From landscape to fork: value chains based on ecosystem services

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From landscape to fork: value chains based on ecosystem services

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Abstract. We present a comprehensive conceptual framework for novel food value chains linking agricultural landscapes (grazing agroecosystems) with consumers and citizens through the ecosystem service concept. The framework integrates three main components that can be affected by markets, policies and other general drivers. The first component is the grazing agroecosystem that provides a wide variety of ecosystem services to society and farmers in particular (e.g. forage). These ecosystem services can be quantified in biophysical terms, but also from a socio-cultural and economic perspective. The second component is the farm that benefits from certain provisioning and non-provisioning (regulating, supporting and cultural) services while at the same time affects the agroecosystem with particular agricultural practices. The farm provides specific quality products that could be linked to the particular landscape or agroecosystem where is located. The third component is the consumer, including diverse quality perceptions and demands for food products, and the societal demands for public goods (non-provisioning ecosystems services) delivered by multifunctional agriculture (e.g. cultural landscape), including "ethical" concerns about the model of agriculture and the food chain. There are driving forces that influence the three components and the interrelations among them. On the one hand, decision makers are responsible for establishing the legal framework and policies in terms of nature protection, agro-environmental schemes for land management, and market, food quality and safety regulations. On the other hand, more general drivers such as climate, markets of inputs and outputs, or consumer's lifestyles and trends, can also affect the agroecosystems, the farms and the consumer demands. We operationalize the framework with empirical data of sheep farming systems in Mediterranean Spain.

Keywords. Sheep farming systems – Public goods – Valuation – Food quality.

Depuis le paysage jusqu'à l'assiette: chaînes de valeur basées sur les services écosystémiques

Résumé. *On présente un cadre conceptuel pour de nouvelles chaînes de valeur mettant en relation le paysage agricole (écosystème agro-pastoral) avec les consommateurs et la société à travers le concept service écosystémique. Le cadre proposé comprend trois principaux éléments qui sont influencés par les marchés, les politiques et d'autres facteurs clés. Le premier élément est l'écosystème agro-pastoral qui fournit une grande variété de services écosystémiques à la société et aux éleveurs, en particulier (par exemple fourrage). Ces services écosystémiques peuvent être quantifiés sous le point de vue biophysique, mais aussi sous une perspective socioculturelle et économique. Le deuxième élément est l'exploitation agricole qui bénéficie de certains services d'approvisionnement et de non-approvisionnement (de régulation, culturels et de soutien) et les agro-écosystèmes sont à leur tour affectés par les exploitations, notamment, avec les pratiques agricoles. L'exploitation fournit des produits de qualité spécifique qui peuvent être lieés au paysage où celle-ci est située. Le troisième élément est le consommateur, en considérant la diversité de la qualité perçue et des demandes par rapport à la production d'aliments, et les demandes de la société pour les biens publics fournis par l'agriculture multifonctionnelle (par exemple, le paysage culturel) et son souci du modèle d'agriculture et des filières. Il y a des forces motrices qui ont des effets sur les trois éléments et leurs interrelations. D'un côté, les décideurs sont responsables de l'établissement du cadre légal et des politiques pour protéger la nature, des mesures agri-environnement pour gérer la terre, et des régulations sur les marchés et la qualité et sécurité des aliments. D'un autre côté, le climat, les changements dans les modes de vie et tendances des consommateurs peuvent aussi influer sur les agroécosystèmes, les exploitations et les demandes des consommateurs. Cette approche est mise en œuvre avec des données empiriques sur des systèmes ovins méditerranéens (Espagne).*

Mots-clés. *Système d'exploitation ovine – Biens publics – Évaluation – Qualité des aliments.*

I – Introduction

Market segmentation and consumer-led product development constitute key strategies for grazing livestock systems to move into high-value food chains. For these strategies to be successful, the farmers and other industry stakeholders should demonstrate and deliver not only higher *intrinsic* quality attributes of products, but also a number of *extrinsic* quality attributes; those referring to the system of production rather than to the product itself (Bernués *et al.*, 2006). According to the consumer information context (availability of quality cues before and after purchase), attributes may be search, experience, or credence in nature, i.e. the consumer can learn about the quality level prior to purchase, after purchase and use or not at all, respectively (Nelson, 1970). The extrinsic quality attributes, mostly credence attributes that cannot be ascertained even after use of the product, are increasingly demanded by the society in response to ethical and safety concerns (Grunert, 2006). Bosmans *et al.* (2005) state that credence attributes such as landscape preservation are essential in order to value high quality meat. Among the extrinsic quality attributes, the type of animal feeding, the origin of the product, and the system of production in terms of animal welfare and the relationships with the environment, are predominant in the perception of quality meat in Europe (Bernués *et al.*, 2003). These authors developed a conceptual model of supply, perception and demand of food quality that revolved around the supply of food products by the industry (including farmers) and the quality perception process by the consumers. In this paper, we expand this farm-to-table approach to a *landscape-to-fork* framework that includes the agroecosystem where farms operate and the concerns of society about the model of agriculture and the food chain. To link the different components of this framework, we use the concept of ecosystem services (ES) that focuses on the linkages between (agro)ecosystems and human well-being (Millennium Ecosystem Assessment, 2005).

II – Material and methods

The framework integrates three main components that are related through the ecosystem services concept. ES are all the contributions, direct and indirect, that people obtain from nature. ES are classified into four groups: *provisioning* ES are energy or material outputs such as meat, milk and fibre; *regulating* ES are biophysical processes such as climate regulation, flood prevention and water purification; *cultural* ES are recreational, aesthetic and spiritual benefits; and *supporting* ES, such as soil formation, photosynthesis or nutrient cycling, are the various processes that are necessary for the production of all the other ES (Rodríguez-Ortega *et al.*, 2014). The so-called non-provisioning ES (regulating, supporting and cultural ES) are mostly public (nonmarket) goods that constitute the essence of multifunctional agriculture.

The first component of our framework is the agricultural landscape, in our case the grazing agroecosystems, that provide a wide variety of ES to farmers in particular (e.g. forage) and society in general. However, many of these ES do not have market price and therefore are often ignored by agricultural policies, so producers are not encouraged to produce them. The second component is the farmer and his or her farm that benefits from provisioning and non-provisioning (regulating, supporting) services and affects the agroecosystem with particular agricultural practices. The farm provides specific quality products that can be linked to the particular agricultural landscape or agroecosystem in which it is located. The third component is the consumer, including diverse quality and safety perceptions about food production, and more generally, the societal demands for public goods (cultural ecosystems services) provided by multifunctional agriculture (e.g. landscape and recreation) and the “ethical” concerns in terms of model of agriculture and the food chain (Fig. 1). There are a number of driving forces that influence the three components and the interrelations among them. On the one hand, decision makers are responsible for establishing the legal framework and policies in terms of nature protection, agro-environmental schemes for land management, and market, food quality and safety regulations. On the other hand, more general drivers such as climate, markets of inputs and outputs, or consumer’s lifestyles and trends, can also affect the agroecosystems, the farms and the consumer/societal demands.

In the next section, we operationalize the framework for the case of sheep farming systems in a Mediterranean mountain region in Aragón, northeast Spain: the "Sierra y Cañones de Guara" Natural Park (SCGNP). The SCGNP constitutes a representative High Nature Value farmland (HNVf) area where livestock is still an important activity. Sheep farming is an important activity in the study area, with 106 farms and 34,709 heads in 2013. Most sheep farms can be considered as mixed sheep-crop systems, with cereals as the main cash crop and forage crops for animal production. Besides, they use temporary leased grazing areas (communal shrub grasslands, stubbles and fallows). These mixed systems are highly diverse in the distribution and management of land use, contributing to maintain biodiversity and increasing the adaptability of farms to changes in the environment (Olaizola *et al.*, 2015). However, only 53% of the total area of the Park was grazed by domestic animals, with an average stocking rate of only 0.15 Livestock Units (LU) per ha (in 92% of the grazed area stocking rate is lower than 0.25 LU/ha) (Riedel *et al.*, 2007). The SCGNP constitutes a Special Protection Area (EU Birds Directive) that includes 3 Sites of Community Importance (EU Habitats Directive). Originally created to protect scavengers and other birds of prey, the SCGNP attracts many visitors due to its rich geological (canyons, caves, etc.), cultural (prehistoric and megalithic art, traditional buildings, villages) and natural (endangered species, diversity of landscapes, birds of prey and scavengers, etc.) heritage. Four sustainability imbalances have been identified (Bernués *et al.*, 2005): low continuity of farming families; intensification of the management system; degradation of grazing resources (abandonment of remote/ marginal areas); and concentration of grazing in easy-to-work areas. As a consequence a general process of vegetation encroachment and landscape change is happening in many areas of the Park (Riedel *et al.*, 2013), jeopardizing the delivery of other ES.

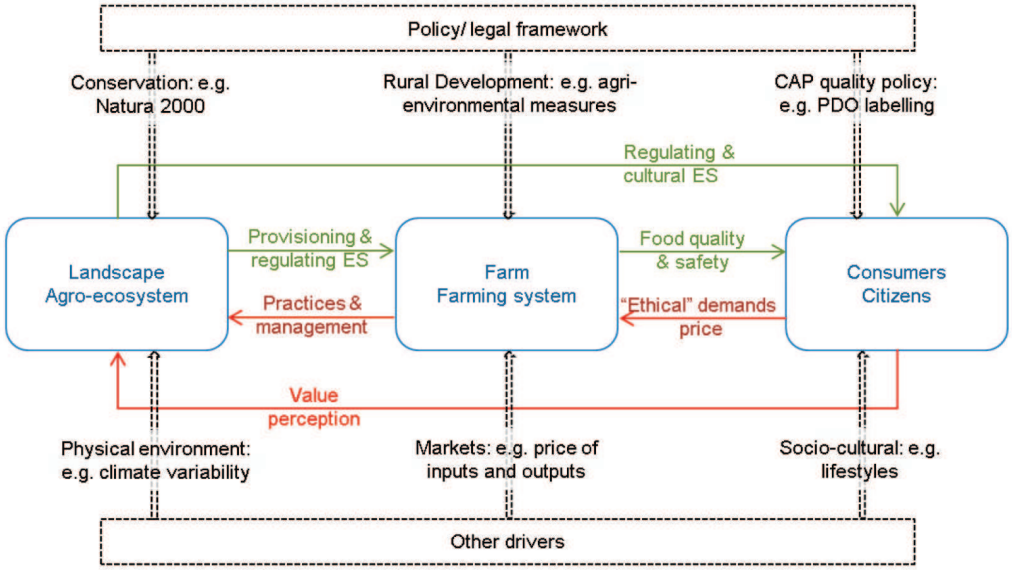

Fig. 1. From landscape to fork: value chains based on (agro) ecosystem services.

III – Results and discussion

1. Grazing agroecosystems provide multiple ecosystem services

Grazing agroecosystems, often located in High Nature Value farmland (HNVf) areas, are multifunctional, delivering multiple private and public goods to society, including the farming community. From the ES perspective, the provision of forage is widely recognized by farmers across different regions in Europe, however, other ES including soil stability and fertility, water quantity and quality, or conservation of botanical diversity are also important (Lamarque *et al.*, 2011). From a wider societal perspective, different studies have pointed out at several non-provisioning ES that are inextricably linked to grazing livestock farming systems and particular agricultural practices (Cooper *et al.*, 2009; Rodríguez-Ortega *et al.*, 2014). Among these, the most important ones are the conservation of the agricultural landscape (cultural ES), the preservation of biodiversity (supporting ES), and the prevention of environmental hazards (regulating ES), e.g. forest fires in Mediterranean areas. Climate regulation trough the storage and sequestration of carbon in grasslands is also a key regulating ES (Soussana *et al.*, 2004).

The number of studies aiming at quantify the relationships between grazing farming systems and ES from a biophysical perspective have raised considerable in Europe in the last years. These studies have focused mainly on biodiversity and landscape (Fig. 2) (Rodríguez-Ortega *et al.*, 2014). These authors also described the concrete land management and agricultural practices that influence the delivery of ES at different spatial levels: the region or landscape level (land-use changes), the farm and farming system level (general management), and the field or patch (concrete agricultural practices). Among the main issues identified, the intensification of farming systems and management regimes, the abandonment of certain practices or land uses (often linked to vegetation encroachment), the changes of land-use, and the grazing management (notably the stocking rate) were the most frequently studied.

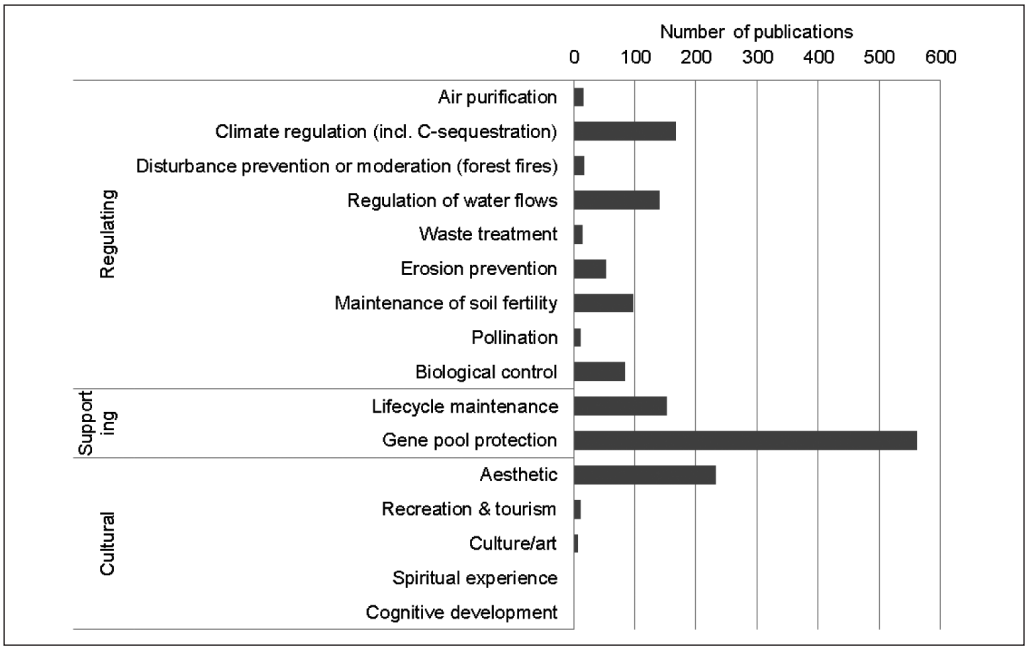

Fig. 2. Number of publications on ecosystem services delivered by grazing farming systems in Europe (biodiversity is included in the gene pool protection service). Source: Rodríguez-Ortega *et al.* (2014).

We illustrate the biophysical effect of grazing livestock on vegetation in the SCGNP in Fig. 3. Shrub encroachment, derived from the abandonment of extensive livestock farming and changes of land use, is a common problem in the Mediterranean mountain pastures of Europe, with direct effects on biodiversity and landscape quality (Riedel *et al.*, 2013). In their research, authors quantified the effects of livestock exclusion vs. grazing on the dynamics of shrub and herbaceous vegetation over a 5-yr period in six representative areas of the park. A sustained increase of the shrub population and biomass was observed throughout the study. Biomass accumulation was greater in non-grazed exclosures but it also happened in the grazed control areas. Authors concluded that with the current stocking rates and management regimes, grazing alone was not enough to prevent the shrub encroachment.

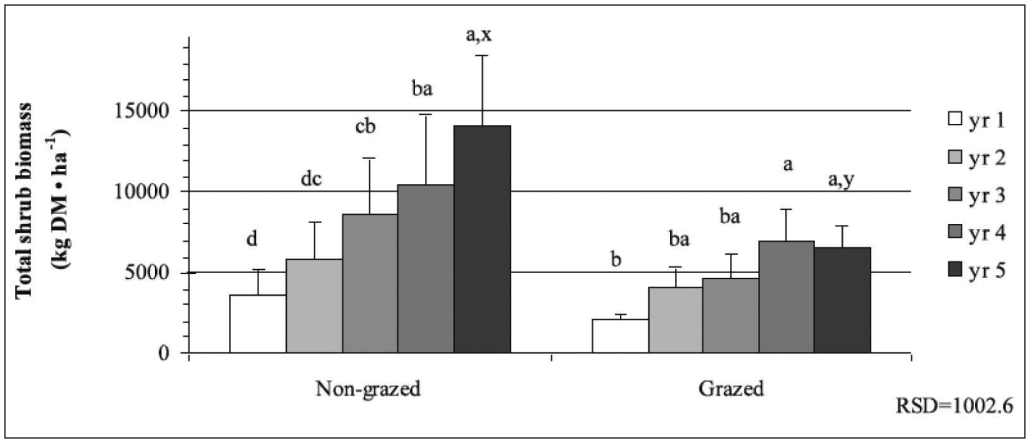

Fig. 3. Effect of time after the start of the experiment on aboveground total shrub biomass (kg DM ha^{-1}) in nongrazed and grazed areas. a, b, c, d: means within nongrazed or grazed areas lacking a common superscript letter differ among years (P,0.05). x, y: means within year lacking a common superscript letter differ among nongrazed and grazed areas (P,0.05). Vertical bars indicate the standard error of the mean. Source: Riedel *et al.* (2013).

2. Farmers, farms and agricultural practices

The farmer and his or her farm (in cooperation with other industry stakeholders) play a key role in the *landscape-to-fork* framework described in Fig. 1. The farm connects the agricultural landscape, or agroecosystem, with the consumers and the society in general. On the one hand, the farm takes advantage from provisioning ES (e.g. forage) and strongly depends on regulating and supporting ES such as climate regulation, soil fertility, water availability, etc. (described above), to produce food and other products for consumption. At this point, the farmer can try to pay attention to consumers' demands for high-value food products (organic, region of origin, environmental friendly, locally produced, directly marketed, etc.) that are often associated with higher quality and safety standards (Bernués *et al.*, 2003). In this sense, grazing livestock systems can have comparative advantages over industrialized production systems if they are able to demonstrate and deliver extrinsic credence quality attributes (explained below) that are related to the system of production (animal welfare, natural/ traditional way of production, animal feeding assurance, or protection of the environment) (Bernués *et al.*, 2006).

On the other hand, the farmer can implement different agricultural practices and management regimes to maximize the provision of food (for example, intensifying the production system) at the expense of the delivery of other ES, often increasing the production of externalities or ecosystem dis-services (Zhang *et al.*, 2007). Alternatively, the farmer can try to optimize the delivery of mul-

tiple ES, including provisioning and non-provisioning ES, i.e., carrying out multifunctional agriculture that delivers a number of public and private goods. The food industry could then "activate", through adequate marketing strategies, the right credence quality attributes on the private goods (e.g. meat) in response to consumers' beliefs and demands for public goods.

The widely described trade-offs between production of food and production of non-provisioning ES, as illustrated in the area of study by Olaizola *et al.* (2015), need to be interpreted within wider sustainability frameworks. Labour productivity of the farm (economic margin per labour unit) constitutes an essential indicator of economic sustainability of farming, however social issues, including labour and farm continuity issues, are also central to explain sustainability at the farm level (Ripoll-Bosch *et al.*, 2012). These two sustainability dimensions, economic and social, together with farm location, will determine the concrete practices and management regimes that the farmer implements.

Economically, grazing farming systems are characterized by a lower inherent productivity, due to the harsh environmental conditions, among other reasons. Due to the inappropriate valuation of non-provisioning ES, farmers have little incentive to provide them because they are not being paid to do so, and, in the absence of well-functioning markets, public intervention is needed to achieve a desirable level of provision in line with societal demands (Cooper *et al.*, 2009). Therefore, it is essential to estimate the economic value of ES provided by grazing agroecosystems (see section III.3). But merely stating the economic value of a given service or set of services does not create incentives to maintain them through appropriate agricultural practices. Agrienvironmental policies are needed to compensate farmers whose agroecosystem management provides ES to society, internalizing ES value into land management decisions (Zhang *et al.*, 2007).

Based on previous research and a bibliographical review (Rodríguez-Ortega *et al.*, 2014), we present an inventory of land use regimes and agricultural practices (with tentative indicators) that could be promoted to enhance the delivery of multiple ES in the SCGNP (Fig. 4).

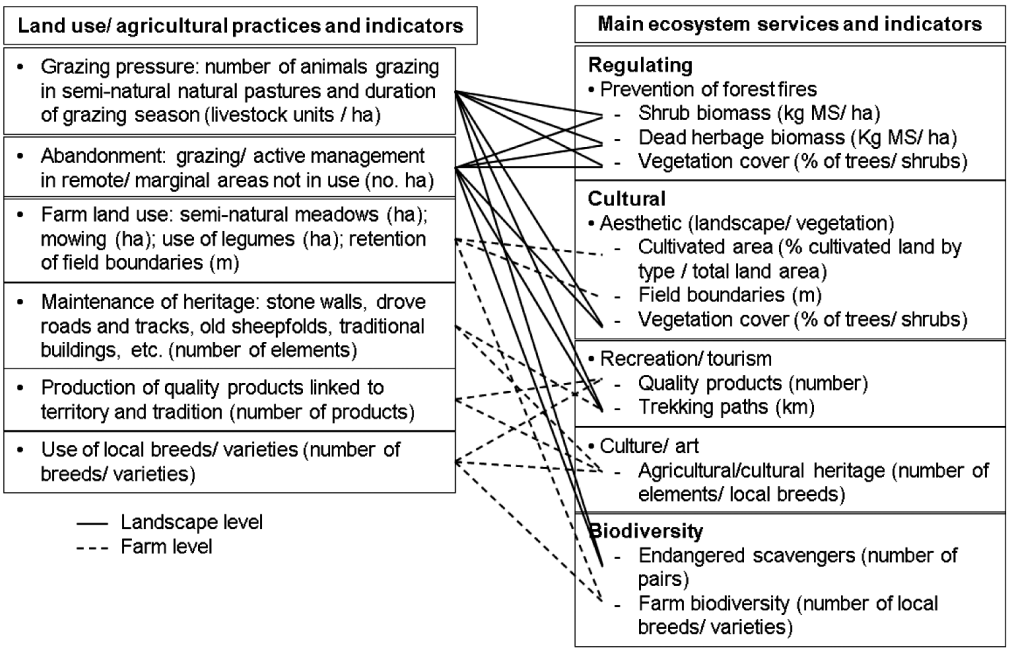

Fig. 4. Agricultural practices and land management regimes that have an influence on ES in the Sierra y Cañones de Guara Natural Park.

3. Consumers and societal demands

The third component of our framework is the consumer, and more generally the society at large. Consumers' demands for differentiated quality food products has been widely discussed in the literature (for example, Guerrero *et al.* (2009), Hersleth *et al.* (2012), Feldmann and Hamm (2015)). In meat, the raising importance of extrinsic quality attributes (related to health and safety concerns of consumers or the raising interest on personal "stories" linked to food and consumption experiences) and the concerns for the animals and the environment (credence attributes) constitute two of the main future trends with regard to meat consumption (Grunert, 2006). This author points out at a general trend of fragmentation and diversification trough marketing meat products based on extrinsic attributes that cover an increasing diversity of consumer lifestyles. This opens up an opportunity for extensive livestock farmers willing to move from the standard bulk production of meat to differentiated, value added products, capable of exploiting the possibilities of alternative ways of producing food in a way that adds to consumer well-being. Nevertheless, environmental differentiation can fail if it does not consider the multidimensional character of quality perception. Grolleau and Caswell (2006) pointed out that credibility of environmental label among consumers is influenced by the accompanying search and experience attributes (taste, satisfaction obtained, etc.).

However, people are not just consumers, but citizens. In Europe, society shows increasing concerns about the impacts of agricultural practice on the environment and supports a shift of agricultural policies towards the supply of public goods (mostly non-provisioning ES). As these ES do not have market price, they are difficult to value and often ignored when designing policies. Apart from the biophysical quantification of ES described in section III.1, we can value ES provided by grazing agroecosystems from the socio-cultural and economic points of view.

Taking as case study the SCGNP described above, Bernués *et al.* (2014) valued the socio-cultural perceptions of the relationships between mountain agriculture (grazing livestock farming systems) and the environment (Fig. 5). Globally, the more frequent ES mentioned during 5 focus groups discussions with farmers and other citizens were: aesthetic (landscape/ vegetation), provision of food (quality and safety of products), gene pool protection (biodiversity maintenance), lifecycle maintenance (nutrient cycling, photosynthesis), provision of raw materials (mainly forage and firewood), and disturbance prevention (forest fires). Other ES such as water purification/waste management (always attached to industrial livestock systems as opposed to grazing ones), soil fertility/erosion prevention, and other cultural ES such as spiritual experience, recreation and culture, were also important. The different ES, specially cultural ES, were discussed in bundles, and often linked to wider sustainability issues in terms of farm economic and social issues or the general socio-economic and policy context (Rodríguez-Ortega *et al.*, 2013).

In the same study, the authors were able to determine the ranking of importance of the most significant ES obtained in the socio-cultural valuation exercise (preservation of the agricultural landscape, conservation of biodiversity, provision of quality products linked to the territory and prevention of forest fires) and the Total Economic Value (sum of the willingness to pay for the different ES) in two representative population samples: local (residents in the SCGNP) and general (Aragón) (Fig. 6).

The authors were able to conclude that in Mediterranean conditions, the prevention of forest fires constituted the key ES delivered by grazing agroecosystems. Second in importance was the production of specific quality products linked to the territory, clearly recognized as a distinctive provisioning service of HNVf. Cultural ES derived from mountain agriculture (agricultural landscape) had great importance for society, not only because of their aesthetic and recreational value but also for educational, cultural and spiritual reasons. Supporting services, in this study represented by biodiversity, were also clearly recognized by farmers and other citizens.

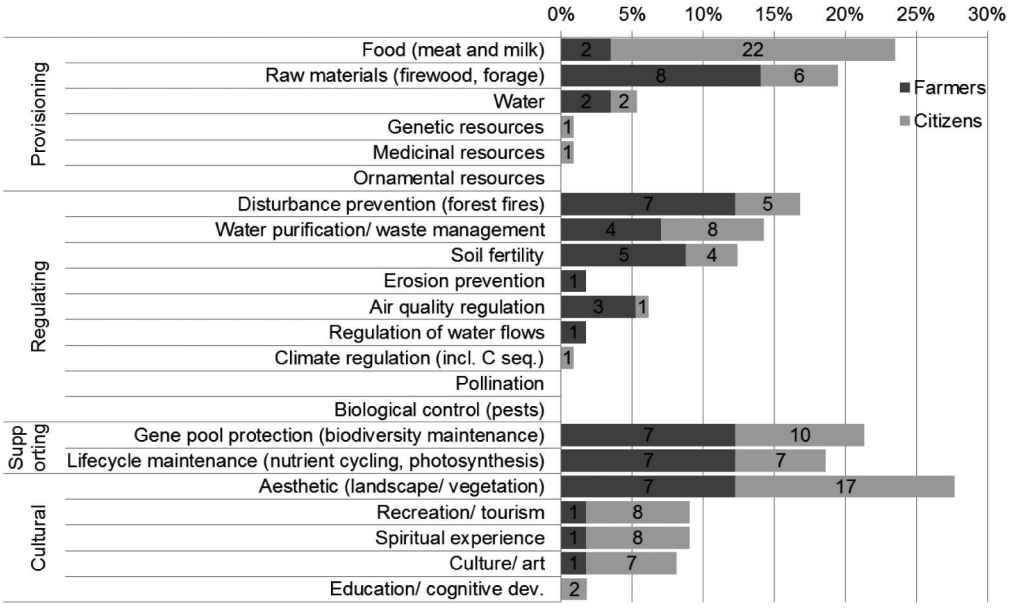

Fig. 5. Percentage and number of times (within bars) that ecosystem services delivered by grazing livestock farming systems were mentioned during the FG with farmers and citizens. Source: Bernués *et al.* (2014).

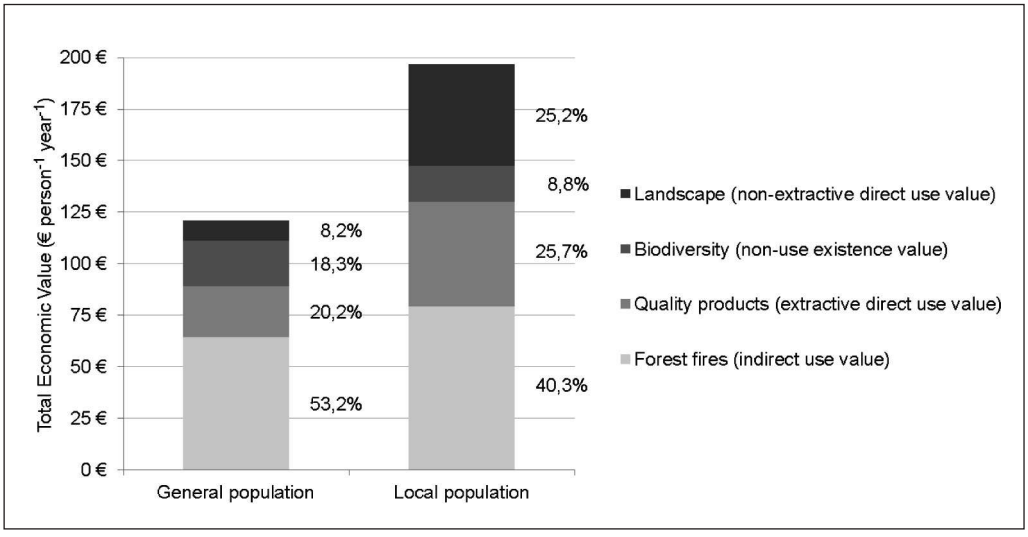

Fig. 6. Willingness to Pay (WTP) (€ person^{-1} year^{-1}) and composition of the Total Economic Value (ranking of importance) for ES in the local and general populations. Source: based on Bernués *et al.* (2014).

IV – Conclusions

We present a novel framework, *from landscape to fork*, for food value chains linking agricultural landscapes (grazing agroecosystems) with consumers and citizens. Farmers and small-scale industry can use the novel concept of ecosystem services to link the different components of the framework and activate the joint delivery of private (e.g. meat) and public goods (e.g. agricultural landscapes). We focus on two aspects that, in our opinion, have the greatest importance for operationalizing these value chains and designing agrienvironmental policies to support grazing farming systems.

First, society (farmers and citizens) clearly perceive the distinctive quality characteristics of food linked to an agricultural landscape or territory as a key provisioning ES of grazing livestock farming systems. A number of extrinsic attributes of food products can satisfy the expectations of consumers for quality, health and safety, and for wider ethical considerations in relation to the model of agriculture and the food chain. Moreover, people seem to link food quality to HNVf, so this type of agriculture could be defined not only in terms of environmental benefits (e.g. biodiversity), but also in terms of the specific market goods that HNVf provide to society.

Second, the raising societal demand for better targeting public goods has fostered the establishment of agrienvironmental policies in Europe. However, the outcomes of these schemes depend on political, sociocultural and institutional contexts. In European HNVf areas, whole-system approaches are needed to identify and quantify the ES that are meaningful to society, establish region-specific targets (and related agricultural practices) to be promoted, and contrast payments with measured ES outputs. This would allow the agrienvironmental schemes that currently support farmers in a horizontal manner to become real payments for ES. In addition, synergies with other policies, such as conservation and rural development policies, should be explored. For example, government authorities could combine voluntary schemes that promote grazing (compensating farmers for nonmarket ES, such as preservation of agricultural landscape, control of shrub growth and biodiversity maintenance) with schemes that promote the differentiation and labeling of local quality food products that are linked to these ES.

References

Bernués A., Olaizola A. and Corcoran K., 2003. Extrinsic attributes of red meat as indicators of quality in Europe: an application for market segmentation. *Food Quality and Preference,* 14, p. 265-276.

Bernués A., Riedel J.L., Asensio M.A., Blanco M., Sanz A., Revilla R. and Casasús I., 2005. An integrated approach to studying the role of grazing livestock systems in the conservation of rangelands in a protected natural park (Sierra de Guara, Spain). *Livestock Production Science,* 96, p. 75-85.

Bernués A., Riedel J.L., Casasús I. and Olaizola A., 2006. The conservation of natural resources as an extrinsic quality attribute of lamb in Mediterranean Areas. In: *Animal products from the Mediterranean area*. Ramalho Ribeiro, J.M.C., Horta, A.E.M., Mosconi, C., Rosati, A. (eds.). Wageningen Academic Publishers, Wageningen, p. 73-82.

Bernués A., Rodríguez-Ortega T., Ripoll-Bosch R. and Alfnes F., 2014. Socio-Cultural and Economic Valuation of Ecosystem Services Provided by Mediterranean Mountain Agroecosystems. *PLoS ONE* 9, e102479.

Bosmans W., Verbeke W. and Van Gysel L., 2005. Valorisation of meat production oriented on "superior" quality: a case study of Belgian farmers' motivations. In: *XIth Congress of the EAAE, The Future of Rural Europe in the Global Agri-food System*, p. 24-27.

Cooper T., Hart K. and Baldock D., 2009. Provision of Public Goods through Agriculture in the European Union. Institute for European Environmental Policy, London.

Feldmann C. and Hamm U., 2015. Consumers' perceptions and preferences for local food: A review. *Food Quality and Preference,* 40, p. 152-164.

Grolleau G. and Caswell J.A., 2006. Interaction between food attributes in markets: The case of environmental labeling. *Journal of Agricultural and Resource Economics,* 31, p. 471-484.

Grunert K.G., 2006. Future trends and consumer lifestyles with regard to meat consumption. *Meat Science,* 74, p. 149-160.

Guerrero L., Guàrdia M.D., Xicola J., Verbeke W., Vanhonacker F., Zakowska-Biemans S., Sajdakowska M., Sulmont-Rossé C., Issanchou S., Contel M., Scalvedi M.L., Granli B.S. and Hersleth M., 2009. Consumer-driven definition of traditional food products and innovation in traditional foods. A qualitative cross-cultural study. *Appetite,* 52, p. 345-354.

Hersleth M., Naes T., Rodbotten M., Lind V. and Monteleone E., 2012. Lamb meat-importance of origin and grazing system for Italian and Norwegian consumers. *Meat Science,* 90, p. 899-907.

Lamarque P., Tappeiner U., Turner C., Steinbacher M., Bardgett R.D., Szukics U., Schermer M. and Lavorel S., 2011. Stakeholder perceptions of grassland ecosystem services in relation to knowledge on soil fertility and biodiversity. *Regional Environmental Change,* 11, p. 791-804.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being*: Synthesis. Washington, DC., p. 137.

Nelson P., 1970. Information and consumer behavior. *Journal of Political Economy,* 78, p. 311-329.

Olaizola A.M., Ameen F. and Manrique E., 2015. Potential strategies of adaptation of mixed sheep-crop systems to changes in the economic environment in a Mediterranean mountain area. *Livestock Science*.

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.

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.

Ripoll-Bosch R., Díez-Unquera B., Ruiz R., Villalba D., Molina E., Joy M., Olaizola A. and Bernués A., 2012. An integrated sustainability assessment of mediterranean sheep farms with different degrees of intensification. *Agricultural Systems,* 105, p. 46-56.

Rodríguez-Ortega T., Oteros-Rozas E., Ripoll-Bosch R., Tichit M., Martín-López B. and Bernues A., 2014. Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. *Animal,* 8, p. 1-12.

Rodríguez-Ortega T., Ripoll-Bosch R., Casasús I. and Bernués A., 2013. Percepciones de ganaderos y ciudadanos sobre las relaciones entre la ganadería de montaña y el medio ambiente: un estudio cualitativo. In: *XV Jornadas de Producción Animal AIDA*. AIDA, Zaragoza, p. 121-123.

Soussana J.F., Loiseau P., Vuichard N., Ceschia E., Balesdent J., Chevallier T. and Arrouays D., 2004. Carbon cycling and sequestration opportunities in temperate grasslands. *Soil Use and Management,* 20, p. 219-230.

Zhang W., Ricketts T.H., Kremen C., Carney K. and Swinton S.M., 2007. Ecosystem services and dis-services to agriculture. *Ecological Economics,* 64, p. 253-260.