Ecology & Management* 66, p. 224-233.

Ripoll-Bosch R., Joy M. and Bernués A., in press. Role of self-sufficiency, productivity and diversification on the economic sustainability of farming systems with autochthonous sheep breeds in less favoured areas in Southern Europe. *Animal* FirstView, 1-9.

Ryan J., Singh M. and Pala M. 2008. Long-term cereal-based rotation trials in the Mediterranean region. Implications for cropping sustainability. *Advances in Agronomy* 97, p. 276-324.

Sanford S. 1983. Management of pastoral development in the third world. John Wiley a Sons Ltd, 330 p.

Sanz A., Bernués A., Villalba D., Casasús I. and Revilla R., 2004. Influence of management and nutrition on postpartum interval in Brown Swiss and Pirenaica cows. *Livestock Production Science* 86, p. 179-191.

Smith J., Tarawali S., Grace, D. and Sones K. 2013 Feeding the World in 2050: trade-offs, synergies and tough choices for the livestock sector. Proceedings of 22nd International Grassland Congress, p. 1-9, Sydney, 15-19 September 2013.

Steinfeld H., Gerber P., Wassenaar T., Castel V., Rosales M. and Haan C.D., 2006. *Livestock's long shadow: environmental issues and options*. FAO Publishing, Roma.

Swift M.J., Izac A.M.N. and van Noordwijk M., 2004. Biodiversity and ecosystem services in agricultural landscapes-are we asking the right questions? *Agriculture, Ecosystems & Environment* 104, p. 113-134.

World Bank, 2008. World Development Report 2008. The World Bank, Washington D.C., USA.

Wright I., 2014. Closing Address: Pastoralism: From Vulnerability to Resilience. In: Symposium of the The 67th Annual Meeting of the Society for Range Management entitled "Unsettled Futures for Subsistence Pastoralism: Adapting Livestock Systems in the Face of Changing Climate and Land Use". Orlando, FL.