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The contribution of ARIMNet to address livestock systems resilience in the Mediterranean region

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Abstract. From 2010 to 2019, the ERA-Nets ARIMNet and ARIMNet2 developed transnational cooperation in the field of agricultural research between Mediterranean countries. Among the major issues that have been addressed, the sustainability and resilience of livestock systems have been the subject of several research projects co-funded by the countries participating in this programme. The different research projects funded have produced knowledge on the efficiency of crop-livestock systems, the adaptive capacity of different livestock systems, their vulnerability and resilience. The crop-livestock association was shown to be particularly relevant in the Mediterranean area, and require the implementation of appropriate policies and collective actions. In addition, the limitations and vulnerability of intensive dairy systems based on imported breeds and feeds have been shown. The advantages in terms of resilience and adaptability of systems based on local breeds were identified. The development of these systems requires the valorization by the market of the quality and specificity of their products. Appropriate public policies and coordination of value chain actors are needed to enable this recognition and development of these farming systems.

Keywords. EU programmes for funding Research – Mediterranean – Livestock systems – Local breeds – Crop-livestock association.

La contribution d'ARIMNet pour aborder les enjeux de résilience des systèmes d'élevage dans la région Méditerranéenne

Résumé. *De 2010 à 2019, les ERA-Nets ARIMNet et ARIMNet2 ont permis de développer la coopération transnationale dans le domaine de la recherche agronomique entre les pays Méditerranéens. Parmi les enjeux majeurs qui ont été traités, les questions de la durabilité et de la résilience des systèmes d'élevage ont fait l'objet de plusieurs de projets de recherche co-financés par les pays participant à ce programme. Les différents projets de recherche financés ont produit des connaissances sur l'efficacité des systèmes agriculture-élevage, la capacité d'adaptation des différents systèmes d'élevage, leur vulnérabilité et leur résilience. L'association agriculture-élevage s'avère particulièrement pertinente dans la zone méditerranéenne, et il existe de réelles opportunités pour renforcer ces systèmes par la mise en œuvre de politiques et d'actions collectives appropriées. Par ailleurs, les limites et la vulnérabilité des systèmes laitiers intensifs basés sur des races et des aliments importés ont été montrés. Les atouts en termes de résilience et d'adaptabilité des systèmes basés sur des races locales ont été identifiés. Le développement de ces systèmes passe par la reconnaissance de la qualité et de la spécificité des produits qui en sont issus et leur valorisation par le marché. Des politiques publiques adéquates et une coordination des acteurs de la chaîne de valeur sont nécessaires pour permettre cette reconnaissance et le développement de ces systèmes d'élevage.*

Mots-clés. *Programmes européens de financement de la recherche – Méditerranée – Systèmes d'élevage – Races locales – Association agriculture-élevage.*

I – Introduction

Despite their diversity and specificities, Mediterranean countries face common challenges when it comes to ensuring food security and socioeconomic development, while conserving natural resources and adapting to climate change. The challenges require research efforts at a regional scale.

Until recent years, coordination of research activities among Mediterranean Countries was weak, it was mainly driven through external incentives of research funding, mainly the European Union Frameworks Programmes for Research. The countries from the non-EU part of the Mediterranean had the possibilities to participate in the research projects, and that was clearly good opportunity to boost research activities and partnership. However, in these programmes, the priorities and the topics to be funded were decided among EU Member States. Thanks to the impulsion of different institutions and notably the CIHEAM, the idea of having a research programme co-shared among Mediterranean countries emerged.

Defining the common research priorities, choosing the tools to support joint activities and implementing them to foster multilateral cooperation was the objectives of the ARIMNet and ARIMNet2 Era-Nets, that have taken place since 2008. The final goal was to achieve the necessary critical mass and build a strong scientific community all around the Mediterranean. By joining their efforts and capacities under a common strategy, the Mediterranean research organizations and funding agencies can achieve a stronger impact on the sustainable development of the region. A total of 47 research projects, and more than 20 million euros have been spent during ten years (2011-2021). ARIMNet2 was followed by the launch of a large-scale initiative, the PRIMA programme, that capitalizes on the results obtained and practices implemented within ARIMNet network. As an initiative under Article 185 TFEU, the PRIMA programme is currently funding annually research and innovation collaborative projects in water resources and food systems domains, with similar but wider objectives.

The issue of the resilience of livestock systems was part of the agenda of ARIMNet and ARIMNet2. This article analyses how this has been addressed in the projects funded by ARIMNet and ARIMNet2, what advances in knowledge they have enabled and how they contribute to the challenges of socio-economic development and natural resource conservation in the region.

II – Objectives and achievements of ARIMNet and ARIMNet2

ARIMNet (Coordination of Agricultural Research in the Mediterranean) and ARIMNet2 were two ERA-Nets funded through the EU FP7 for the period 2008-2013 and 2014-2017 respectively. Largely implemented inside the EU as a major tool for enhancing cooperation in European research, the ERA-Net instrument was extensively used during the FP7 programme. However, it seldom involved non-EU countries, ARIMNet was unique in that sense that it gathers countries from North, South and East Mediterranean. As required in the ERA-Net tool, the funds for coordination among countries came from the EU FP7 whereas the funds to support multilateral research project as well as other joint activities are co-funded by participating countries. And this co-funding of common activities is the backbone of joint strategy.

ARIMNet involved 15 partners (national funding agencies and research institutions) from 11 countries and ARIMNet2 involved 24 partners from 15 Mediterranean countries.

Over the years, ARIMNet and ARIMNet2 have achieved important results, the main one being the co-financing of transnational research projects. Four calls were launched to support transnational collaborative research projects (Table 1). Gathering at least three different countries with one from EU country and one from Mediterranean non-EU country, were part of the conditions to apply to these calls. In 2017, the call for research projects was focused on young researchers, as a consequence of a dedicated summer school organized in 2016 to enhance young researchers' involvement.

Table 1. Characteristics of the four calls for research projects, funded through ARIMNet and ARIMNet2

Year of Publication of the Call	2011	2014	2016	2017
Type of project	Collaborative projects (min 3 countries)	Collaborative projects (min 3 countries)	Collaborative projects (min 3 countries)	Young Researchers collaborative projects
Countries participating in this call	Italy, Greece, Spain, Israel, Egypt, Morocco, Tunisia, Algeria, Turkey, France, Cyprus	Italy, Greece, Spain, Israel, Egypt, Morocco, Tunisia, Algeria, Turkey, Malta, France, Portugal, Slovenia, Croatia	Italy, Greece, Spain, Israel, Egypt, Morocco, Tunisia, Algeria, Turkey, Malta, France, Portugal, Slovenia, Croatia, Egypt, Greece, Spain, Morocco, Tunisia, Algeria, Turkey, France, Croatia, Slovenia	Egypt, Greece, Spain, Morocco, Tunisia, Algeria, Turkey, France, Croatia, Slovenia
Topics	1) Developing sustainable production in the context of increasing ecological and climatic stresses; 2) Food chain from production to consumption: enhancing the advantages of Mediterranean Agriculture and Food; 3) Sustainable management of landscape and resources used by agriculture	1) Developing sustainable production in the context of increasing ecological and climatic stresses; 2) Food chain from production to consumption: enhancing the advantages of Mediterranean Agriculture and Food; 3) Sustainable management of landscape and resources used by agriculture	1) Promoting sustainable agriculture for socio-economic development; 2) Valorising local products through food value chains improvement	1) Promoting sustainable agriculture for socio-economic development; 2) Valorising local products through food value chains improvement
Total funding available (Million €)	7	5.6	4.8	3.4

The analysis of the domains covered by the 47 projects funded during the all period (Figure 1) shows the diversity of topics covered. It shows also an imbalance between the projects addressing crop production (cropping systems plant health and valorisation of plant products) compared to the projects addressing livestock systems and animal production. Regarding the animal productions, four projects addressed issues related to livestock systems, three of them to animal health and three of them to animal product food chains and food technologies:

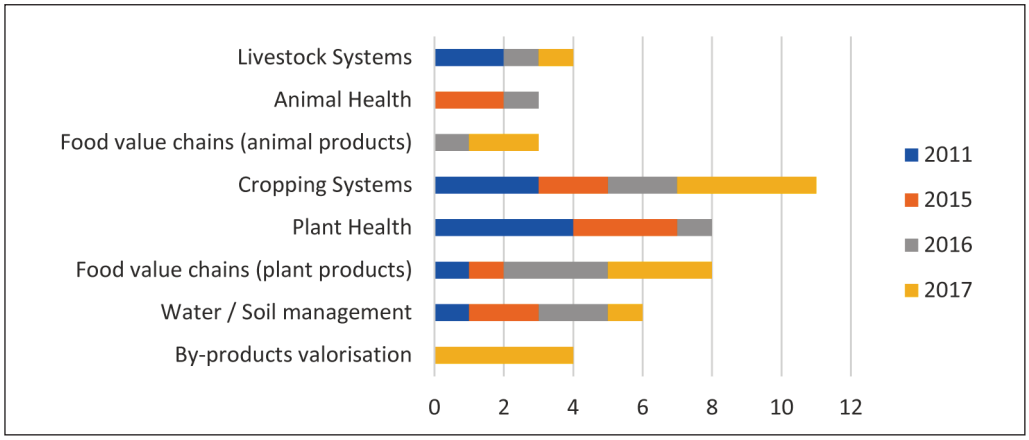

Fig. 1. Number of projects by ARIMNet and ARIMNet 2 funded per scientific domain.

Considering the main domain of this special issue of *Options Méditerranéennes*, about "Combining the diversity of resources and farming practices to ensure resilience of livestock farming systems at different scales", to analyze how the resilience of livestock systems have been addressed in the projects funded by ARIMNet, we choose to focus on the five following projects: CLIMED, DOMESTIC, PERFORM, BIOVISOL, CDCMT, CARAVAN (box 1).

Box 1. Selected projects funded by ARIMNet and ARIMNet 2

CLIMED (2012-2016 funded through ARIMNet 2011 Call) "**The future of Mediterranean Livestock Farming Systems: Opportunity and efficiency of Crops – Livestock Integration"** involved Egypt, Morocco, France. Its objective were: identifying efficient crop-livestock systems for better utilization of water, soil, crop residues, rangelands and increasing farm production to meet the rising local demand of safe animal products, assessing adaptive capacities, vulnerability and flexibility of the farming systems; Developing future scenarios and priorities for livestock development in the Mediterranean context.

DOMESTIC: (2012-2016- Funded through ARIMNet Call 2011) "**Mediterranean biodiversity as a tool for the sustainable development of the small ruminant sector: from traditional knowledge to innovation**" gathered partners from Greece, Morocco, Cyprus and France, was focused on sheep and goat local breeds. It aimed to investigate the factors that influence the sustainability of sheep and goat production systems, by examining the components of the production systems, the supply chain and the regulatory organization. The main results of this project concern the links between local breeds' management, and product valorisation.

PERFORM (2017-2020 ARIMnet2 Call 2016) **"Breeding and management practices towards resilient and productive sheep and goat systems based on locally adapted breeds"** gathered six partners from four countries (France, Greece, Morocco and Egypt). Its objective was to strengthen the capacity of local livestock systems to cope with changes and hazards and to support the livelihoods of rural families. The project focused on the changes of practices of farmers and other stakeholders involved in the dynamic of the local breeds, as the main lever associated with the evolution of the production systems.

BOVISOL (2018-2021, ARIMNet 2 Young Researcher Call 2017) **"Breeding and Management Practices of Indigenous Bovine Breeds: Solutions towards a Sustainable Future"**, involved researchers from Algeria, Tunisia and Greece). Its aim is to provide an overall perspective of the local bovine breeds and their production systems and of improvements that could be proposed in terms of animal breeding, feeding practices, hygiene conditions and product quality certification that would improve the productive system without altering its traditional label.

CDCMCT (2018-2021, ARIMNet 2 Young Researcher Call 2017) "**Characterization of dairy chain in Mediterranean countries and adoption of optimum technologies to improve dairy value chain**", 5 countries Algeria, Greece, Spain, France, Egypt. Farming practices in feed management and milking, storage, transport and processing as well as quality and safety of milk and/or dairy products will be assessed by analyzing physicochemical parameters, microbiologic profile, mycotoxins etc.

CARAVAN: ARIMNet2 Call 2016 (2017-2020) **"Toward a Camel transnational Value chain"** The project involved partners from 6 countries (Spain, Italy, France, Algeria, Morocco, Tunisia). It aimed at promoting integration along the dromedary value-chain. Standardization of animal identification and phenotype systems were conducted with the aim to contribute to genetic improvement. Processing technologies in the production of fermented milk were studied with the aim of improving practices towards quality and safety.

In this special issue, we will examine the scientific outputs of these different projects against the rational that was developed by the ARIMNet in its Integrated Strategic Research Agenda (ISRA) consortium in 2016.

III – The main challenges for livestock production systems in the Mediterranean countries as described in the ARIMNet2 Integrated Strategic Research Agenda

The Integrated Strategic Research Agenda, elaborated under the aegis of ARIMNet2 (ARIMNet2, 2016), was the result of a common reflection that identifies the priorities set in the different calls for research projects and other joint activities. It points out the food security, poverty alleviation and natural resource preservation nexus as the main challenge to be addressed (Figure 2). This led the ARIMNet2 partners to identify three objectives and define thematic priorities on which to focus their actions: 1) promoting a balanced territorial development 2) enhancing value chains, 3) increasing the efficiency and sustainability of production systems.

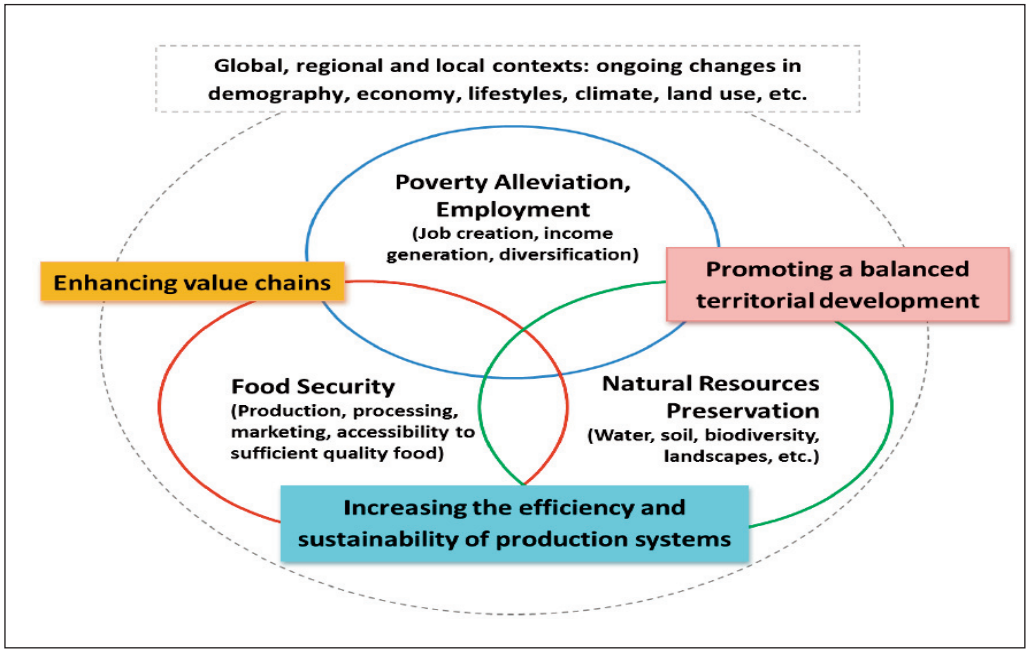

Fig. 2. The Mediterranean food security, poverty alleviation and natural resource preservation nexus in the ARIMNet2 Integrated Strategic Research Agenda.

The Mediterranean agriculture systems have known increasing pressures that include strong demographic growth, urbanization, increasing demand for animal products (especially in southern regions), a demand for more safe animal products, and a high competition for land and water. In this context, the livestock systems experience pressures on biomass to feed animals raise many challenges and sometimes competition in the trade-offs in the use of resources (land, water, and nutrients) that can affect the sustainable development of these systems.

Livestock activities are now recognized for their multiple roles in reducing vulnerability in fragile environment and their roles in diversification and intensification processes. However, the main rec-

ommendations of recent scientific assessments (IAASTD,2009, IPCC, 2019) provide evidence of the difficulties to capture the complex biological, social, and economic dynamics of the variety of challenges likely to confront future crop and livestock production and their integration. The Mediterranean livestock farming systems have also known important changes with the irrigation development and the social and political changes that have affected the livestock management (settlement, mobility, transhumance, etc.), the land tenure and land use, and then the sustainability of the whole production systems.

The South Mediterranean countries show an increasing demand for different animal products in link with the demographic growth and the emergence of a medium social class although North Mediterranean countries record a stagnating consumption of animal products of local origins (mainly sheep meat). These two trends question the ecological equilibrium and socio-economic viability in these zones: the intensification in the South raises the question on the sustainable use of natural resources (soil and water) and the desertion in the North threatens the biodiversity, increase the risk of fire events, and the social life of these highlands. Moreover, we observe important cultural food changes linked to urban expansion and new life conditions, and the increasing demand of "safe" and "ecological" products. These dynamics constitute new opportunities for the agro-ecological systems of the Mediterranean zone with potential pathways for livestock development. If livestock has always played an important role in the valorisation of the resources on these environments, the high competition on animal products at the international level threatens the social and environmental co-viability of these systems and then their future.

Small ruminants are present strongly all-round the Mediterranean countries; with differences between North Mediterranean countries (NMC) and South East countries (SEMC). Northern countries, benefiting from more favourable climate and Common Agricultural Policy, have larger cattle herds, where dry climate and poor rangelands in the south fit more with small ruminants. The region hosts about 5% of the world cattle herd and 13% of the small ruminants. Sheep and goats and its meat production, are important in all Mediterranean countries. Goat is also important in France and Spain for dairy products. Camel herding is important enterprise in the poor pastoral areas and arid areas, as a cheap source of meat. Camels' immigration from sub-Saharan countries to North Africa represents a potential regional trade business.

Pastoral systems are particularly important. NMCs have an average yearly rainfall above 500 mm, where it is below that in SEMCs and even below 300 mm in North Africa with large arid areas. Lack of rainfall is also combined with high temperatures, exacerbating aridity. With the dry climate and consequently lack of ranges, pastoral systems are widespread in the Mediterranean, animals are forced to move to feed in semi-arid regions.

Animal health, with the fragility of the Mediterranean ecosystem, concentrations of human and animal populations, the proximity of humans and animals, difficulties in implementing effective health inspections, and the effect of climate change, are factors that favour the persistence of pandemic animal diseases, the resurgence of epidemics and the emergence of new pathogens. It constitutes a major constraint on husbandry and economic practices in livestock production systems in the region.

Climate changes and associated risks for animal health need to be addressed. Dealing with increasing risks will depend on the efforts to adapt livestock systems. Issues as animal breeding for robustness, adaptation to heat and other extreme conditions, and breeding for higher production under changing abiotic stress should be taken into consideration. Changes in animal production may affect the release of greenhouse gases and therefore interact with mitigation efforts.

Utilization and management of natural resources by bovine and ovine sectors are important for Mediterranean countries. Bovine production is in competition with other agricultural and non-agricultural uses in the Mediterranean, for natural resources as land and water; they are more and more constrained by climate change context as well as by human health, animal welfare and environ-

mental legislations. Sustained research and innovation efforts on animal nutrition, health and breeding as well as on consumers' preferences will contribute to improve bovine production in the Mediterranean and will as adaptation to the ongoing changing in the socioeconomic issues (population, urbanization, etc.) and the growing concern for human health and environmental protection.

Mediterranean dairy and meat sectors experienced changes in recent years. Dairy sector is a strategic socio economic sector in Mediterranean countries. The recent changes in consumption habits of return to traditional and local products, incentivize the development of new forms of traditional dairy products. One of the main challenges is to support this changes as part of the cultural, economic and environmental sustainability of the territories. Dairy manufacturing in NMC are dedicated to cheese processing with high added-value products. Meanwhile, family dairy processing is important activity for rural communities, both for their livelihood and as an important nutritional source. The trade of ovine meat, experienced important changes over the last decade: traditionally south countries were the main suppliers of north countries, but progressively, fluxes have developed from the North to the South and between southern countries.

Box 2. Research challenges on livestock Systems in the Mediterranean (adapted from ARIMNet 2 ISRA, 2016)

Livestock farming systems need to adapt to the multiple and complex changes occurred and will occur in the region. An important issue is that livestock management has been separated in some countries, from cropping activities with the subsequent negative impacts on water and nutrient cycles and ecosystem services.

Efforts are required to encourage integration of crop-livestock systems for more appropriate land use of diversified ecosystems; valorisation of manure, labor, diversification of the products at the farm in relation to the growing demography, pressure on land, and increasing competition.

The main research challenges perspectives are:

1) Identifying efficient crop-livestock systems capable of better utilization of water, soil, rangelands, forages and crop residues, i.e. enhance resource efficiency, and increase the production to meet the rising demand for safe animal products (towards greater socio-economic efficiency);
2) Assessing adaptive capacity, vulnerability and flexibility in the face of current stresses and changes;
3) Assessing socio-ecological, co-viability and resilience with regard to demographic growth, in a historical perspective;
4) Developing future scenarios and priorities for livestock development in the Mediterranean context to increase their capabilities.

IV – How the projects funded by ARIMnet and ARIMNet2 contributed to address these challenges?

Considering that the Mediterranean livestock farming systems need to adapt with multiple and complex changes in the past and present history of the zone, the overall objective of the **CLIMED** project aimed to assess technical, economic and socio-ecological viability of crop-livestock systems in the Mediterranean context. The goal was to help farmers, local communities, researchers and decision makers in thinking future planning for Mediterranean livestock and design priorities, rules,

policies that could better deal with the socio-environmental issues in link with demographic and land pressure, increasing demand and strong high international competition. The potential sustainable intensification processes are generally complex depending both on exogenous opportunities and on endogenous capacities and representations. The CLIMED teams assume that the mixed farming systems, as livelihood strategy, and the integration of livestock and crops, to improve economic and environmental efficiency through recycling, are possible options for sustainable intensification of farming systems. Surveys and monitoring at farm level were conducted to assess various efficiencies. Interviews of actors, mobilization of databases and previous studies were performed to analyse the dynamics of systems in the last decades and to assess their adaptive capacities. Finally, a transversal analysis enables to identify five archetypical farming systems at Mediterranean scale and to perform a qualitative assessment, from quantitative results obtained in the three countries (Alary *et al*., 2019) and Fig. 3 below:

1) The crop specialized system: specialization in high-value crops in the favourable zones, mainly irrigated zones. This specialization is largely driven by the research of labour productivity and social valorisation in link with the educational level or aspirations in terms of living conditions. This specialization extends in all the plains of the coastal line in south of France and Morocco and in the recent New Reclaimed Land (NRL) in Egypt. It has also been encouraged by regional and national policies of rural development in France and in Morocco based on irrigation development and agrarian reform in Egypt in favour of graduates and private entrepreneurs.
2) The dairy specialized system: observed in the favourable zones of Morocco and Egypt (Srairi *et al*., 2014). This specialization concerns mainly large dairy farms that have been driven – and sometimes structured- by the milk agro-industrial sector.
3) The mixed crop-livestock systems: the majority of farming systems in the NRL (Alary *et al.,* 2020, Alary *et al*., 2018) and in the irrigated zone of Morocco, it is no longer present in the south of France, limited in the interstice between the plains and the mountains.
4) The mixed livestock-crop systems: the majority of integrated systems in the rainfed zone, also called agro-pastoral systems due to the maintenance of short seasonal mobility during the favourable climatic years (Osman *et al.,* 2014).
5) The meat specialized systems in vulnerable zones like the mountains in France or the arid and semi-arid zones in Morocco or Egypt, based on the capacity to increase the resource access by the mobility thanks to an extended social network (Alary *et al.,* 2016).

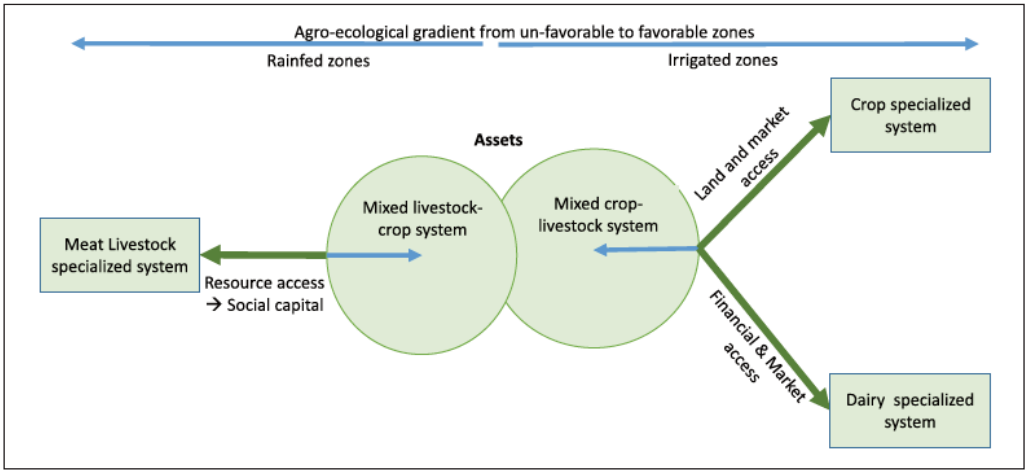

Fig. 3. Specialized vs Diversified Crop-Livestock systems (from Alary *et al.,* 2019).

They identified two main trends within these five archetypical systems: a centrifugal trend of specialization, toward cash crop or dairy herd in favourable areas, and pastoral meat system in harsher environment, and a centripetal trend of diversification, maintaining mixed crop-livestock systems in irrigated areas and agro-pastoral livestock-crop systems and in intermediate rain fed areas. Specialization trend is very strong in France and diversification the most developed in Egypt and Morocco. Those trends may lead to a territorial specialization. The issues of crop-livestock integration had then to be addressed at farm scale for mixed systems, considering the relations between a diversity of farms co-existing in a local territory and the relations between specialized territories. The mobility of the flocks is the mean to organise those relationships. The mixed crop-livestock systems exhibited: (i) a good environmental efficiency, recycling the biomass between activities, (ii) a good economic robustness because of the combination of activities and the security net through social network, but (iii) low labour productivity and incomes, due to a weak access to land and water, to the amount of routine work requirement for integration practices and low empowerment through collective actions. The reproduction of this mixed system is endangered, because of low incomes and the poor social consideration. In another hand, the institutions, through policies and planned infrastructure programmes, have mainly supported the specialized systems that exhibited limits in terms of socio-ecological viability, as dairy farming for instance. Actually, despite the importance to improve the whole dairy chain in Mediterranean countries, a lack of clear information on dairy farmers, collector and processors, milk quality and safety, sales in the region mainly in North Africa limits the stakeholders and deciders to make changes in the sector.

Thus, the **Project "Characterization of Dairy Chain in Mediterranean Countries and Adoption of Optimum Technologies to Improve Dairy Value Chain"** (CDCMCT) aims to identify the different strategies, by characterizing the dairy farms, and evaluating the quality and safety of raw milk they produce, in Algeria, Greece and Egypt to develop dairy sector (see the paper published in this special issue of *Options Méditerranéennes*). In the three countries, most farms are small scales, and dairy farmers produce many traditional dairy products for their families, except for cow dairy farmers who are selling all the milk within a more or less integrated system. Sheep-goat milk quality is good, likewise cow milk physicochemical parameters are within the recommended values in all milk samples collected in Algeria, Greece and Egypt, however the protein and fat contents can't satisfy the dairy processors demand of high quality. In Egypt, buffalo milk, which is very nutritive, is very commonly consumed. Mastitis seems to be one of the major issue that farmers have to face in Algeria and Egypt, probably due to poor hygienic practices. The project team makes thus some recommendations to provide guideline of good practices for Algerian and Egyptian farmers to limit the mastitis in the farms and to initiate new actions for improving milk quantity, quality and safety, as genetic selection and hydroponic fodder production.

Main issues of CLIMED research –as developed in (Alary *et al*., 2019)– pinpointed necessity in: i) overwhelming antagonism between social vulnerability and ecological efficiency of mixed crop livestock farming systems through dedicated rural development policies; ii) limiting micro-regional specialisation processes through the maintaining of a diversity of systems, developing for instance opportunities in promoting territorial food projects and environmental rules reintroducing diversity in cropland occupation; iii) taking advantage of spatial mobility abilities of livestock farming in the Mediterranean to reinforce crop – livestock integration at regional level, promoting collective actions allowing a wider range of livestock farmers of hinterlands to participate, limiting so these efficiency loss and reinforcing sustainability for most vulnerable livestock farmers.

Until recent years, in the Mediterranean, local breeds were considered to be of low productivity and they were largely ignored. The improvement of the livestock sector efficiency was achieved through the use of imported breeds, that were raised either directly in the farms or by crossing with local breeds. It is only recently that the advantages of local breeds in terms of robustness, capacity to valorise local feed resources and to adapt to climate change have been highlighted. As a result,

the questions of their performance, through identification of breeds traits of interests and improvement of the management of livestock systems based on local breeds have arisen, as well as that of the valorisation of their specific productions.

Several projects supported by ARIMNet (**Domestic, Perform, Bovisol**) addressed these issues through different aspects. They share the objective of producing comprehensive approaches of the functioning of the livestock systems linking the farm level, the socio-technical systems and the value chains of the products.

First, the link between the local breeds characteristics and the farming systems management is studied in the perspective of assessing and improving the sustainability of the livestock systems based on local genetic resources.

As part of the **DOMESTIC** project, Araba and Boughalmi (2016) compared three sheep production systems in the Eastern Middle Atlas of Morocco i.e. agro-silvo-pastoral, pastoral and oasis systems through a multicriteria assessment method. They showed that the farms belonging to the two extensive farming systems i.e. agro-silvo-pastoral and pastoral presented better overall sustainability scores than the oasis farms. In these extensive farming systems, local breeds (Timahdite and Beni Guil) and a high vegetation diversity including pastoral species are observed, whereas in the oasis farms the sheep population is less diversified and mainly issued from informal crossbreeding.

The challenges for local breed management in the Mediterranean have been largely studied, in the **DOMESTIC** and **PERFORM** projects. In the **PERFORM** project, it has been showed (Perucho *et al*., 2019a) that in this region where informal crossbreeding with highly productive breeds was widely practiced, a diversity of breeding strategies involving local purebred and crossbred flocks coexist. In the case of the local pure breed, the Karagouniko breed, breeding males are obtained from an exchange between farms among flocks under milk recording scheme. Traditionally associated with grazing on native grasslands, the farming of Karagouniko breed suffered from the decline in the quality of collective rangelands. Dairy policies have encouraged intensification at the expense of traditional practices (earlier lambing period or earlier weaning age). One characteristic of the Karagouniko breed is its resilience in face of climate change, as shown by Karatzia *et al.* (in this issue), with ewes' welfare indices remaining within desirable levels in a context of extreme severe heat stress conditions.

In the **PERFORM** project, the link between breed characteristics and farming practices is further explored. Farmers' preferences for animal trait is analysed to identify how breeding objectives fit farmers' expectations in terms of breeds traits of interests (Perucho *et al.,* 2019 b). Detailed results for the different regions studied (Corsica and Thessaly) should help better define priorities for breeding objectives in local breeding schemes.

Even if most of the research activities on local breeds funded by ARIMNet concern sheep or goats, the **BOVISOL** project focuses bovine cattle farms. Its objective is to find solutions to make the traditional farming systems based on local breeds more productive, competitive and sustainable. in the three countries studied (Algeria, Tunisia, Greece) the local bovine breeds' populations face similar problems such decline, inefficient breeding schemes and unfavorable rearing conditions. In the same time, they are still largely used in traditional extensive family farms, that share similar characteristics in terms of flock management (mixed herds with free grazing and complementary feed in the winter, reproduction through natural mating). A paper presented this special issue of *Options Méditerranéennes* (Tsiokos *et al.)* analyses the characteristics of 318 farms of the three countries and the motivations of farmers for choosing a breed.

Camel farming still plays a marginal role worldwide. However, camel farming plays a central role in the preservation of rural societies, in the development of natural resources in desert areas through a multifunctional livestock system, and in the management of water scarcity.

The **CARAVAN** project addressed the issue of camel sector in order to better understand herd management and camel production and to improve their performance. It has been shown under Algerian pastoral conditions (Gheressi *et al*., 2020) that in the traditional pastoral management of dromedary herds in south-eastern Algeria, dromedaries show poor reproductive performance. The project identifies the need to improve the training of camel breeders in order to improve the performance of the sector.

The second research question addressed in these projects focused on local breeds is the valorisation of the product and the link between the breed characteristics, the production system and the product qualities.

The **DOMESTIC** project addressed this issue through different aspects. Boughalmi *et al.* (2016) studied the opportunities to create a grass-lamb value chain in the Middle Atlas of Morocco area (They showed that a good adaptation of the local breeds, the quality of feed resources available in large rangelands and local expertise of breeders allow to produce a low cost and high quality lamb. However, they identify several difficulties and obstacles in the value chain organization that hinder the lamb valorisation. They suggest that a better organization of stakeholders should be encouraged and promoted to valorise the product.

The need for a better coordination among actors inside the value chain has also been pointed out as a main factor for improving milk valorisation for the cases of Cyprus sheep and goat milk. Ha djipavlou *et al.* (2020) showed that the factors that affected farmer decision for the choice of a milk market channel were the sheep milk price, the type of contract with buyers (formal or informal), the payment method and the price differentiation according to specific milk quality specifications. They identify that stronger forms of coordination between all the links in the value chain are required.

By comparing the cases of four different countries (France-Corsica, Cyprus, Greece-Ipeiros, Cyprus, Morocco), Lauvie *et al*. (2016) underlined the diversity of stakes for product valorisation that depends on the breed status and the type of product. They showed that ultimately there is little evidence of links between the dynamics of breed management and the dynamic of product valorisation.

V – Conclusion

If we compare the results obtained in the ARIMNet-funded research projects with the strategic challenges identified in the ARIMNet strategic agenda (Box 2), we can see that the various research projects funded have produced knowledge on the various questions raised on the efficiency of cereal-livestock systems, the adaptive capacity of diverse livestock systems, their vulnerability and resilience. Three conclusions can be drawn.

The first concerns the association of animal and crop production in mixed crop-livestock systems. This association is identified today as a major pillar of agro-ecology. This is even more relevant in the Mediterranean area, due to the vulnerability of ecosystems and the characteristics of natural resources. The work carried out in the various projects has shown that there are real opportunities to make this association a success through the implementation of appropriate policies and collective actions. Secondly, the projects have shown the limitations and vulnerability of intensive dairy systems based on imported breeds and feed. The difficulties faced by farmers in these specialized systems are numerous. Finally, several projects identified livestock production based on local breeds as a perspective to be developed, as local breeds have the capacity to valorise fodder resources and to cope with climatic conditions as well as the diversity of food habits and diets within the Mediterranean area. These livestock systems, which have certain advantages in terms of resilience and adaptability, will only be able to develop if the specific products they produce are characterized and valued by the market for their specific characteristics. Adequate public policies and coordination of value chain stakeholders are needed to enable this recognition and development of these farming systems.

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