



ARIMNet2

Coordination of Agricultural Research
in the Mediterranean



INTEGRATED STRATEGIC RESEARCH AGENDA (ISRA)



Action title: ARIMNet2 - Coordination of Agricultural Research In the Mediterranean

Website: <http://www.arimnet2.net>

Coordination: Florence Jacquet, Institut National de la Recherche Agronomique (INRA, France)

Funding: ARIMNet2 (2014-2017) is an ERA-NET coordinated by INRA (France). It has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 618127.

Authors: The ISRA has been written by a working group composed of: Uygun Aksoy (SSAB chair), Bernard Hubert (SSAB vice-chair), Adel Aboulnaga (governing board member), Marina Montedoro (WP1 leader), Serenella Puliga (WP1 leader), Florence Jacquet (ARIMNet2 coordinator), Fabrice Gouriveau (ARIMNet2 assistant coordinator), with the contribution of all SSAB members, Dunja Bandelj, Marcello Pagliai, Mohamed Ben Hamouda, Maroun El Moujabber, Egizio Valceschini, Reinhart Ceulemans, Mohamed Badraoui, and on behalf of the Governing Board.

The ISRA has been approved by the ARIMNet2 Governing Board in Lisbon on 15 March 2016.

Reference: ARIMNet2, 2016. ARIMNet2 Integrated Strategic Research Agenda (ISRA).

Disclaimer: The views and opinions expressed in this document are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Union.



INDEX

INDEX	3
LIST OF FIGURES.....	5
LIST OF TABLES	6
PHOTOGRAPHY CREDITS.....	6
ACRONYMS	7
FOREWORD	8
ARIMNet2 CHALLENGES	9
MEDITERRANEAN CONTEXT	9
EUROPEAN RESEARCH AND INNOVATION POLICY IN THE MEDITERRANEAN.....	10
COORDINATION OF AGRICULTURAL RESEARCH IN THE EUROPEAN UNION	11
FACCE-JPI	11
The vision of the Standing Committee on Agricultural Research.....	12
WHAT IS ARIMNet2?	13
Scope and objectives of ARIMNet2.....	13
Lessons learnt from the 2015 ARIMNet2 call.....	14
Scope of the ARIMNet2 ISRA	16

ARIMNet2 STRATEGY FOR THE MEDITERRANEAN REGION	17
LEARNING FROM PREVIOUS STUDIES	17
MAIN ISSUES AND TARGETS.....	18
Population and societies	18
Natural resources.....	20
Crop production systems.....	23
Perennial systems (olive, grapes and fruit production).....	24
Annual crops (cereals, legumes and vegetables).....	26
Specific high added-value plants	27
Animal production systems.....	27
Some common specificities of Mediterranean livestock systems.....	27
Bovine and ovine sectors	29
Aquaculture and fishery.....	32
Food chains.....	33
Lifestyles, food, and health	34
Food industries and local conditions	34
Smallholdings poorly integrated into formal supply chains.....	35
ARIMNet2 STRATEGIC PRIORITIES.....	36
The prioritisation process	36
Thematic priorities.....	38
Increasing the efficiency and sustainability of production systems.....	38
Enhancing value chains	38
Promoting a balanced territorial development	39
INSTRUMENTS TO IMPLEMENT THE ISRA	39
Instruments to strengthen capacities	39
Instruments to develop shared equipment.....	40
Instruments to enhance collaborative projects.....	40
ISRA MONITORING AND EVALUATION.....	40
ARIMNet2 PERSPECTIVES	41
CONTRIBUTION OF ARIMNet2 TO THE IMPLEMENTATION OF THE FACCE-JPI STRATEGIC AGENDA.....	41
CONTRIBUTION OF ARIMNet2 TO THE EURO-MEDITERRANEAN RESEARCH AND INNOVATION POLICY.....	42
ANNEX 1: ARIMNet2 PARTNERS	43
ANNEX 2: ARIMNet2 WORK PACKAGES	44
ANNEX 3: ARIMNet2 GOVERNANCE	45

LIST OF FIGURES

Figure 1. The five core themes and three trans-thematic clusters of FACCE-JPI (FACCE-JPI, 2016)	12
Figure 2. Participation of the Mediterranean countries involved in the first ARIMNet2 call (2015), expressed as the percentage of project proposals involving a given country, in reference to the 146 projects presented	15
Figure 3. Number of project proposals received for each of the eleven topics considered for the 2015 ARIMNet2 Call, and topics addressed by the ten projects selected for funding	16
Figure 4. Trends in Mediterranean urban/rural population between 1960 and 2013, in North Mediterranean Countries (NMCs, top) and South and East Mediterranean Countries (SEMCs, bottom) (Source: PRIMA proposal, based on World Development Indicators, 2014)	18
Figure 5. Total agricultural exports and imports of SEMCs in billion US dollars (PRIMA Proposal, updated with WTO Database, 2015)	19
Figure 6. Desertification and soil erosion transforming fertile agricultural-prone lands into barren landscapes	21
Figure 7. Water: a very valuable resource in the Mediterranean region that must be carefully managed	22
Figure 8. Freshwater withdrawals for agricultural, industrial and domestic use (in % of total freshwater withdrawal) in some Mediterranean countries (FAO Aquastat, 2013)	22
Figure 9. Experimental setups to test new crop varieties, improve their water and nutrient use efficiency, enhance their resistance to pests and diseases, and boost the productivity and sustainability of farming systems	23
Figure 10. Some of the most important fruit crops cultivated in the Mediterranean region and exported worldwide, fresh or processed (e.g. beverages, compotes, marmalades)	25
Figure 11. Examples of plant species with a high value on the national and international markets for their visual, olfactory, organoleptic or pharmaceutical properties	27
Figure 12. Cattle, sheep and goat heads (in millions) in Mediterranean countries (FAO, 2014)	28
Figure 13. Importance of pastoral systems in the Mediterranean region for sheep, goat and cow husbandry	29
Figure 14. Sheep meat production and consumption in Mediterranean countries (FAO, 2013; OECD, 2013; For Tunisia and Morocco: authors' calculations based on 2010 national data)	31
Figure 15. Dairy production and transformation at the small and large scale	31
Figure 16. Development of sustainable aquaculture and fisheries as an alternative food source	33
Figure 17. Different kinds of healthy food distribution and preservation forms	34
Figure 18. Changes in the Mediterranean diet – from a traditional balanced diet to a carbohydrate-rich and saturated fat-rich fast food diet	35
Figure 19. Small producers using low-cost animal-pulled carts to transport their products	36
Figure 20. The food security, poverty alleviation and natural resource preservation nexus	38

LIST OF TABLES

Table 1. List of the ten projects (2013–2016) financed through the 2011 ARIMNet call (details at www.arimnet2.net)	14
Table 2. List of the ten projects financed through the 2015 ARIMNet2 call	15
Table 3. Olive oil production in the Mediterranean area [average from 2009/10 to 2014/15] [International Olive Oil Council, November 2015]	25
Table 4. Wheat production, import and export of some Mediterranean countries in 2013 [FAO, 2016]	26
Table 5. Research topics of the first ARIMNet2 call (2015) and their main contribution to Mediterranean social environmental and economic challenges	37

PHOTOGRAPHY CREDITS

- Figure 6. ©Bernard Hubert (Moroccan landscape); ©Pierre Arragon-CIHEAM (Soil erosion gullies, downstream the Sidi Salem dam canal, North-West Tunisia)
- Figure 7. ©Bernard Hubert (Nil Delta , Egypt; Irrigated field, Spain); ©Pierre-Éric Lauri, APMed Project (Micro-irrigation of an orchard); ©Pierre Arragon-CIHEAM (Tunisian market gardener)
- Figure 9. ©Bernard Hubert (Experimental field, INRA, Morocco); ©Michel Desbois-CIHEAM (Experimental setup at CIHEAM)
- Figure 10. ©INIA (Experimental cereal field being harvested for yield and quality studies, Spain); ©Pierre Arragon-CIHEAM (Olive grove, Greece); ©Paola Caruso, ORPRAMed Project (Mandarin tree, Italy, Sicily); ©Pierre-Éric Lauri, APMed Project (Apple orchard, France); ©Uygun Aksoy (Traditional fig orchard, Turkey); ©Ahmet Altındışli (Sultana seedless grapevine, Turkey)
- Figure 11. ©Jacques Lorthiois-CIHEAM (Lavender field for the production of dry lavender and lavender extract); ©Unknown-CIHEAM (Woman from a local cooperative crushing argan kernels for the production of argan oil, Souss Massa Daraa Region, Morocco)
- Figure 13. ©Yiannis Dekolis, DoMEsTic Project (Mixed sheep and goat herd, Iperos region, Greece); ©Pierre Arragon-CIHEAM (Goats climbing on argan trees to feed on the leaves, Essaouira region, Morocco); ©Véronique Alary, CLIMED Project (Newly reclaimed lands, El-Hamam, Egypt)
- Figure 15. ©Bernard Hubert (Milk producer in Morocco); ©Unknown-CIHEAM (Parmigiano-Reggiano cheese factory in Parma, Italy)
- Figure 16. ©Emmanuel T. Koutrakis (Small inshore fishing boat, Greece; Small fish fishing in Vistonida Lake, Greece)
- Figure 17. ©Pierre Arragon-CIHEAM (Traditional fruit and vegetable markets, Morocco); Fabrice Gouriveau (Mediterranean supermarket)
- Figure 18. Pixabay (Typical components of a balanced Mediterranean diet, renowned for its health benefits – UNESCO Intangible Cultural Heritage of Humanity; Typical components of a carbohydrate- and fat-rich “fast-food” diet)
- Figure 19. ©Pierre Arragon-CIHEAM (Dairy family in Morocco); ©Bernard Hubert (Farmer transporting straw with a traditional horse-pulled cart; Small-scale milk producer delivering his milk churns using a donkey-pulled cart)
- Pages 46–47. ©Véronique Alary, CLIMED Project

ACRONYMS

AKIS	Agricultural Knowledge and Innovation Systems
ARIMNet2	Coordination of Agricultural Research In the Mediterranean, 2014–2017
CAP	Common Agricultural Policy
CGIAR	Consultative Group on International Agricultural Research
EC	European Commission
EIP	European Innovation Partnerships
ERA	European Research Area
ERA-NET	European Research Area Network
ERC	European Research Council
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GVA	Gross Value Added
IPCC	Intergovernmental Panel on Climate Change
ISRA	Integrated Strategic Research Agenda
JPI	Joint Programming Initiative
KIC	Knowledge and Innovation Community
MENA	Middle East and North Africa
MPC	Mediterranean Participating Country
NMC	North Mediterranean Country
OECD	Organisation for Economic Co-operation and Development
PPP	Public-Private Partnership
RDI	Research, Development and Innovation
SCAR	Standing Committee on Agricultural Research
SMC	South Mediterranean Country
SRA	Strategic Research Agenda
SSAB	Scientific and Strategic Advisory Board
SEMC	South and East Mediterranean Country
TFEU	Treaty on the Functioning of the European Union

Euro-Mediterranean cooperation in the field of research, development and innovation (RDI) has a major role to play in delivering economic, environmental and social benefits at a wide scale. Indeed, investing in research and innovation boosts employment and economic growth and reinforces economic stability, hence contributing to improve regional and global welfare and prosperity. It also supports democracy and peace, and responds to the democratic and economic aspirations that are so close to European values. Although science alone will not build democracy and economic growth, it can contribute significantly to them. To achieve that, a holistic strategy for the Mediterranean region is needed to better focus cooperative research on shared current and future challenges, build sustainable synergies, reduce fragmentation and allow for a more efficient use of public funds.

ARIMNet2 (Coordination of Agricultural Research In the Mediterranean, 2014-2017; www.arimnet2.net), an ERA-NET coordinated action funded by the European Union under the Seventh Framework Programme for research, technological development and demonstration, has designed this Integrated Strategic Research Agenda (ISRA) as a central and key output aimed to constitute a basis to set up a common vision and strategy on the challenges and priorities for agricultural research in the context of the Mediterranean area¹.

This ISRA highlights and addresses the main agriculture-related societal challenges faced by the whole Mediterranean area in the fields of food security, rural development, water and natural resource management in agriculture. The Scientific and Strategic Advisory Board (SSAB), composed of elected members from EU and non-EU ARIMNet2 participant countries and representing major Mediterranean initiatives on agriculture, played a central role in producing this ISRA.

The compiled information and the discussions led to a document composed of three sections:

1. ARIMNet2 challenges
2. ARIMNet2 strategy
3. ARIMNet2 perspectives

Section 1 identifies the key challenges faced by the Mediterranean region and addressed by ARIMNet2, explains the main features of collaborative research and innovation in the region, presents the ARIMNet2 initiative (scope, objectives and actions towards agricultural research cooperation), and finally specifies the scope and purpose of the ISRA.

Section 2 highlights and discusses the ARIMNet2 strategy with respect to the key selected challenges related to population and societies, natural resources, crops and livestock production systems (including poultry, aquaculture and fisheries) and value chains. The main outcome of this framework is that these challenges are a tremendous nexus between food security, poverty alleviation and sustainable natural resources conservation, requiring a holistic vision and integrated approaches. Based on that analysis, the core of the document then displays the strategy proposing priority thematic areas to address those challenges. The strategies discussed are limited to the scope of ARIMNet2 and thus do not include issues related to forestry and off-shore fisheries.

Section 3 presents ARIMNet2 perspectives and focuses on its contribution to European and Euro-Mediterranean RDI policies.

The ISRA has the ambition to support priority setting in the Mediterranean area and to guide policy making at national, regional and international levels in the fields of research and innovation, without limiting its scope and function to the funding bodies involved in the ARIMNet2 joint initiative.

1. The ARIMNet2 consortium comprises Algeria, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Malta, Morocco, Portugal, Slovenia, Spain, Tunisia and Turkey. In addition to those countries, we also consider in the ISRA the other Mediterranean countries. Statistics presented include in the Mediterranean area: Albania, Bosnia and Herzegovina, Jordan, Lebanon, Libya, Monaco, Montenegro, Palestine and Syria.



ARIMNet2 CHALLENGES

MEDITERRANEAN CONTEXT

The diversity and complexity of the demographic, social, ecological, economic and political contexts of the Mediterranean countries have a significant influence on the development of the European population, and this reality cannot be overlooked.

In terms of demography, while the population in the Mediterranean region was around 520 million inhabitants in 2015, it is expected to reach 586 million inhabitants by 2030 and 650 million inhabitants by 2050². This means that, compared to the 323 million inhabitants recorded in the region in 1975, the population will have almost doubled in fifty years. The overall population of the five North African countries on the Mediterranean Sea [i.e. Algeria, Egypt, Libya, Morocco and Tunisia] represents nearly two fifth of that of the European Union with its 28 Member States. Contrary to European countries such as Italy, Portugal, Greece and Spain with a median age of the population ranging between 43.2 and 45.9 years and belonging to the first ten countries with the oldest populations in the world in 2015, the demographic structure of the South is larger in the younger age-classes, meaning that it will still grow at a positive rate, while the growth rate of the European population is nearly stable. Within the South and East Mediterranean Countries

2. United Nations, 2015. *World Population Prospects (2015 Revision). Key Findings and Advance Tables*. Department of Economic and Social Affairs, Population Division. NY, USA, 66 p.

3. http://ec.europa.eu/eurostat/statistics-explained/index.php/Agriculture_statistics_-_North_Africa_and_Eastern_Mediterranean

4. IPCC, 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, USA, 1535 p.

(SEMCs), the increase in the total and urban population is expected to generate serious problems in terms of access to resources and land use planning.

The economic importance of the agricultural sector (including fishing) varies considerably among the SEMCs³: in 2011 it represented 1.9, 3.3 and 4.1% of the gross value added (GVA) of Israel, Jordan and Lebanon respectively but over 15% in Morocco and 20% in Syria (according to 2009 figures). In the EU-27, it contributed 1.7% to the total GVA in 2010. In some countries there was a decline in the economic importance of agriculture like the decline in Egypt from a 16.3% share in 2003 to 13.2% in 2011. The difference in the importance of the agricultural sector in terms of employment is even more pronounced: in Israel and Jordan, the sector (including hunting, forestry and fishing) provided between 1-2% of total employment whereas in other countries of the region agriculture jobs are much more significant: 11% employed in Algeria, 13% in Syria, 16% in Tunisia and about 40% in Morocco and 29% in Egypt (including fishing) in 2011. During the same period in the EU, the share of agriculture, forestry and fishing was only 5.0% of total employment. In the Mediterranean countries, the high employment rate in agriculture strongly contributes to ensuring adequate food supply, both in terms of quality and quantity.

Clearly, food security and safety do not depend only on structural and socio-economic factors but also on the proper use and conservation of natural resources such as biodiversity, soil and water, and are strongly linked to climatic conditions. As the Mediterranean is already marked by drought, climate change⁴ (e.g. decreased precipitation, increased air temperatures and extended drought periods) appears to threaten seriously the overall productivity and sustainability of farming systems and thus food security.

The current social and political situation in the Mediterranean basin invites us to reflect upon the challenges facing economies in EU's bordering countries and the potential leverage for sustainable

development in the region. An improvement of livelihoods is among the main demands of Mediterranean citizens, facing a multidimensional insecurity that plunges them in a highly vulnerable situation on a daily basis. The access to food and water interconnected with multiple challenges – political, social, or economic – that limit food and water availability is of paramount importance in the region. This affects the socio-economic conditions, wellbeing and health of people living in the Mediterranean area, and the societal stability of the region, therefore impacting European Union as a whole. Agriculture has an important part to play in the economic development of the South and East, and its development is an opportunity for boosting European competitiveness. As internal markets would absorb most of the production, this would create jobs, making farming attractive to young people from rural and urban origins, who will then support agricultural activities in the future. The Mediterranean natural environment is highly vulnerable, and the region is one of the world's most threatened by climate change, which could worsen stresses that are already high, i.e. drought, high frequency of extreme climatic events causing catastrophic soil erosion, floods and landslides, and endemic and emerging diseases both in crops and animals. Moreover, the Mediterranean region is one of the hotspots of global biodiversity, with a remarkable richness in cultivated and wild species, which must be preserved as a common world heritage. This rich diversity is a valuable asset which can be valorised through the production, transformation and commercialisation of specific agricultural, food and/or bio-products.

The magnitude of the challenges raised by demographic changes combined with the over-use of limited natural resources is amplified by the rising cost of energy coupled with increasing water scarcity. The misuse of irrigation water, deteriorated water quality and overexploitation of genetic resources have caused a deficit in food production and, in turn, the limited food availability produces various conflicts at the domestic, sector (from agriculture and aquaculture to urban areas, industry, transportation and tourism) and transboundary levels.

EUROPEAN RESEARCH AND INNOVATION POLICY IN THE MEDITERRANEAN

In 1995, the Barcelona process leading to the Euro-Mediterranean Partnership started a long process where cooperation and research have a crucial role not only for the Mediterranean area but for Europe as a whole.

Over the years, EU Instruments have played a key role in promoting and framing cooperation efforts between the EU and Mediterranean countries. They have indeed driven the proliferation of transnational user-oriented innovation initiatives connecting a diversity of stakeholders from the public and private sectors, including actors from the research/academic sector (e.g. Universities, research or technological institutes), the industry, the government and the civil society (The "Quadruple Helix Model"⁵). The initiatives

involving countries from both sides of the Mediterranean Sea are highly relevant and desirable, not only because of the historical relationships binding these territories or their geographical and even sometimes cultural proximity, but also because they face common multiscale challenges related to food security, poverty alleviation and natural resource conservation that they must address jointly, and which call for the evolution of agriculture and development practices and their adaptation to current and future changes (e.g. climate, land use, lifestyles, etc.).

EU efforts in promoting transnational cooperation, for example through enhanced researchers' mobility and knowledge and experience exchanges, the sharing of protocols and infrastructures, co-supervised PhD thesis and the implementation of transnational projects, have boosted the development of partnerships and networks involving research and industry teams as well as stakeholders representing the government and civil society.

Agriculture, food and water issues appear to be the main focus of Euro-Mediterranean RDI activities, as evidenced by the great number of bilateral and multilateral cooperation initiatives, transnational projects and publications in those fields, and this level of activity and prolificacy has a lot to do with the support given through the successive EU framework and national/bilateral cooperation programmes.

Besides direct links among researchers, joint initiatives bringing together national research organisations and national funding agencies have been prioritised by European Research Policies. Joining forces between national research systems have been encouraged in the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007–2013), under its Cooperation, Ideas, People and Capacities programmes. This has led to the development of over hundreds of European Research Area Networks (ERA-NETs) and several Joint Programming Initiatives (JPIs) supported by the European Commission (EC) that further enhanced the cooperation among EU Member States. Among these initiatives, some were launched to strengthen the scientific links between EU Member States and their Mediterranean Partner Countries.

ARIMNet (Coordination of Agricultural Research In the Mediterranean Area) (ERA-NET, 2008–2012) has been the main instrument of this cooperation between 2008 and 2012, and after 2012 it was followed by several initiatives focused on other thematic areas, e.g. FORESTERRA and ERANETMED (being a non-thematic ERA-NET, ERANETMED develops activities on Energy, Water, Food and the Environment). Meanwhile, it is worth mentioning the INCO-Nets MIRA and MEDSPRING that played a significant role in enhancing the dialogue among Mediterranean countries, respectively during the 2008–2012 and 2012–2016 periods. ARIMNet2 (2014–2017), which follows and complements ARIMNet, has emerged in this context.

ARIMNet involved 13 partners (funding agencies and research institutions) from 12 countries, including 6 EU Member States (Cyprus, France, Greece, Italy, Portugal and Spain) and 6 non-EU Mediterranean countries (Algeria, Egypt, Israel, Morocco, Tunisia and Turkey). In 2011, a call for research proposals was successfully launched: 11 countries participated, on an equal basis, in designing the priorities and procedures for the call and in co-funding resulting research activities. As a result, 10 research projects were implemented between 2012 and 2016, with a total funding of 7 million euros.

5. <https://ec.europa.eu/digital-single-market/en/open-innovation-20>

FORESTERRA (Enhancing Forest Research in the Mediterranean through improved coordination and integration) (ERA-NET, 2012-2015): This project strived to reinforce the scientific coordination and integration of Mediterranean Forest Research programmes through scientific cooperation between countries from the Mediterranean area, including EU Member States (Spain, France, Italy, Portugal, Bulgaria, Slovenia, Croatia and Greece) and non-EU Mediterranean countries (Algeria, Turkey, Tunisia and Morocco), and involving also countries from other Mediterranean climate areas (Australia, South Africa, Chile and California). In November 2013, FORESTERRA launched a call for research entitled "Mediterranean-scale approach to study global change drivers, impacts and indicators on forest ecosystems and to foster forest system resilience through managing biodiversity", with a budget of ca. 1.5 million euros (funded by 12 institutions from 10 Mediterranean countries). One networking action (MedWildFireLab) and one proposal (INFORMED) were funded.

MEDSPRING (Mediterranean Science, Policy, Research and Innovation Gateway) (INCO-Net, 2012-2016): This project aims at developing a dialogue among governmental institutions, research organisations, associations and the civil society, by reinforcing the Euro-Mediterranean Cooperation on Research and Innovation in relation to the Euro-Mediterranean EU policy as defined in the Euro-Mediterranean Conference of Barcelona [2-3 April 2012]⁶. It addresses the prioritised areas of water, food, energy, health, transport and marine environment.

ERANETMED (ERA-NET, 2013-2017): This programme involves Algeria, Cyprus, Egypt, France, Jordan, Greece, Germany, Italy, Lebanon, Malta, Morocco, Portugal, Tunisia, Turkey and Spain, and it addresses the main Euro-Mediterranean societal challenges (energy, water and food, health, marine environment) that are not covered by ARIMNet2. In 2015, the consortium launched a call for research proposals on renewable energies and water resources and their connections for the Mediterranean region, with a total co-funding of approximately 13 million euros. It launched its second call in March 2016 with an 11 million euros virtual common pot.

In addition to these initiatives, the running EU research and innovation policy (i.e. H2020 and rural development instruments) offers EU Members and their partner countries (in particular Mediterranean countries) support to implement fundamental research such as the one promoted by the European Research Council (ERC), and/or applied and innovation-driven research. These joint cooperation and programming actions strengthen scientific, political and cultural relationships among the partner countries involved. Many bi- or multi-lateral and networking initiatives have been implemented creating a cooperative environment and reaching promising results in some areas. Nonetheless, these efforts still remain insufficient and fragmented, given the dimension of the challenges ahead in the Mediterranean region.

Recognised as a priority by Mediterranean governments, the sustainable management of agricultural and food systems is a cornerstone of the sustainable development in the Mediterranean region. Multiple dimensions are at stake: sustainable agriculture, land-use and forestry management, environmental management of production systems, water and energy-saving techniques, health, and coastal zone dynamics. The strong inter-linkages and interdependencies that exist among climatic, environmental, social, economic and institutional drivers make monothematic and exclusive approaches inadequate to correctly address these complex problems. Integrated approaches are needed to face the multiple, emerging and interrelated problems that Mediterranean societies have to cope with. Ultimately, addressing these core challenges through research and innovation could generate job opportunities and accelerate the socio-economic development of the region, as well as facilitate the intercultural and intergenerational dialogue.

The challenge for all Mediterranean countries, beyond the enhancement of their own agricultural research capacity, is to bring together their national capacities through a mechanism which allows for the alignment of programmes and the implementation of new joint actions, such as transnational calls for research and innovation. This cooperation aims to achieve the necessary critical mass and therefore ensure that research has a stronger impact on the development of the whole region.

In this perspective, the role of the EU is crucial given the urgent need to develop new instruments and policies supporting the Mediterranean agricultural research and innovation efforts for sustainable development of the entire region. ARIMNet2 and other similar initiatives can serve as a benchmark for the EU Policy to set the framework that will allow the enhancement of food security and socio-economic development by promoting productive as well as resilient and sustainable agricultural systems making a rational use of natural resources.

At the EU level, there is still a lot to be gained from the improved alignment and interoperability of national research programmes. The aim is to improve the efficiency of the investment in research at the level of the Member States and the European Research Area through the facilitation of cross-border research development and innovation projects based upon countries' priorities and goals, and using a variable geometry approach. The coordination landscape since ERA-NETs were first introduced has changed remarkably: they are now working closely with other initiatives, particularly with the Joint Programming Initiatives, European Innovation Partnerships, Knowledge and Innovation Communities (KICs) and Public-Private Partnerships (PPPs). The cooperation with Mediterranean partner countries has to move in the same direction.

COORDINATION OF AGRICULTURAL RESEARCH IN THE EUROPEAN UNION

Two European initiatives are highlighted here, as they have been taken into consideration in the elaboration of the ARIMNet2 strategy.

FACCE-JPI

Since 2010, the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI)⁷ brings together 21 countries committed to building an integrated European Research Area addressing the interconnected challenges of

6. http://www.ec.europa.eu/research/conferences/2012/euro-mediterranean/index_en.cfm

7. <http://www.faccejpi.com>

sustainable agriculture, food security, impacts of climate change and economic growth. It follows a creative approach relying on a transdisciplinary research base encompassing scientific as well as economic and social aspects.

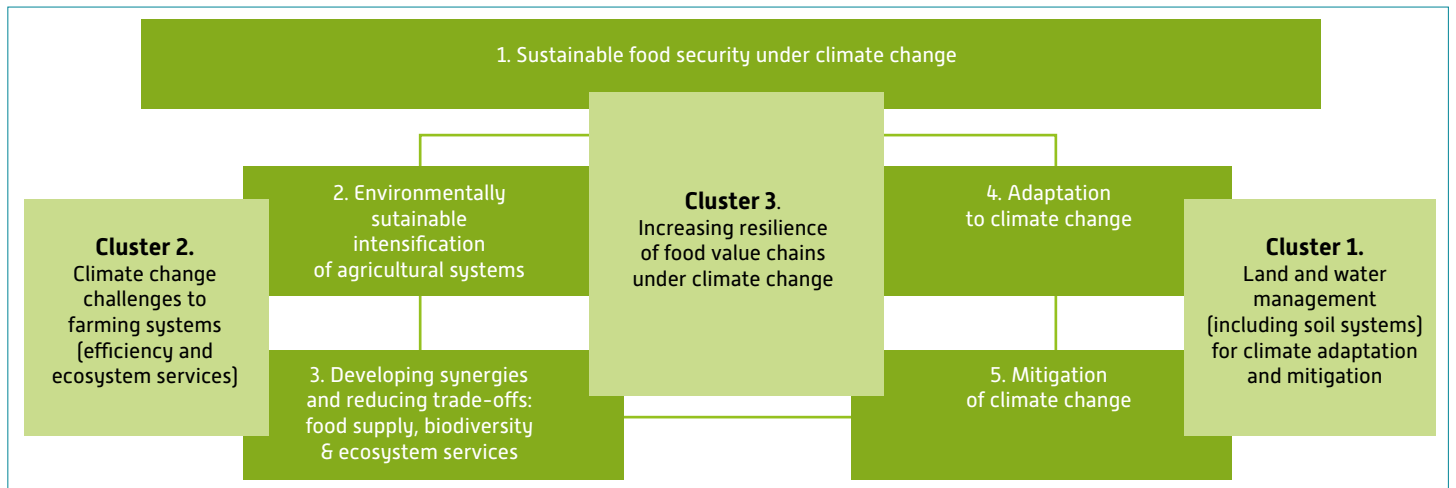
The FACCE-JPI Strategic Research Agenda (SRA) defines short, medium, and long-term strategic priorities (“core themes”) for trans-disciplinary and innovative European research on agriculture, food security and climate change, sets out joint actions for each theme, and provides a framework for the alignment of existing programmes and joint research efforts to achieve the twin objectives of food security and combating climate change. Based on that agenda, FACCE-JPI strives to reinforce knowledge exchange, infrastructures and platforms, as well as training and capacity building, and it ensures the evaluation and monitoring of its activities. The SRA defines five core research themes and three trans-thematic clusters (Figure 1) which provide an integrative approach to identifying research priorities and correspond to the three target scales at which FACCE outputs can be delivered, i.e. farming systems, landscapes and value chains.

From the ARIMNet2 consortium perspective, it is clear that there is much to gain by drawing upon the challenges and scientific priorities identified by FACCE.

The vision of the Standing Committee on Agricultural Research

The Standing Committee on Agricultural Research (SCAR)⁹, since its establishment in 1974, advises the European Commission on European agricultural and wider bioeconomy research. It currently represents 37 different countries, its members being ministries (or other organisations such as research councils) from all EU Member States, with Candidate and Associated Countries as observers. The SCAR evolution in the last ten years reflects the significant changes to the agricultural research agenda over the years. In its original form the SCAR focused on primary agricultural production. Since then, the research and innovation landscape has continued to evolve and this needs to be reflected in how the Committee will operate in the future. SCAR’s activities now encompass the whole bioeconomy area, including food production and processing chain, non-food biomass development for industrial products and

Figure 1. The five core themes and three trans-thematic clusters of FACCE-JPI (FACCE-JPI, 2016).



These core research themes are gradually taken into account by national research agendas in view of aligning national programmes where much research is already undertaken, and inspire pilot joint actions on topics where research is lacking. An implementation plan was launched during the summer of 2013, setting out short-term and mid-term priority actions to implement the FACCE-JPI strategic research agenda, in coherence with the first Work-Programme of Horizon 2020. FACCE-JPI member countries suggest promoting greater coordination with selected European Agriculture Research and Development initiatives active in the FACCE-JPI and involving EU strategic partners. They consider ARIMNet2 as particularly relevant since most of the topics addressed by FACCE are strongly related and common to the Mediterranean area as clearly declared also in the “FACCE JPI European and International Strategy 2016-2020.”⁸

processes, and sectors such as forestry, fisheries and aquaculture. The SCAR membership takes opportunities back to the national level to prevent unnecessary duplication or overlap in the Member States and Associated Countries’ own processes in research policy development and strategic programming activities.

Two activities are today at the core of the SCAR strategy:

- Advice on the development of research and innovation in the bioeconomy. Building on the work underway in the dedicated strategic working groups, SCAR provides advice on possible synergies between EU and national research initiatives in the field of bioeconomy.
- Advice on food security in a global context. When SCAR was established a relevant dimension for coordination of research was introduced among Member States. While this dimension is still relevant, the fact that the most important challenges that research needs to tackle (e.g. food and nutrition security, sustainable primary production and climate change) have a global dimension that calls for EU research to fully contribute at this level. Thus, SCAR has an important role to play in the international dimension of agricultural research

8. <https://www.facejpi.com/Document-library/European-and-International-Strategy>

9. <http://ec.europa.eu/research/scar/index.cfm?pg=home>

coordination and also at the level of the Mediterranean area. Relevant issues are, among others: the role of the European farming and food industry in achieving global food and nutrition security; food safety in a global production and trade environment; the relation between agricultural research and agricultural research for development; the relationship between the EU Framework Programme for Research and Innovation, national research programmes and the research agenda of the CGIAR (Consultative Group on International Agricultural Research); and the development of the international RDI agreements with non-EU overseas countries.

SCAR activities also involve specific studies, as the 4th SCAR Foresight Exercise¹⁰ launched in 2014 to explore the interactions between the primary sector and the bioeconomy, not only in a future perspective but also by developing a paradigm for the bioeconomy under the fundamental constraint of sustainability, a key aspect for the Mediterranean area. The report (see highlights in the following box) calls for the implementation of a sustainable bioeconomy through a set of principles such as "food first", sustainable yields, circularity and diversity. It represents not only a roadmap for a sustainable bioeconomy helping to boost employment, growth and investment in rural economies, but also an important contribution towards global goals such as achieving food and nutrition security, mitigating and adapting to climate change, and sustainably managing our natural resources.

WHAT IS ARIMNet2?

ARIMNet2 (Coordination of Agricultural Research In the Mediterranean; www.arimnet2.net) is an ERA-NET Action (2014-2017) financed by the European Union under the Seventh Framework Programme for research, technological development and demonstration, aimed at enhancing the coordination of agricultural research in the Mediterranean area. It follows and builds upon ARIMNet (2008-2012), an action launched in 2008 as the first ERA-NET bringing together Mediterranean countries from the EU and from the Mediterranean eastern and southern shores.

ARIMNet involved 13 partners (funding agencies and research institutions) from 12 countries, including 6 countries from the European Union (Cyprus, France, Greece, Italy, Portugal and Spain) and 6 non-EU Mediterranean countries (Algeria, Egypt, Israel, Morocco, Tunisian and Turkey).

ARIMNet2 involves new partners totalling 24 national funding agencies and research institutions from 15 countries including Algeria, Croatia, Cyprus, Egypt, France, Greece, Italy, Israel, Malta, Morocco, Portugal, Slovenia, Tunisia, Turkey and Spain.

At the crossroad of thematic (led by FACCE-JPI) and regional (Mediterranean) issues, ARIMNet2 operates as a network identifying scientific priorities, providing funding and reinforcing research cooperation opportunities to address the huge societal challenges faced by the whole Mediterranean area and their implications for the agricultural sector ranging from food production, to water and natural resources use and rural development.

Highlights from the SCAR 4th Foresight Exercise

Concerning research:

- Transdisciplinarity is central to transformational innovation which is usually generated at the boundaries between domains; disciplinary silos may advance knowledge but do not adequately address the big challenges;
- Education systems should prepare scientists, technicians, professionals to complexity, transdisciplinarity and dialogue;
- Career development for scientists should not discourage engagement in transdisciplinary research, involvement in innovation projects, partnership and mobility with the industrial sector.
- We should exploit the fastest growing fields: Data revolution, Gene-Bio-Nano technologies, solar energy, etc.
- Research should support the development, application and adaptation of the concepts of circularity, cascading and sustainability, key concepts to move from principle to science;
- Innovation in the AKIS (Agricultural Knowledge and Innovation Systems) is needed (generation, diffusion, sharing and application of knowledge), as well as open science (access and data);
- Innovation is not only about technology, but also about social models, businesses, markets and behaviours. Social Sciences and Humanities are a fundamental element of research initiatives;
- Engagement with the society, participatory approach and dialogue must be promoted.

Concerning policies:

- Complexity and interconnections between sectors require coordinated policies at the European, national and regional level and good governance is crucial;
- Policies should coherently help the transition to climate smart, resource-efficient and public-health oriented development models: synergies instead of trade-offs;
- Strong coordination between Ministries on research policy issues that are relevant for the Bioeconomy (already in place in several MS) will increase impact;
- Working in this very complex and diverse domain means that the continuity and active membership of SCAR members becomes increasingly important;
- Renewed efforts towards alignment and coordination of programmes is needed;
- Link research and rural development policies to obtain the innovation needed.

Scope and objectives of ARIMNet2

ARIMNet2 builds upon and consolidates the experience and achievements of ARIMNet. Indeed, the better knowledge of current research programmes, the experience of a successful transnational co-funded call in 2011 (Table 1), as well as the commitments and willingness to implement several joint activities and to fund jointly transnational calls have contributed to strengthen the relationships between partner countries and have built a strong cooperation momentum. ARIMNet2 aims to:

- Develop an Integrated Strategic Research Agenda (ISRA) describing key priorities for the European Union and Mediterranean countries in the field of Mediterranean Agriculture Research and Innovation;
- Consolidate the cooperation mechanism started in ARIMNet through the setup of two joint calls for transnational research projects and the elaboration of guidelines for monitoring the research

10. <https://ec.europa.eu/research/scar/index.cfm?pg=foresight4th>

Table 1. List of the ten projects (2013-2016) financed through the 2011 ARIMNet call (details at www.arimnet2.net).

PROJECT ACRONYM	PROJECT TITLE	PARTNER COUNTRIES (in bold, the coordinating country)
APMed	Apple and peach in Mediterranean orchards – Integrating tree water status and irrigation management for coping with water scarcity and aphid control	France , Israel, Italy, Morocco, Spain
ARIDWASTE	Development of specific agricultural practices with the use of recycled wastes suitable for intensively cultivated Mediterranean areas under degradation risk	Greece , Israel, Italy, Spain
CLIMED	The future of Mediterranean livestock farming systems: Opportunity and efficiency of crops – livestock integration	France , Egypt, Morocco
DoMEsTic	Mediterranean biodiversity as a tool for the sustainable development of the small ruminant sector: from traditional knowledge to innovation	Greece , Cyprus, France, Morocco
MEDILEG	Breeding, agronomic and biotechnological approaches for reintegration and re-valorisation of legumes in Mediterranean agriculture	Spain , Algeria, Egypt, France, Italy, Morocco, Portugal, Tunisia
PESTOLIVE	Contribution of olive history for the management of soil-borne parasites in the Mediterranean basin	France , Greece, Italy, Morocco, Spain, Tunisia, Turkey
PoH-MED	Potato health – Managed for efficiency and durability	France , Algeria, Egypt, Morocco
REFORMA	Resilient, water- and energy- efficient forage and feed crops for Mediterranean agricultural systems	Italy , Algeria, France, Italy, Morocco, USA
SAFEMED	Food safety regulations, market access and international competition	France , Algeria, Italy, Morocco, Spain, Tunisia
SWIPE	Predicting whitefly population outbreaks in changing environments	Israel , France, Greece, Italy, Spain, Turkey, USA

projects funded through joint calls;

- Demonstrate the feasibility of other joint activities in some areas relevant to the project and implement those that are jointly strategic;
- Set up pilot actions to develop scientific exchanges among researchers in the Mediterranean area;
- Enhance transnational cooperation and knowledge generation and innovation within the Mediterranean region by sharing objectives and priorities, seeking to establish a common vision on agricultural research and innovation;
- Strengthen the coordination and coherence of the research programming between regional and national institutions;
- Support capacity building in scientific methods, concepts and infrastructure;
- Increase the excellence and relevance of agricultural research in order to address the huge societal challenges related to food, rural development, water and natural resources utilisation that Mediterranean countries are facing today;
- Expand the reflection on Agricultural Knowledge and Innovation Systems (AKIS) that developed inside the EU to the Mediterranean region in order to reinforce the impact of research on the rural development and the economy of the region;
- Establish a solid cooperation framework that will lead to a stable and long-lasting cooperation between EU Member States, associated countries and South Mediterranean Countries (SMCs).

Lessons learnt from the 2015 ARIMNet2 call

The 2015 ARIMNet2 first joint transnational call was launched in September 2014 with the participating funding organisations pooling 7.2 million euros to co-fund transnational research projects.

The process for identifying priorities, evaluating and selecting the projects to be funded took place on the basis of co-decision among participating countries. Eleven topics were identified as priorities to address the challenges faced by the Mediterranean agriculture in terms of sustainable agricultural production, food security and sustainable natural resource management.

A total of 146 transnational projects were submitted, involving 54 countries (South, East and North Mediterranean countries). [4.6 countries per project in average] (Figure 2). Finally, 10 transnational projects were selected for funding after a scientific evaluation by an independent international scientific evaluation panel supported by external reviewers (Table 2).

The eleven ARIMNet2 Topics

- Topic 1: Increase in resilience, rusticity and productivity of Mediterranean agricultural production systems;
- Topic 2: Improving input use management, at the level of the production systems;
- Topic 3: Common Mediterranean challenges in animal and plant health;
- Topic 4: Sustainable Mediterranean aquaculture and fisheries;
- Topic 5: Innovation in agroindustry;
- Topic 6: Logistics, supply chain organisation and transportation;
- Topic 7: Food safety and food sanitary issues;
- Topic 8: Food consumption patterns: consumers' behaviour, quality of products, diet and nutrition;
- Topic 9: Agricultural and food policies;
- Topic 10: Sustainable management of water and other resources used by agriculture;
- Topic 11: Landscape and spatial management, competition with other land uses, peri-urban and urban agriculture.

Figure 2. Participation of the Mediterranean countries involved in the first ARIMNet2 call (2015), expressed as the percentage of project proposals involving a given country, in reference to the 146 projects presented.

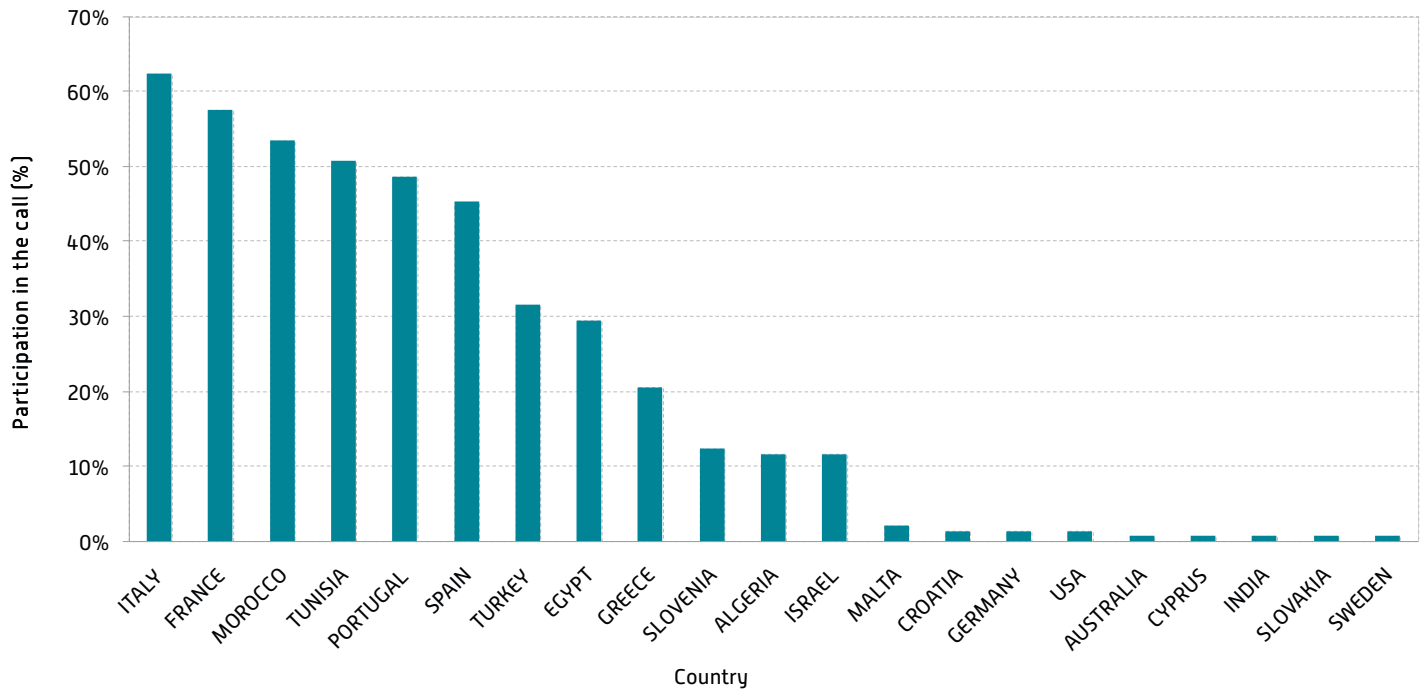


Table 2. List of the ten projects financed through the 2015 ARIMNet2 call.

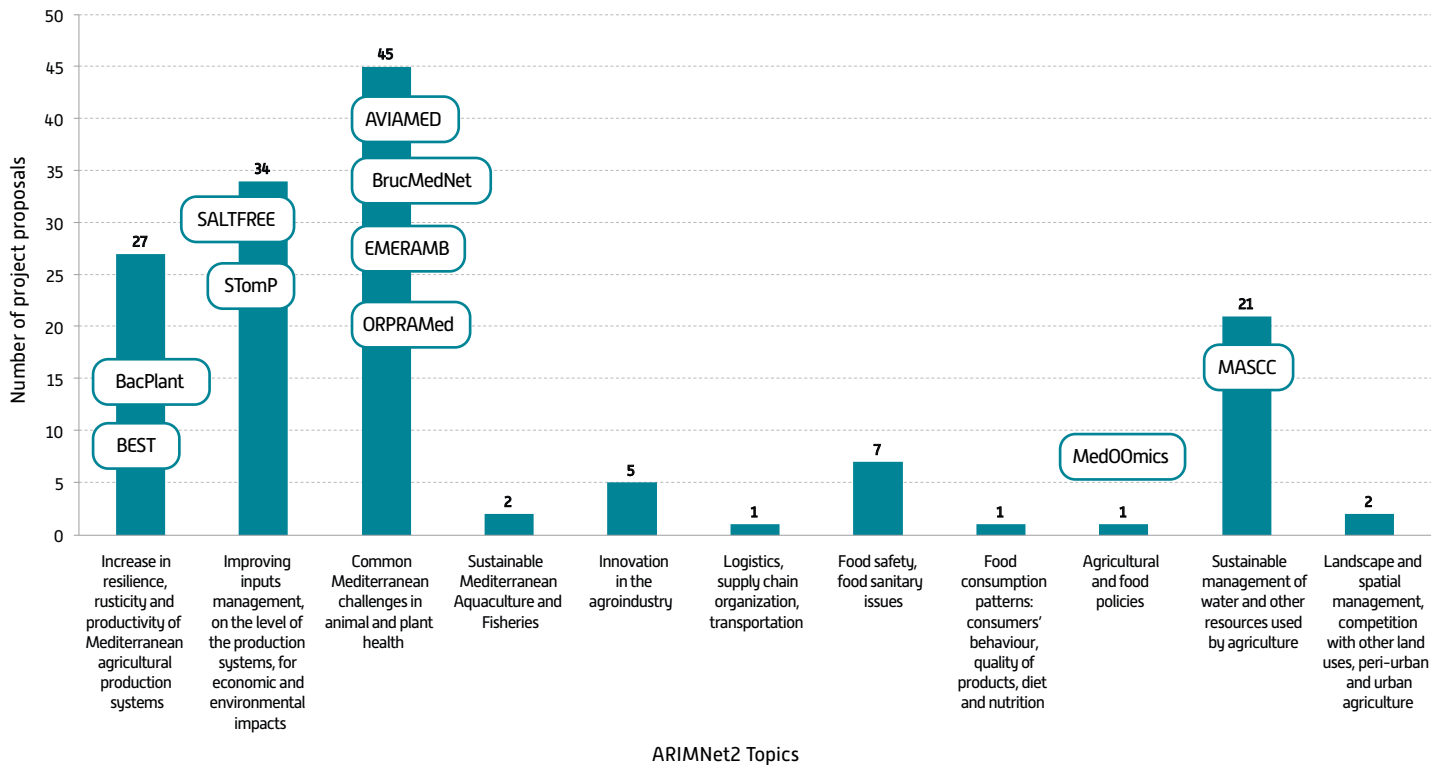
PROJECT ACRONYM	PROJECT TITLE	PARTNER COUNTRIES (in bold, the coordinating country)
AVIAMED	Avian viral disease prevention and control with plant vaccines for the Mediterranean area	Italy , Egypt, Morocco
BacPlant	Towards a sustainable agriculture by increasing plant tolerance to biotic stress under climatic change	France , Morocco, Tunisia
BEST	Exploring genotypic diversity to optimise barley grain and straw quality under marginal/stressful growth conditions	Tunisia , Egypt, France, Morocco, Slovenia
BrucMedNet	Improvement of epidemiological and serological tools for diagnosis and control of Brucellosis in the Mediterranean region	Italy , Egypt, Greece, Portugal
EMERAMB	Emergent viruses and virus vectors in Mediterranean basin crops	Spain , Egypt, France, Greece, Israel, Italy, Morocco, Slovenia, Turkey
MASCC	Mediterranean agricultural soils conservation under global change	France , Italy, Morocco, Portugal, Spain, Tunisia
MedOOmics	Mediterranean extra virgin olive oil omics: profiling and fingerprinting	Portugal , France, Tunisia, Turkey
ORPRAMed	Risk assessment of introduction of <i>Xanthomonas citri</i> subsp. <i>citri</i> through commercial trade of ornamental rutaceous plants in the Mediterranean basin	Italy , Spain, France, Turkey
SALTFREE	Salinisation in irrigated areas: risk evaluation and prevention	Portugal , Egypt, Italy, Tunisia
STomP	Sustainable tomato production: plant defence enhancement, development of new biopesticides and optimisation of environmental, water and chemical inputs	Italy , France, Greece, Morocco

Regarding the topics' coverage, Figure 3 shows the distribution of pre-proposals submitted among the 11 priorities and indicates the ten selected projects.

The proposals were unequally distributed among the eleven topics, with a concentration on issues related to animal and plant

health, agricultural production systems and water management in agriculture. The topics relating to food chains and territorial development did not raise applicants' interest. This is partially due to the decision of some funding agencies to concentrate their funds on selected topics, e.g. Italy on topics 2, 3 and 10, and Spain on topics 3, 6 and 10.

Figure 3. Number of project proposals received for each of the eleven topics considered for the 2015 ARIMNet2 Call, and topics addressed by the ten projects selected for funding.



Similar results were obtained in the call launched by ARIMNet in 2011 with 75% of the proposals being related to “production systems”, while only 25% to “food chain” and “natural resources management”, even if all these topics were declared to be fundable by all the countries in this case.

The small number of projects addressing food chains, policies and territorial development raised concerns that were taken into account in preparing the following joint activities.

Poverty alleviation, employment creation, economic growth and social development require a real change in the way the agro-food sector is organised, modernised and linked with urban areas. To disregard these topics would limit the impact of ARIMNet2 on one of its main objectives that is to contribute to the improved and sustained economic and social development of the Mediterranean area. Broadening the base while designing the research project may require the adoption of a more holistic approach, may involve more scientific fields and/or researchers and/or implementers, and may demand a better coordination.

It is well known that research targeting agriculture and related fields must possess multi-dimensional facets based on societal, political, environmental, technical (basic and applied sciences), economic and/or management aspects. Additionally, there are significant interactions, in many cases site-specific, which may lead to Gordian knots. The main feature of ISRA is the systemic approach that is implemented in defining the priority thematic areas. This approach is expected to deliver results that will have a greater impact and at the same time will support those applying for calls.

Scope of the ARIMNet2 ISRA

The ISRA constitutes a basis to set up a common vision on challenges and priorities for agricultural research in the context of the Mediterranean area. The overall and main objective of ISRA is to build the roadmap for joint actions in the framework of ARIMNet2. The document describes the key priorities for the EU and Mediterranean countries in the field of Mediterranean agriculture, defines the scientific strategic priorities shared among partners and establishes the ways the research agenda is to be implemented and reviewed on a regular basis. It addresses the ways to reinforce research activities in the Mediterranean, to share research infrastructures and platforms, and to develop training and knowledge exchange. The ISRA builds upon complementarities and synergies with other initiatives, in particular the FACCE-JPI and Water-JPI on the one hand and the Mediterranean initiatives (e.g. ERANETMED) on the other.

From the regional perspective, the Euro-Mediterranean Conference on Research and Innovation organised in Barcelona in 2012 concluded with a recommendation to revisit the partnership by focusing on co-ownership, mutual interest and shared benefits. These are the principles behind ARIMNet and ARIMNet2. Under the current economic conditions, there is a greater need to enhance multilateral cooperation for research to strengthen the economies of the Mediterranean countries and to help finding solutions to global and regional challenges. In 2014, EU Member States and South and East Mediterranean Countries proposed to the Commission to implement a long-lasting and ambitious initiative to enhance the Research and Innovation cooperation in the Mediterranean area. The PRIMA initiative¹¹ has emerged from the need to foster socio-economic development in the area and from the role that research

can play in achieving this objective. Today, as stated by the PRIMA initiative, the mutual interest in the region is focused on the sustainability of the agro-food systems from production to consumption, the increased pressure on water and other natural resources and the protection of the rich natural and cultural heritage, in a context of uncertainties linked to climate and socio-economic changes.

Towards an enhanced research and innovation cooperation in the Mediterranean region

Facing the multiple, emerging and interrelated issues and challenges of the Mediterranean area calls for an integrated and shared approach towards research and innovation promotion, which should multiply job opportunities, boost the socio-economic development and facilitate the intercultural and intergenerational dialogue; Science is to provide convincing evidence to support desirable transitions. There is a strong need for the establishment of a real partnership towards a common knowledge and innovation space in the Mediterranean region, as a key to its sustainable development. It is the role of the ISRA to provide a general common frame to ARIMNet2 action, and beyond that, to give ideas for further actions.

ARIMNet2 STRATEGY FOR THE MEDITERRANEAN REGION

LEARNING FROM PREVIOUS STUDIES

As a preliminary work to the preparation of the ISRA, a review of the prospective studies conducted for Mediterranean agriculture in recent years was carried out¹². Foresight literature, including studies or projects such as MEDITERRA¹³, PARME¹⁴, MEDPRO¹⁵ and SUSTAINMED¹⁶, was carefully reviewed.

Five major issues were identified through this literature review that focused mainly on the SEMCs:

Import dependency

Actually, the region depends heavily on imports for only a few commodities in addition to tropical products, which cannot be produced locally: cereals, sugar, oils and oilseeds, as well as dairy products. It is for cereals that the total import bill for the whole region is the largest (more than 12 billion US dollars in recent years) in spite of Turkey often being a net cereal exporter. Given the importance of cereals in the diet of most people, particularly the poorest, this cereal import dependency is the source of a major concern with

economic, social and political ramifications. Two questions are thus raised: 1) Can domestic production be increased? and 2) Can agricultural and food imports be better managed? Answers could be that 1) Accelerating the rate of growth of domestic production involves many challenges for public authorities in SEMCs and should be given prime importance in a strategic research agenda for the region, and 2) Better management of agricultural and food imports have not yet received much attention and could also deserve an agenda for research (analysis of government behaviours towards this issue and how they can be improved).

Stubborn rural poverty

Poverty, particularly rural poverty, has been and remains a major issue in SEMCs, mainly Arab countries. Among poverty alleviation policies, a key place has been given to food policies in many countries, notably in Algeria, Egypt, Morocco and Tunisia. The dilemma faced by public authorities for decades has been striking. The budget share of food is very high among the poor. Thus, keeping the price of food as low as possible is an effective way to protect them. But in North Africa, many farmers are also poor and their welfare is negatively affected by low prices for the products they sell. Hence, in many countries of the region, public authorities have put in place a complex system of market interventions, setting a wedge between producer and consumer prices. As a result, public budget costs have escalated and they will continue to do so in the future if the policy mix is not radically changed. This illustrates one of the thorniest interactions among policy challenges faced by countries in the region: What is the most appropriate market intervention, given the import dependency discussed above? And what is the best rural poverty alleviation policy, given the major role given to market interventions in this domain? The link between these two challenges is critical because agriculture remains the main source of income for many rural poor.

Deteriorating natural resources

Soil, water and biodiversity, the main natural resources of interest here, are under threat dramatically in the Mediterranean region and this threat will sharply increase with global warming. Great challenges arise for the countries of the region. Soil erosion seems to be rapidly increasing in particular in many dry and remote regions because the poor rural population cannot afford the investments which would be necessary for prudent sustainable management of the resource. Short-term pressures resulting from poverty and demographic growth lead to over-consumption (cultivating marginal lands, overgrazing and excessive collection of fuel wood). New methods of intervention, more inclusive and targeting jointly the management of soils, water and biodiversity, have been suggested and experimented in recent years and will continue to require efforts in the future. Water resources are recognised as critical in the Mediterranean region. Reducing waste and increasing water use efficiency would require major changes in behaviour by a variety of water users and social constraints of various sorts must be overcome. The sustainable management of water resources has been, and will continue to be, extremely challenging. Biodiversity is also under threat in the region. Protecting species and protecting ecological sites requires the integrated management of the environment (ecosystemic approach) as well as major communication and training efforts. In other words, the challenges faced to conserve biodiversity are very similar to those resulting from the imperative obligation to sustainably manage soil and water.

11. <https://ec.europa.eu/research/environment/index.cfm?pg=prima>

12. Petit M., El Hadad-Gauthier F., 2014. Review of prospective studies for Mediterranean Agriculture - Implications for Agricultural Research. Working Document, ARIMNet2 Project, 45 p.

13. <http://ciheam.org/index.php/fr/publications/mediterr-2014>

14. <http://www.agropolis.fr/pdf/gestion-projets/fiches-synthese-arp-parme-2011-english-version.pdf>

15. <http://www.medpro-foresight.eu/fr>

16. <https://sustainmed.iamm.fr>

Worrisome demographic trends

In spite of the demographic transition, in which several SEMCs are definitely engaged, total population continues to increase, many young people begin to enter the labour market creating a huge gap between national labour demand and supply, and – most importantly for our purpose – the total rural population continues to increase in most of the region. Contrary to what happened in Europe and other developed countries during the past century, the modernisation of agriculture cannot be driven in SEMCs by a rapid decline in agricultural employment and a massive substitution of capital for labour, with the size of farms increasing. In this region, the number of hectares per agricultural worker, already very small, will continue to decrease, which will make any increase in the average productivity of labour very difficult and will dampen the possibility of improved agricultural income per person working in agriculture. Hence, it will be important to diversify the sources of income for rural households, thereby increasing the urgency of non-agricultural job creation in rural areas, a great challenge indeed, given what was just said about the huge increase in the total supply of labour in the whole economy.

Erosion of the Mediterranean diet

Deterioration in the nutrition quality of the diet portends serious public health problems, associated in particular with the spread of obesity. This concern justifies enhanced attention to food safety measures and institutions, as well as a major education effort on healthy nutrition. In addition, the link with agricultural and rural development policies, illustrated by the motto of the Mediterranean Diet, "from landscape to the table", adds another dimension to the complexity of the challenges identified above.

These five stakes are serious and call for new and sometimes radical public policies. Research, notably agricultural research, can make a significant contribution to the elaboration of these new policies as well as providing new technical solutions to some of the problems identified above.

Based upon the existing challenges and outcomes of the previous works, the priority issues that Mediterranean societies have to address were determined and targeted through the ISRA in order to develop stronger research networks and programmes. The facts and figures presented here do not have the ambition to fully describe all Mediterranean challenges. Indeed, they are often well-known features underscored by other studies/initiatives. Our goal here is thus to point out what we consider as most relevant for identifying priorities.

MAIN ISSUES AND TARGETS

Population and societies

While the total population in Europe reached 738 million inhabitants in 2015, it is now expected to drop to 734 million inhabitants by 2030

17. United Nations, 2015. *World Population Prospects (2015 Revision). Key Findings and Advance Tables*. Department of Economic and Social Affairs, Population Division. NY, USA, 66 p.

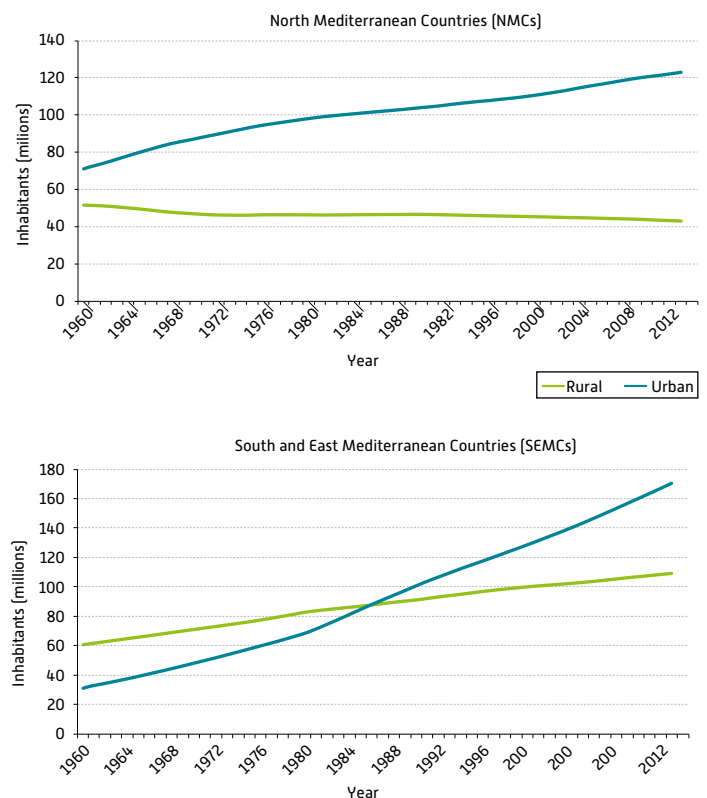
18. http://ec.europa.eu/eurostat/statistics-explained/index.php/Urban-rural_typology

19. World Bank, 2011. *MENA Development Report. Poor places, thriving people: how the Middle East and North Africa can rise above spatial disparities*. Washington DC, USA 392 p.

20. <http://www.worldbank.org/en/region/mena>

and to 707 million by 2050¹⁷. Nonetheless, SEMCs still have higher population increase rates. According to 2010 OECD figures (original OECD classification and new urban-rural typology¹⁸), 40.4% of the EU-27 is classified as predominantly urban, 35.4% as intermediate and 24.2% as predominantly rural. A similar fast urbanisation trend exists in the South and East Mediterranean, as underlined in the 2011 World Bank MENA Development Report¹⁹. Indeed, in 1960, in the Middle-East and North Africa (MENA), 65% of the population was rural, but in 2007, 65% was located in urban areas. While in Mediterranean EU countries the rural population remains stable (c. 40 million inhabitants), it has been and is still tremendously increasing in the SEMCs, from 60 to more than 100 million inhabitants during the last 50 years. In both situations, we observe an increase in urban population to 170 million inhabitants in the SEMCs and 120 million in the North (Figure 4).

Figure 4. Trends in Mediterranean urban/rural population between 1960 and 2013, in North Mediterranean Countries (NMCs, top) and South and East Mediterranean Countries (SEMCs, bottom) (Source: PRIMA proposal, based on World Development Indicators, 2014).



The 3% of MENA surface area that is densely populated is home to 92% of the population²⁰. This area has a population density of over 50 persons per km². Domestic migration is a significant problem as revealed by the average urban population growth rate (3.3% per year) compared to 2.6% for the national average. This region also has the highest share of its population (53%) living in coastal areas that are vulnerable to climate change.

The Mediterranean region faces similar problems; however, the situation is aggravated by the higher population growth rates in SEMCs creating regional disparities with regards to natural resources. The magnitude of the problem increases for these countries where the economic costs of environmental degradation are high,

ranging from 2.1% of the gross domestic product (GDP) in Tunisia, to as much as 7.1% of the GDP in Iran²¹. The ecological footprint of the nations from the Mediterranean region shows that there is a risk of deficit in nearly all of them when compared with their bio-capacity. In NMCs, a deficit exists since the 1960s and in many SEMCs the situation changed and a deficit also appeared towards the end of the 1970s²².

The Mediterranean is a highly fragmented region showing one of the sharpest differences in GDP per capita in the world. The way the region as a whole manages the use of scarce resources will have significant impacts on economic growth and social stability. The high unemployment rate and marked domestic and international migrations are all influenced by the socio-economic instability and will be largely determined by how human capital will develop and flow across the region. Moreover, the political problems, and especially polarisation, affect alliances.

The World Development Indicators showed that, in 2000, the economic added-value of an EU agricultural worker was still 13 times higher than the average one in Morocco, Algeria, Tunisia, Syria and Turkey. This shows that the economic gap between North and South is still very deep, having significant consequences on the market. Among all Mediterranean countries the main and common challenge seems to be management of natural resources for security and sustainability of agro-food systems in the region.

Most of the SEMCs (except Turkey) are net importers of agricultural products (mainly cereals) and this trend has even accelerated during the last decade (Figure 5).

Globally, total agricultural exports have almost doubled during the last two decades (they have been multiplied by four in Egypt and by 5 in Algeria). The population living in the Mediterranean basin

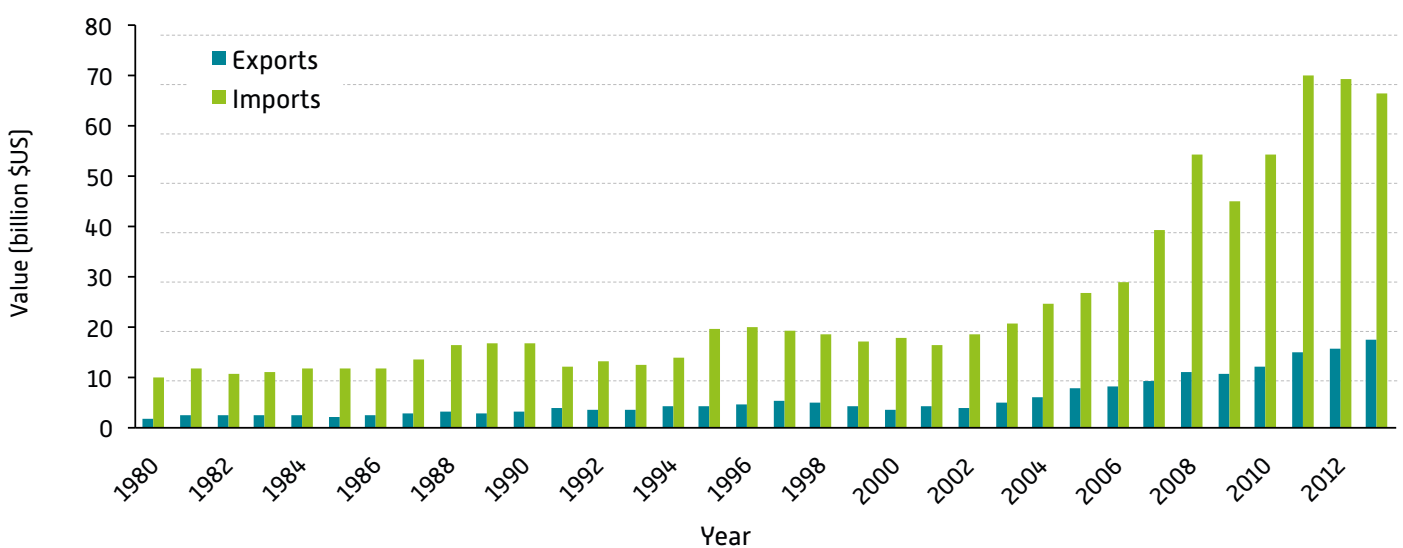
represents 7% of the global population, and imports 22% of the world cereals, while SEMCs have 4% of the population and 12% of the cereal imports. Moreover, North African and Near East countries are net importers of the main animal products. Egypt and Algeria are dramatically depending on food importations as they had a negative balance of respectively 2.7 and 2.2 billion euros in 2001. On the other hand, Turkey and Morocco are the only southern countries with a positive balance of 2.0 and 0.2 billion euros respectively in 2001. Morocco has a positive advantage in fish products and is considered to have one of the best fishing potentials in the world. Consequently, apart from France and, to a lower extent, Turkey, all the other Mediterranean countries are large net food importers²³ with a percentage of $[(\text{exports} - \text{imports}) / \text{consumed calories}]$ below -25%, and this situation may not change significantly in the short-term.

Some southern Mediterranean countries are almost dependent on the EU market for exports while others have negligible figures for the exports to the EU. In 2007, the average share of southern Mediterranean exports directed to the EU was 47%; however, exports to the EU account for over 70% of their total trade volume in the case of Morocco and Tunisia, for approximately 45% in Algeria and Syria, about 30% in Egypt and only 3% in Jordan²⁴.

Additionally, southern Mediterranean countries have the lowest levels of trade integration between neighbouring countries, with less than 6% of their total trade.

Better management of the research and innovation will result in shared benefits no matter if they are supplying or demanding goods to and from the European market and increase South to South integration. Many agro-food products are perishable in nature

Figure 5. Total agricultural exports and imports of SEMCs in billion US dollars (PRIMA Proposal, updated with WTO Database, 2015).



21. <http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/MENAEXT/0,,contentMDK:20525954~pagePK:146736~piPK:226340~theSitePK:256299,00.html>

22. <http://www.footprintnetwork.org/en/index.php/GFN/page/trends>

23. <http://faostat3.fao.org/home/E>

24. <https://www.weforum.org>

and may require even variety specific conditions for storage, transportation, safety and quality standards. In case of significant differences among countries in this regard, failures may occur and create a trade barrier. To facilitate trade there is a need for alignment of the legislation supported by research, institutional

building and investment in infrastructure and human capacity building. The population increase rate is still high in non-EU partners leading to higher young, urban and total populations; moreover, ageing is a serious problem for the EU. On both banks, the future of farming is addressed, and making it attractive and providing some wealth is at the core of the agenda of our societies.

The recent trends in demographic development and concentration of the population on the shoreline, adopting an urban lifestyle with consumption patterns more than ever based on exogenous models and imported products, lead to a growing divide between the shoreline and the upcountry. These changes result from local competition between different land uses both within the agricultural sector with changes in the dominant practices (traditional vs. market-oriented crops and practices) and between agricultural and other land use types with a sprawl of urbanised areas in particular on coastal zones.

These main changes are not independent and act in a feedback loop: the disturbance of traditional agriculture territories surrounding urban areas due to the expansion of cities leads to the development of a market-oriented agriculture further away to feed cities, while these developments disturb ecosystems in rural areas. We are thus witnessing the emergence of new forms of poverty (both urban and rural) accompanied with a new web of landscapes and problems related to the management of residual land at risk (soil degradation, weak management of stocks and hydric flux, etc.). Thus, there is a need to rebuild solidarities between urbanised shoreline and the upcountry by developing production systems well adapted to site-specific conditions. This issue is particularly relevant and important for the Mediterranean region and needs to be studied in detail. This divide raises several problems such as land rights, integrated territorial and renewable natural resource management, urban and peri-urban agriculture, modes of organisations of producers and marketing circuits (export/import) inside a given sector.

The undernourished population percentage is below 5% in most of the countries. The dietary energy consumption is quite good for the Mediterranean countries (all above 2,800 calories per capita and per day), especially if considered in contrast with the majority of the more Sub-Saharan countries²⁵. However, changing consumption habits result in diversions from the Mediterranean diet putting forward the question of healthy diets in terms of forestall public health risks resulting from a "standardised" nutrition. Does the Mediterranean region paradoxically not run the risk of being one of the areas on the planet with the least familiarity with the Mediterranean diet? If, due to rural poverty and high prices, the main local products are destined only for exports or important occasions, how would consumers react to a context of rising prices for agricultural raw materials at the world level especially if these products are increasingly imported?

25. FAO, 2004. *The State of Food and Agriculture 2003-2004. Agricultural Biotechnology Meeting the needs of the poor?* Rome, Italy.

26. Meinzen-Dick R. and Quisumbing A., 2011. *Women in Agriculture, Closing the Gender Gap*. In FAO, 2011. *State of Food and Agriculture 2010-2011, Chapter 4 – Gains from closing the gender gap*, p.40-45. <http://cdm15738.contentdm.oclc.org/utis/getfile/collection/p15738coll2/id/127433/file-name/127644.pdf>

Despite efforts put into education, a gender gap in economic activity still exists in non-EU Mediterranean countries. Reports of the Food and Agriculture Organization's (FAO's) State of Food and Agriculture 2010-2011 and the World Bank's World Development Report 2012 highlight the importance of gender equality in agriculture. In this respect, research and innovation related to activities in which women are traditionally involved such as the post-harvest handling and processing of crops, for the development of simple and user-friendly technologies that can be utilised on-farm for value adding will help to save labour, generate income, improve nutrition and prevent losses. Moreover, special emphasis is given to the long-term impact assessment to recognise the different needs of men and women²⁶. Women play a major role in the Mediterranean agriculture especially in family farming; therefore, gender sensitive and/or specific techniques and technologies should receive special attention. Ecologically and economically sustainable practices such as bio-intensive management systems where female farmers actively take part can be developed for small plots and family farms.

The demographic challenge

- The overall Mediterranean population is increasing, mainly in the southern shore.
- Population is aging in the North, while it is young in SEMCs.
- The urban/rural population ratio is increasing across the whole Mediterranean area.
- In SEMCs, rural population is still increasing.
- Urbanisation on the coastal zones modifies the organisation of food supply chains.
- Imports/exports are growing.
- Trade integration level between Mediterranean countries is still relatively low, in particular concerning South-South trade.

Natural resources

Mediterranean countries rely on a great diversity of incredibly valuable natural resources, i.e. biotic or abiotic materials that we can use but cannot make up, such as water, air, soils or biodiversity whose management is of vital importance for societies. However, the Mediterranean ecosystem is rather complex and fragile, threatened by climate and land use changes, soil erosion, compaction and salinisation, water pollution (e.g. eutrophication, contamination by pesticides and heavy metals), habitat destruction and fragmentation, and biodiversity loss. Addressing these challenges effectively calls for sustainable practices adapted to current and future changes and pressures. The Mediterranean region as a whole faces similar problems, but there are significant regional differences with regards to natural resources availability and use, which are strongly linked to population size, growth, urban/rural ratio, among others. The situation is indeed aggravated and more worrisome in South and East Mediterranean countries, where population growth rates are higher and where rural populations heavily depend on non-renewable energy sources and wild commodities.

Soil degradation (e.g. loss of organic matter, compaction and sealing, desertification, salinisation, contamination) and erosion (e.g. aerial, fluvial), and the subsequent loss of fertility of agricultural lands, are

critical issues and major obstacles to the sustainability of all forms of agriculture in hilly and mountain areas (Figure 6). Indeed, erosion exceeds often 30 times the rate of sustainability (tolerable erosion) and soil degradation over the last 40 years caused a decrease of about 30% in their water holding capacity as well as an impairment of several other ecosystem services (e.g. water filtering, biodiversity conservation). Unfortunately, these issues are expected to get worse under current climate change scenarios (IPCC, 2013). In the Mediterranean region, arable land degradation still continues. Intensified agricultural practices and pasture use coupled with population growth threaten these lands, lower productivity and lead to desertification.

Taking into consideration both the environmental and economic effects, the efficient use and cycling of nutrients, namely nitrogen, still remains a priority in the region. Phosphorus also receives attention since it is a limited resource at the global scale and is seen as a key tool to support North African countries' economic growth.

As regards water, it is a scarce, valuable and coveted resource in the Mediterranean (Figure 7), and it will be even more so in the future. The Mediterranean climate is characterised by infrequent rainfall [less than 100 days a year] that is unevenly distributed [long periods of summer drought] and sometimes quite sparse [limited to about 300 to 500 mm of precipitation per year in some semi-arid regions]. Most countries in the region face problems of misuse and overuse of water resources. For example, the mobilisation of surface water by waterworks and groundwater pumping have lowered water tables, altered rivers' hydrologic regimes and environmental flows, and disturbed downstream aquatic and semi-aquatic ecosystems. In addition, poor management of agricultural inputs (e.g. fertilisers, pesticides) has led to the deterioration of water quality in watersheds and aquifers making it improper for human consumption and/or irrigation. Additionally, the Mediterranean is considered one of the most vulnerable regions to climate change, which will consequently worsen the existing problems of drought, extremely high temperatures, unexpected climatic events, and increased endemic and emerging crop and animal diseases. The sea level rise observed in the Eastern Mediterranean is alarming, even if the impact of the climate change phenomenon has not yet been fully clarified. Since 1992, the average rise is estimated at around 12 cm

[i.e. 0.5 cm per year] in the Eastern coast causing greater sea water intrusion and salinity problems which threaten land resources. Consequently, carrying out a thorough climate change risk assessment for agricultural production systems (plant and livestock) and food supplies is of great importance. It has indeed become urgent to develop strategies to mitigate and adapt to the effects of climate change. In fact, most climate change scenarios for the region forecast decreased rainfall and higher temperatures, while the population will continue to grow until 2030.

In most Mediterranean countries, except France, almost 70% of available water resources are used for agriculture (Figure 8). This intense use competes seriously with other industrial and social uses, including domestic water consumption in the cities, tourism on the coast or other similar uses, etc., and this competition is exacerbated by the fact that the water resource is limited in quantity and quality (and almost no more is suitable for irrigation) and threatened by climate change.

For an effective management of water flow and quality, what is needed is, on the one hand, to ensure observations of surface water and groundwater at different scales and, on the other hand, to develop appropriate models for understanding better the processes involved in the water cycle, stakeholders' behaviour and the impacts of different management practices. It is essential, therefore, to begin today to design new ways of water management, to ensure greater equity and efficiency of resource use and to monitor its impacts on ecosystems, soils and societies at different levels of organisation.

Since water is a scarce resource in the Mediterranean, not only the plant material but management systems must be developed to improve water-use efficiency and reduce water consumption. However in case of rain-fed cultures, supplementary irrigation programmes may also help to enhance yields and quality. The choice of an appropriate and rational irrigation management is of key importance.

Water storage systems could experience major changes in some Mediterranean areas, which have important implications for agricultural production planning, as well as the development of insurance systems. It is very important to strengthen strategies including water capturing, storing, and management, increasing the efficient

Figure 6. Desertification and soil erosion transforming fertile agricultural-prone lands into barren landscapes.



Moroccan landscape

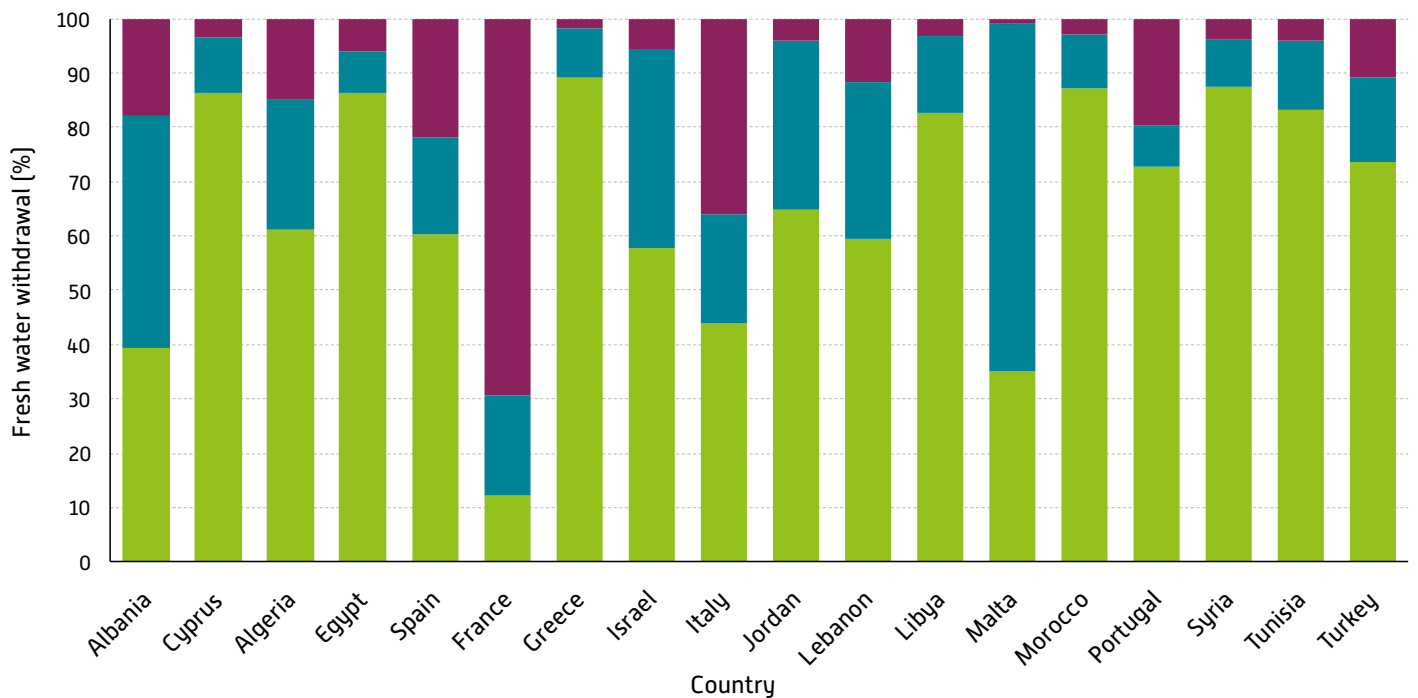


Soil erosion gullies, downstream the Sidi Salem dam canal, North-West Tunisia

Figure 7. Water: a very valuable resource in the Mediterranean region that must be carefully managed.



Figure 8. Freshwater withdrawals for agricultural, industrial and domestic use (in % of total freshwater withdrawal) in some Mediterranean countries (FAO Aquastat, 2013).



use of irrigation for climate change adaptation. Smart irrigation systems combining remote sensing, sensors and software that provide near-real-time estimates of irrigation needs, as well as precision irrigation, deficit irrigation, fertigation and safe water reuse technologies will need to be further developed in drought-prone areas, the pricing of water and its sharing among multiple users and sectors need to be studied and improved.

Concerning biodiversity, the Mediterranean region is well-known as one of the richest areas in the world in terms of plant and animal richness and diversity, and it is recognised as one of the 25 Global Biodiversity Hotspots. It hosts 25,000 native species and more than half of these are endemic²⁷. This incredibly rich biodiversity can be utilised as an efficient tool to implement climate-smart agriculture and is a golden asset to promote ecotourism. As an illustration, the region has rich traditions associated with the use of medicinal and aromatic plants. Plant-derived products are indeed used whether traditionally or industrially to produce medicines, cosmetics (e.g. Argan oil from Morocco), perfumes and food additives. The increasing demand and unsustainable collection from the wild has resulted in the erosion of the diversity of several plant species. The current situation urges policies to protect better medicinal and aromatic plants from extinction, by framing the collection of wild specimen and by regulating their sustainable cultivation, to attenuate the pressure on wild populations.

To alleviate the pressures on ecosystems and their potential deleterious consequences on biodiversity and food security, the rich Mediterranean agrobiodiversity can be utilised through collaboration as the major pool to develop new species/types. A key challenge concerns plant and animal breeding. Preserving genetic resources, defining new breeding targets in response to elevated CO₂, to abiotic (e.g. high temperatures, water deficit, ozone, salinity, etc.) and biotic stresses (e.g. from emerging pests and diseases) and developing advanced infrastructures for plant and animal breeding are key priorities.

Water, soil and biodiversity resources are exposed to multiple pressures under climate and land use changes, and it is thus evident that adaptive management methods must be developed at a range of interconnected scales (e.g. from the field to the watershed), taking into account the diversity of regional contexts.

Efforts must be made to connect, following a trans-sectoral and multidisciplinary approach and in a long-term perspective, the multiple stakeholders involved (e.g. government, academia, industry, administration, civil society; public and private actors) from all concerned sectors (agriculture, rural development, water, energy, land planning, etc.), to improve their coordination and cooperation and increase their capacity to jointly reduce the vulnerability of ecosystems to extreme events, and effectively cope with them.

Crop production systems

In the Mediterranean area, the land has been cultivated for millennia since the very early stages of agriculture/domestication and

27. Cuttelod A., García N., Abdul Malak D., Temple H. and Katariya V., 2008. *The Mediterranean: a biodiversity hotspot under threat*. In: J.-C. Vié, C. Hilton-Taylor and S.N. Stuart (eds). *The 2008 Review of The IUCN Red List of Threatened Species*. IUCN Gland, Switzerland.

28. http://ec.europa.eu/agriculture/envir/index_en.htm

The natural resources challenge

- Mediterranean countries face multiple and interlinked challenges related to natural resources conservation, including soil loss and degradation, water pollution, habitat destruction and fragmentation, and biodiversity loss, in a rapidly evolving climate and socio-economic context.
- Agriculture is one of the major drivers of the state of natural resources together with urbanisation and industry, and has therefore a crucial role to play in their sustainable exploitation and conservation.

landscape are thus the product of continuous interactions between humans and their natural biotic and abiotic environment. The genetic bases for grains, legumes, seeds, fresh and dried fruits, nuts, vegetables, medicinal and aromatic plants, culinary herbs and cash crops are rather wide and the climatic conditions avail the commercial production of these species. However, genetic erosion is still quite intense, as a consequence of various factors. Today, the development of vast monocultures composed of very few species targeted to world-wide trade may result in complex issues such as the loss of soil fertility, the intensive use of inputs leading to soil and water pollution, or the fragmentation of habitats and subsequent loss of biodiversity.

The Common Agricultural Policy (CAP) has identified three priority areas²⁸ for European countries to reduce the impact of farming practices on natural resources: (1) Biodiversity and the preservation and development of "natural" farming and forestry systems, and traditional agricultural landscapes; (2) Water management and use; and (3) Dealing with climate change. These priorities also address the threats that Mediterranean countries have to face, which impact annual or perennial systems or wild species at various levels, and the solutions may vary due to the specificities of the farming systems in use. Research on crop production systems is critical to improve their productivity in a sustainable way (Figure 9).

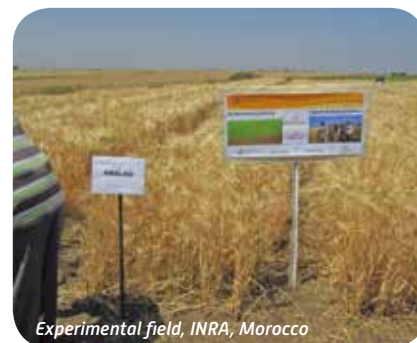


Figure 9. Experimental setups to test new crop varieties, improve their water and nutrient use efficiency, enhance their resistance to pests and diseases, and boost the productivity and sustainability of farming systems.



The Mediterranean region is surely a hotspot for biodiversity but it is also a particular reservoir of various virulent plant pests and diseases. These could propagate towards the North under the influence of climate change and of the intensification of the exchanges (e.g. trade and tourism) between the different regions. This issue is of greatest importance for the fruit production sector. Indeed, fruit trees are perennials and thus, economic losses might persist over long periods, and also, the preservation and/or exchange of genetic material requires specific conditions. The recent outbreak of *Xylella fastidiosa* in olive groves in southern Italy is a clear example of such kind of threat. Plant diseases and pests also cause significant losses in cereal crops and vegetables, as well as in date palm (e.g. date palm weevil). Ensuring regional food security also requires a more effective fight against plant pests through the identification of plants' resistance genes and the better management of cropping systems to limit the spread of diseases, the development of resistance by pathogens, and the loss of effectiveness of pesticide treatments. In particular, biological diversity plays an important role in controlling animal and plant pests, as regards both the temporal (crop succession) and the spatial dimension at various organisational levels (from the plot to the whole landscape).

Perennial systems (olive, grapes and fruit production)

The major Mediterranean crops grown on large areas are mostly perennials and 16% of the total cultivable land of the Mediterranean area is occupied by a wide range of fruit species (Figure 10), producing stone fruits (e.g. olives, peaches, apricots, cherries and dates), fleshy fruits (e.g. grapes, citrus), pome fruits (apples and pears) and nuts (e.g. hazelnut, pistachios, almonds and pine nuts) as well as Mediterranean "minor" species such as pomegranate, figs, prickly pear or carob. Their economic importance may vary from the internationally-traded level as it is the case for olive oil, dates, citrus or grapes, which are mainly destined to the export markets (namely to the EU), to locally important species such as quince, cornelian cherry or berries grown only in home-gardens²⁹. The relative importance of each species varies from one country to another: e.g. Turkey leads the production of cherries, hazelnuts, dried figs, grapes and apricots; Tunisia is the major exporter of dates; Egypt ranks 4th worldwide for the exportation of oranges and potatoes; and France and Italy lead wine exportations³⁰.

Perennial fruit species are either grown extensively as rain-fed (e.g. olives, almonds, hazelnut, pistachio, prickly pear, figs and carob) or grown intensively under irrigated conditions (e.g. citrus, peaches, grapes and cherries). Site-specific ecological factors and cultural practices affect the yield and quality, therefore, the selection of the appropriate species, variety or rootstock and implementation of suitable management systems play a vital role. In the case of fruit production, the juvenile period may vary between 2 to 8 years and current research strives to shorten this period either through the use of new cultivars or through innovative orchard management

systems, aware that any wrong decision while establishing the orchard might cause serious delays as well as economic losses.

Among Mediterranean fruit trees, the olive tree is probably the most emblematic and Mediterranean countries are by far the world leaders in olive oil production. In those countries, olive groves cover vast areas as monocultures and they represent an important source of employment and a driver of economic development for many rural communities. EU-Mediterranean countries have a share of 73.7% followed by other Mediterranean countries as Turkey, Syria and Tunisia (Table 3).

Current olive production systems are the result of millennia of evolution and adaptation of cultivation techniques and cultivars to local and global conditions. Nonetheless, their sustainability and profitability calls for research to allow for further improvements of the rain-fed olive ecosystems. In this respect, research targeting the breeding of new cultivars or rootstocks and developing management systems for specific pedoclimatic zones will increase their economic performance while decreasing their environmental impact.

Overall, a research emphasis is required for maintaining and/or improving the yield and quality of various fruit species without increasing the impact of their production on the fragile natural resources of the Mediterranean. Since plant-soil-water relationships play a key role in determining orchard productivity and fruit quality, sustainable and innovative management systems with a particular emphasis on soil fertility and water management will help to enhance resource use efficiency.

To protect soil from erosion, an adequate supply of organic matter is crucial, because it helps to improve the structural characteristics of the soil; the role of the vegetation cover is also critical, as it attenuates the impact of rain drops and subsequently surface crusting and reduces the intensity of surface runoff, hence preventing soil loss. For tree crops, the promotion of surface grass/legume cover is a viable strategy, particularly in areas where a significant increase in climate aggressiveness is expected³¹. The greatest hindrance to its diffusion is the competition for water between herbaceous cover and the main crops. Where it is possible to overcome this constraint, such a management system has proved more effective than reduced tillage. Testing cover crops and/or green manuring crops at cultivar level is required at major Mediterranean microenvironment levels and for main fruit production systems. Moreover, there is a great variability among fruit trees with respect to drought, salinity or alkalinity tolerance, and research work seeking to reveal and understand adaptation, avoidance, resistance or tolerance mechanisms is still needed.

Changes in climate also impact the synchrony in pollination and result in yield reduction. Thus pollinating varieties must be re-evaluated and/or pollinating agents must be revisited and maintained in orchards so as to maintain this vital ecological service. To ensure proper orchard establishment, density and tree architecture studies are required to mitigate and adapt to climate change effects. The challenges raised by climate change urge breeding programmes that utilise rapid and safe techniques for variety (main commercial varieties and/or pollinators) and rootstock development in order to provide higher adaptability to changing conditions in a diversity of environments.

29. Tous J. and Ferguson L., 1996. *Mediterranean fruits*, pp. 416-430. In: J. Janick (ed.), *Progress in new crops*. ASHS Press, Arlington, VA.

30. <http://www.worldstopexports.coms>

31. Gómez J.A., Campos M., Guzmán G., Castillo-Llanque F. and Giráldez J.V., 2014. *Use of heterogeneous cover crops in olive orchards to soil erosion control and enhancement of biodiversity*. Minutes of ELS2014 –The Earth Living Skin: Soil, Life and Climate Changes, Bari, Italy.

Figure 10. Some of the most important fruit crops cultivated in the Mediterranean region and exported worldwide, fresh or processed (e.g. beverages, compotes, marmalades).



Table 3. Olive oil production in the Mediterranean area (average from 2009/10 to 2014/15) (International Olive Oil Council, November 2015³²).

TERRITORY / COUNTRY	PRODUCTION (1,000 TONNES)	SHARE OF THE WORLD PRODUCTION [%]
WORLD	2,911.2	
Spain	1,274.9	43.8
Italy	395.1	13.6
Greece	284.3	9.8
Tunisia	180.3	6.2
Turkey	166.3	5.7
Syria	164.7	5.7
Morocco	123.3	4.2
Portugal	68.9	2.4
Algeria	52.1	1.8
Jordan	21.2	0.7
Lebanon	17.8	0.6
Palestine	17.3	0.6
Libya	15.6	0.5
Israel	13.3	0.5
Egypt	12.3	0.4
Albania	8.9	0.3
Cyprus	5.5	0.2
France	4.5	0.2
Croatia	4.5	0.1
Slovenia	0.5	0.0
Montenegro	0.5	0.0
Malta	0.04	0.0

32. <http://www.internationaloliveoil.org/estaticos/view/131-world-olive-oil-figures>

In the Mediterranean region, fruit farm size ranges from a few large-scale commercial farms to a high number of small family farms. Survival of family farming is crucial for the rural livelihoods. For rural development, farmers may be encouraged to yield by-products that will allow them to get additional income during the off-seasons.

Land and water ownership is still a problem in some areas. Since water is a scarce resource in the Mediterranean, not only the plant material (fruit species and rootstock) but also management systems must be developed to improve water-use efficiency (i.e. by reducing evapotranspiration and overall water consumption). However, in case of rain-fed cultures, supplementary irrigation programmes may also help to enhance the yields and quality in addition to ground cover management. The choice of an appropriate and rational ground/irrigation management scheme is of key importance in fruit orchards since they occupy the same land and interact with the rhizosphere for decades. For long-term sustainability, the management of on-farm and surrounding areas play an important role and it should obey the traditional landscape and provide a habitat for preserving beneficial insects and biodiversity.

Annual crops (cereals, legumes and vegetables)

Mediterranean countries are also leaders in various annual crops such as cereals, root and tuber crops and vegetables. Production volumes and trends vary notably from one country to another³³. Concerning wheat as staple food (Table 4), SMCs are all net importers; if Egypt is known as a major wheat importer, it experiences an increase in both the area and value of its wheat production whereas the production is stable in Tunisia and France (among the top wheat exporters).

Legumes are also an essential part of the local diet in almost all Mediterranean countries and they complement daily protein intake requirements, even if not subject to exportation. Developing rotation and/or green manuring programmes integrating legumes with other species will lower the use of nitrogenous fertilisers, enhance soil organic matter, structure and nitrogen levels, improve the protein contents of the harvest, and finally lower production costs and boost competitiveness.

Soil is becoming a more limited resource; therefore, the systems developed must also help to control erosion that is often aggravated by inadequate plantation models and/or unsuitable land management techniques. We must foster management practices that minimise or eliminate soil tillage (conservation tillage), including crop rotation and use of catch crops (cover cropping), consider the burying of crop residues or mulching with plant material (organic mulching), adopt organic fertilisation and, more generally, reduce crop intensification and respect the suitability of soils.

In that sense, precision farming and user-friendly irrigation techniques and programmes well adapted to specific Mediterranean ecosystems' conditions should be promoted and adequate support should be provided to farmers in their implementation. They can complement farmers' choices in terms of plant material and agronomic approach, helping them to better manage nutrients and water inputs as well as pesticides applications, towards more productive, healthy and resilient agroecosystems.

Research policies should prioritise the development of integrated systems that are equally efficient in water, plant nutrients and

Table 4. Wheat production, import and export of some Mediterranean countries in 2013 (FAO, 2016³⁴).

COUNTRY	WHEAT PRODUCTION (average of 2012, 2013, 2014) (1,000 tonnes)	WHEAT IMPORT IN 2013 (1,000 tonnes)	WHEAT EXPORT IN 2013 (1,000 tonnes)
Algeria	3,055	6,304	0
Egypt	9,178	10,288	0
France	39,293	311	19,638
Greece	1,782	848	208
Italy	7,369	5,793	188
Libya	200	1,863	0
Morocco	5,309	2,728	0
Spain	6,241	3,401	592
Tunisia	1,337	1,485	0
Turkey	20,383	4,053	275

The other cereals and field crops are mainly grown for animal feed and fodder and must be taken into consideration as an integral part of livestock production systems. To ensure their sustainability, policies need to be closely linked with fodder crops that are well suited to local conditions.

energy use and that ensure market competitiveness. The performances of traditional Mediterranean crops with a greater adaptability need to be optimised under rain-fed and irrigated (deficit and optimum) systems.

Mediterranean countries rely on fertiliser and pesticide importation for plant production. Except for Morocco, an exporter of natural phosphates worth around 1.5 billion US dollars, all

33. <http://www.fao.org/giews/countrybrief>

34. <http://faostat3.fao.org/browse/Q/QC/E>

Mediterranean countries import mainly nitrogenous fertilisers³⁵. Turkey pays almost 25% of its total export value of agricultural products for the importation of fertilisers³⁶. Therefore, developing varieties with high nutrient efficiency or rotation systems that reduce additional off-farm fertiliser requirements or systems promoting the use of on-farm inputs are of vital importance.

Pesticide use, as shown by FAO figures, is decreasing in some countries (e.g. in Northern Mediterranean countries and Turkey) while it remains stable (e.g. in Tunisia) or increases (e.g. in Egypt) in others. The growing concern for safe agro-food products and changing trade regulations force Mediterranean countries to adopt comparable regulations and instruments. From the pesticide residues point of view, vegetables are more prone to pesticide spray since they are mostly grown under intensive systems including glass or plastic house conditions and destined to direct consumption. The variations in the regulatory framework, number of registered pesticides and differences in maximum allowed limits for contaminants also hinder trade between the north and south of the Mediterranean. Increased cooperation and deeper analyses of the cases will help to solve such problems. Research and innovation, on the other hand, will surely find safer alternative systems/techniques to control weeds, pests, diseases and obtain adequate yields and quality. Breeding programmes benefiting from rich biodiversity should be integrated in the strategies especially for major species.

Specific high added-value plants

The Mediterranean area is characterised by a rich plant diversity that is actively consumed by the local population which has led to the world-wide known concept of "Mediterranean diet" associated with a natural and healthy connotation. The Mediterranean diet is based on the daily consumption of fruits and vegetables, grain (mostly whole), olive oil, nuts, beans, legumes, seeds, herbs and spices, all easily found across the region. They have a significant importance in supplying carbohydrates, vegetal proteins, phytochemicals, many vitamins and minerals. In addition to their contribution to nutrition and health, they have multiple uses in medicine, industry or agriculture, agroforestry and soil conservation, and they bring value to marginal lands in semi-arid environments and contribute to rural development.

Some locally consumed wild or cultivated species with high added-value (e.g. aromatic and medicinal plants used by the food, cosmetic and pharmaceutical industries, Figure 11) can be evaluated in respect of their health properties and commercialised to widen the Mediterranean crop range. The demand for fresh or dried culinary herbs is increasing in the European market. The rich Mediterranean flora can be excavated in this respect. Similarly, the needs from the cosmetic and pharmaceutical industries must be considered.

Non crop species such as wild herbs used as vegetables or others found in rich plant germplasm bear the potential to develop new crops or to regenerate old local products. Both the interest for the Mediterranean diet and typical products and tourism activities help to disseminate these minor/local species and to raise awareness on their health, ecological and socio-economic benefits.

Figure 11. Examples of plant species with a high value on the national and international markets for their visual, olfactory, organoleptic or pharmaceutical properties.



Lavender field for the production of dry lavender and lavender extract



Woman from a local cooperative crushing argan kernels for the production of argan oil, Souss Massa Daraa Region, Morocco

The plant production challenge

- Mediterranean populations have been cultivating for millennia a wide range of perennial and annual plants and trees to cover their food needs first and to serve other uses then.
- Plant production is supported by a wide genetic diversity, specific climatic conditions and a long agricultural tradition, but it must cope with multiple constraints (e.g. water stress, soil degradation and plants pests and diseases) and often relies on chemicals importations (e.g. fertilisers and pesticides).
- Research targeting the breeding of new cultivars or rootstocks and developing management techniques for specific pedo-climatic zones will increase the economic performance of plant production systems while decreasing their environmental footprint.
- Research policies should prioritise the development of integrated systems that are equally efficient in water, plant nutrients and energy use and that ensure market competitiveness.

Animal production systems

Some common specificities of Mediterranean livestock systems

Small ruminants are present all around the Mediterranean

Strong differences exist between Mediterranean countries in terms of ruminant production: northern countries, which benefit from a more favourable climate and from the EU Common Agricultural

35. www.faostat3.fao.org

36. www.tarim.gov.tr

Policy, have greater cattle herds than southern countries where dry climate and poor grasslands fit better small ruminants such as sheep and goats (Figure 12). The region hosts about 5% of the world cattle herd and 13% of the small ruminants.

Algeria, mainly because of their wide arid areas³⁸. This lack of rainfall is also combined with very high temperatures, exacerbating aridity. Because of the dry climate and consequently the lack of grass, pastoral systems are widespread in the Mediterranean region

Figure 12. Cattle, sheep and goat heads (in millions) in Mediterranean countries (FAO, 2014³⁷).



Sheep husbandry and meat production is important in all Mediterranean countries, ranging from around 100 tonnes per year in Malta to over 280,000 tonnes in Algeria and Turkey. Goat meat production is most significant in SEMCs, ranging from 32 tonnes per year in Malta to over 55,000 tonnes in Egypt and Turkey, without accounting for the household consumption, which is quite elevated for this species. The goat sector is also important for France and Spain for dairy products. Camels are widespread in southern countries, where camel herding is an important enterprise in the poor pastoral areas and arid lands, as a cheap source of meat, although few economic data are available to characterise its economic importance. Camels' immigration from sub-Saharan countries to North Africa represents a potential regional trade business, accompanied with security and transboundary diseases risk. Buffalo husbandry is very important in Egypt as well as in Italy for quality milk and cheese production. Nevertheless, it does not represent a major animal production activity at the level of the Mediterranean area as a whole.

Importance of the pastoral systems

While NMCs, including Turkey, have an average yearly rainfall above 500 mm, this average is below 500 mm in SEMCs such as Lebanon and Syria and even below 300 mm in Egypt, Libya and

as the animals are forced to move to feed in semi-arid regions. In most parts of the pastoral area from North Africa, the grass availability period lasts around three months. This low feed availability limits the milk yield of local cows which ranges from 2,100 to 3,400 litres of milk per year, depending on the calving season³⁹. For other sources, the average milk yield can even be as low as 1,000 litres per cow and year⁴⁰. Nonetheless, pastoral systems can be compatible with a fairly good productivity for small ruminants (Figure 13), especially when the ewes receive good quantity of concentrate feed, mainly cereals purchased at a high price, except when government subsidies exist.

Diversity of the poultry production systems

Poultry meat is today consumed all around the Mediterranean and is even often the most consumed meat. In the MENA region, it represents currently one third of the total meat consumed⁴¹. Its consumption has strongly increased during the last forty years (representing less than 10% in the 1960s), while in the same time, the consumption of meat from small ruminants has strongly decreased (from 30% in the 1960s to 15% today). Poultry meat consumption is largely based on imports but also on local production. This change in consumption has been accompanied with the appearance of intensive poultry operations producing large quantities of eggs and poultry meat.

However, the rural sector ensures 20-35% of the poultry production in SEMCs. It is important for the livelihood of rural societies,

37. <http://faostat3.fao.org/browse/Q/QA/E>

38. *The State of Food and Agriculture 2003-2004. Agricultural Biotechnology Meeting the needs of the poor?* Rome, 2004.

Figure 13. Importance of pastoral systems in the Mediterranean region for sheep, goat and cow husbandry.



Mixed sheep and goat herd, Ipeiros region, Greece



Goats climbing on argan trees to feed on the leaves, Essaouira region, Morocco

especially for women, as the main source of income and animal protein feeding their children. It is mostly raised inside the houses under moderate hygienic conditions which complicate the control of endemic diseases (i.e. Avian Flu), with the subsequent animal and human health issues. Value chain development is a hot issue for the development of this sector.

Another type of rural poultry husbandry system in SEMCs is the semi-intensive broiler production system, which tends to develop around small towns and cities. It is commonly used by small-scale producers and characterised by having one or more pens in which the birds can forage on natural vegetation and home residues to supplement their feed supply. It applies semi-intensive techniques and is linked to some extent with a developed value chain, thus representing an interesting source of supplementary income.

Animal health as a major common issue

The fragility of the Mediterranean ecosystem, the flows and concentrations of human and animal populations, the proximity of humans and animals, the sometimes uncontrolled use of antibiotics and anti-parasitic products, the difficulties in implementing effective health inspections, and the effects of climate change are all factors that favour the persistence of pandemic animal diseases, the resurgence of epidemics and the emergence of new pathogens. Not only does this pose a threat to human health, but it also constitutes a major constraint on efficient agricultural, husbandry and economic practices in agricultural and livestock systems in the region. The issue of animal health must be addressed in relation to the factors driving the emergence of new pathogens and vectors and considering the integrated management of zoonoses. There is a need to address the effects of climate change and the associated risks for animal health (including existing and emerging diseases). Dealing



Newly reclaimed lands, El-Hamam, Egypt

with increased risks will depend on the efforts to adapt livestock systems, both in confined and pasture systems (the former are also affected by climate change). Issues such as animal breeding for robustness, e.g. adaptation to heat and other extreme conditions, as well as breeding of plants for better nutrient composition and higher production under changing abiotic stress conditions, should be taken into consideration. Changes in animal production may affect the release of greenhouse gases and therefore interact with emissions mitigation efforts.

Bovine and ovine sectors

We chose to focus on the bovine and ovine sectors because of their importance for Mediterranean agricultural systems, not only in terms of food production but also with respect to natural resources use and management.

Bovine sector

The Mediterranean bovine sector has experienced considerable structural changes over the last decades. It has been influenced by a diversity of drivers acting at the global, European and national levels to increase livestock systems' efficiency, productivity and/or sustainability, including: the European Common Agricultural Policy and national agricultural policies; the recent global economic crisis (e.g. drop in purchasing power); changes in demography; shifts in consumption habits (e.g. changes in the quantity of red meat consumed in the diet influenced by income level and preferences); sanitary crises (e.g. Bovine Spongiform Encephalopathy, Foot and Mouth disease, Bluetongue disease); embargos and free exchange

39. Mouffok C. and Madani T., 2005. An effect of calving season on milk production of the Montbeliarde breed under Algerian semi-arid conditions. In: INRA and Institut de l'Élevage, Proceedings of the 12th Gathering on Cattle Research, Paris, 208 p.

40. Ghersi G., 2002. L'agriculture des pays méditerranéens du sud entre conquête des marchés européens et réponse aux besoins de subsistance. In: Proceedings from "Comprendre les agricultures du monde", Mission Agrobiosciences, Marciac, France, 17 p.

41. INRA, Pluriagri, 2015. Addressing agricultural import dependence in the Middle East – North Africa Region through the year 2050. Short Summary of the study. <http://prodnra.inra.fr/ft?id=7AECC48F-AF48-4E85-BBC6-940B893F2D9B>

agreements; and the growth of international competitors (e.g. India – largest world beef exporter since 2015, followed by Australia, Brazil and USA)^{42, 43}.

The trend in cattle (i.e. bovine) meat production within the Mediterranean area has changed over time and differs across countries⁴⁴. In 2013, France (1.4 million tonnes), followed by Turkey (869,292 tonnes), Italy (842,000 tonnes), Spain (580,840 tonnes), Egypt (472,000 tonnes), Morocco (254,000 tonnes) and Algeria (139,948 tonnes) were the largest cattle meat producers in the Mediterranean. Between 2004 and 2013, while the production was stable in France (ca. 1.4 million tonnes), it dropped in Italy (from 1.14 million to 842,000 tonnes) and Spain (from 713,886 to 580,840 tonnes) and increased sharply in Turkey (from 365,000 to 869,292 tonnes), Egypt (from 325,154 to 472,000 tonnes), Morocco (from 140,000 to 254,000 tonnes) and to a lesser extent in Algeria (from 125,000 to 139,948 tonnes). During the same period, the size of the European cattle herd decreased by 10%, mainly due to the restructuring of the milk sector: indeed, the population of milking cows, which represent two thirds of all European cows, shrank by over 12% while the population of suckler cows remained relatively stable, and much larger than the dairy population in all European countries (except Spain and Ireland).

When considering beef and veal meat consumption, strong disparities exist across Mediterranean countries, reflecting disparities in living standards and preferences: in France, Italy, Egypt, Turkey and Spain, people consume in average around 24, 21, 11, 8 and 6 kg of beef per capita per year^{45, 46, 47, 48}. As a comparison, EU inhabitants consume in average around 10.5 kg of beef per year, much less than pig (31 kg/capita/year) and poultry (21.6 kg/capita/year)⁴⁹, and this consumption dropped by 13% during the last two decades, notably in NMCs (Greece, Spain, Portugal, Italy), explained by an increase in the price of meat coupled with a decrease in purchasing power, and by a dietary shift influenced by health and environmental concerns.

As regards bovine trade, the European and Mediterranean bovine meat balance is negative. A great part of the beef and veal trade is organised within the Mediterranean area: for instance, live animals are exported from France to Italy and Spain to be fattened, and France also exports meat to Greece and Italy. European countries

also export beef and veal meat to Middle-East and North-African (MENA) countries although India, Brazil and Australia are now their main suppliers..

Despite a reduction in the price difference between the meat sold by world leading beef producers and Mediterranean producers, the gap remains quite important, and the Mediterranean beef sector suffers from a competitiveness deficit.

Mediterranean bovine production systems are in competition with other agricultural and non-agricultural uses, especially for natural resources such as land and water, and they are more and more constrained by the current climate change context as well as by human health, animal welfare and environmental legislations. Sustained research and innovation efforts on animal nutrition, health and breeding as well as on consumers' preferences will contribute to improve the cattle production potential of the Mediterranean area and its sustainability, and will support the sector in its adaptation to the changing demand driven by the ongoing changes in socio-economic factors (population, urbanisation, etc.) and the growing concern for human health and environmental protection.

Ovine sector

The trade of ovine meat, which has long been polarised, has experienced important changes during 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 countries⁵⁰.

According to 2013 FAO data⁵¹, Turkey is today the first Mediterranean producer of sheep meat (295,000 tonnes in 2013), followed by Algeria (280,000 tonnes), Spain (118,000 tonnes), Morocco (118,000) and France (111,000 tonnes) (Figure 14). In some cases, this production could even be higher due to the fact that the data are based on records from registered slaughters, which means that domestic slaughtering is not taken into account. This is quite common in southern Mediterranean countries where most of the animal trade concerns living heads. In France, the production is decreasing and the breeding flock is falling by around 1.5% per year. This trend mainly affects northern France, whereas the Mediterranean area of France has maintained its production, supported by specific grants of the CAP second pillar. This is also due to the dynamism of the dairy sheep sector compared to the meat sector in this country. France imports a large amount of sheep meat from the UK (40%) and Ireland (20%), but also from New-Zealand (17%), which has a leadership situation on the world market. Greece has the highest consumption of the area and consequently imports a great part of its sheep meat from Spain and New Zealand.

Characteristics of Mediterranean dairy and meat products

Overall, the dairy sector (Figure 15) is a strategic economic sector and emblematic social sector in Mediterranean countries. Nowadays, the recent changes in consumption habits with an observed return to more traditional and local products incentivise the development of new forms of traditional dairy products at the territorial level. One of the main challenges is to support this diversity of models as part of the cultural, economic and environmental sustainability of the territories. Besides, goat and sheep dairy systems located in the Mediterranean coastal line play an important role in terms of landscape management and biodiversity preservation.

42. Chotteau, 2014. *La filière viande bovine française. La Revue Scientifique Viande et Produits Carnés*. Institut de l'Élevage.

43. Pons V., Pouch T., 2015. *Viande bovine : une décennie de mutations sur le marché mondial. Assemblée Permanente des Chambres d'Agriculture (APCA)*. http://www.momagri.org/FR/articles/Viande-bovine-une-decennie-de-mutations-sur-le-marche-mondial_1284.html

44. http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Statistics_on_slaughtering_all_species_by_country_2014.png

45. <http://www.interbev.fr/wp-content/uploads/2014/10/essentiel-filiere-viande-bovine-francaise-2014.pdf>

46. http://www.magrama.gob.es/es/alimentacion/temas/consumo-y-comercializacion-y-distribucion-alimentaria/informeconsumoalimentacion2014_tcm7-382148.pdf

47. OECD Data: <https://data.oecd.org/agroutput/meat-consumption.htm>

48. http://www.magrama.gob.es/es/alimentacion/temas/consumo-y-comercializacion-y-distribucion-alimentaria/informeconsumoalimentacion2014_tcm7-382148.pdf

49. OECD/Food and Agriculture Organization of the United Nations, 2015. *OECD-FAO Agricultural Outlook 2015*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/agr-outlook-2015-en>

Figure 14. Sheep meat production and consumption in Mediterranean countries (FAO, 2013; OECD, 2013; For Tunisia and Morocco: authors' calculations based on 2010 national data).

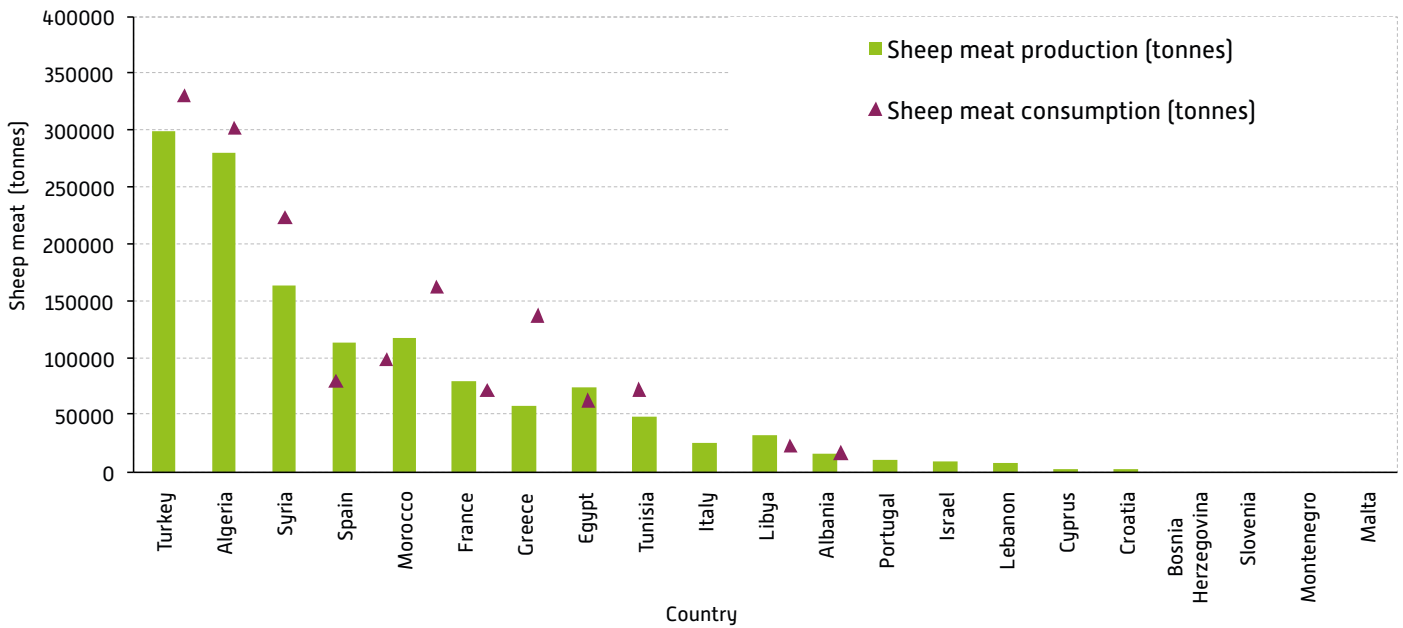


Figure 15. Dairy production and transformation at the small and large scale.



50. FranceAgrimer, 2015. *Marché mondial de la viande ovine : un commerce en mutation. Les Synthèses de France Agrimer no. 22, Septembre 2015.*

51. <http://faostat3.fao.org/browse/Q/QL/E>

52. <http://faostat3.fao.org>

53. <https://data.oecd.org/agroutput/meat-consumption.htm>

Ovine dairy systems⁵⁴ in the northern Mediterranean region are mainly dedicated to cheese processing with the production of high added-value products (with certificates of origin or geographical indications). With a production of 1.90 and 1.23 million tonnes in 2013, France and Italy respectively are the biggest Mediterranean cheese producers. Greece remains the biggest producer of sheep milk cheese with 125,000 tonnes produced in 2013, followed by Spain (62,400 tonnes), Syria (60,500 tonnes), Italy (52,502 tonnes) and France (28,470 tonnes). As regards goat milk cheese, France is the biggest producer with 93,455 tonnes produced in 2013, followed by Greece (40,000 tonnes) and Spain (37,800 tonnes).

The bovine milk production ceased in the northern Mediterranean to concentrate in more favourable zones, where it is mainly oriented towards the production of raw milk for the industrialised sector. The other zones with a production of added-value cow milk cheese are located in the mountainous areas (like the South-Alpes, Massif Central and Pyrenees), at the border of the Mediterranean zone. The suppression of milk quotas in 2015 accentuates this process. France and Italy are the biggest Mediterranean cow milk cheese producers, and rank second and fourth worldwide respectively.

On the other hand, milk is the main bovine and ovine product in SEMCs. Indeed, cattle are raised mainly for milk production, while the produced calves are used as a meat source. Meanwhile, family dairy processing of ovine milk is a very important activity in these countries for rural communities, both for their livelihood and as an important nutritional source of animal protein, especially for women and children.

Light carcasses are a specificity of Mediterranean meat production systems. Mediterranean consumers are used to consuming 90% of their bovine meat as young. Furthermore, the frequent milking of small ruminants also leads to light young carcasses. For instance, the "lechal" in Spain or the "agnello" in Italy have an average carcass weight of 10 and 7 kg respectively. In Middle-East countries such as Turkey and, to a lower extent, Syria, a great part of lambs come from a specific breed, the Awassi, which is aimed at both meat and milk production, with a specific fat tail. Carcass weights are therefore also high in these countries (with an average of 15.8 kg in Turkey). On the other hand, in most SEMCs, sheep are slaughtered at a higher weight because they are mainly consumed for religious or social events considering the symbol associated with rams.

Aquaculture and fishery

Aquaculture has become a major industry in the Mediterranean with the pioneering development of shellfish farming during the first half of the 20th century, followed by marine fish farming in the 1970's (Figure 16). Today, aquaculture production in neighbouring countries in the Mediterranean has exceeded that of caught fish and its growth should continue at a steady pace for decades to come. While the total fishery yield of Mediterranean fleets is estimated at 970,110 tonnes of edible marine produce, aquaculture in Mediterranean countries yielded over 1.6 million tonnes in 2014 (an increase of 89% compared to 1995 yields)⁵⁵. This rapid (and sometimes illegal) growth in the Mediterranean is preoccupying. It can be the

source of conflicts of use and pollution phenomena, salinisation of low-lying land, biodiversity loss, etc. Developing sustainable aquaculture is based on adopting an ecosystem approach that seeks to optimise the supply of commercial services (production of foods or substances of economic interest and cultural heritage for tourism, etc.) while ensuring the long-term future of services engaged for aquaculture production (water quality, producing seed/juveniles, etc.). Thus, there is a need for a better knowledge of farmed organisms (e.g. genetic architecture of traits of interest, physiology of sexual development and biological bases of domestication) and their production systems (integration in the environment, design of "mixed-farming" systems embracing crops, livestock and aquaculture, to minimise environmental impacts or even improve their ecological footprint). Microbiological engineering could be useful to try to alter the digestive capacities of farmed marine animals to plant-based foods and develop innovative aquaculture foodstuffs. Overall, the socio-economic development and governance of the industry (foresight analysis, new tools and management methods) must be enhanced.

Although industrial fishing (e.g. red tuna) is often the focus of attention, most fishing in the Mediterranean is, in fact, artisanal. It consists of, on the one hand, specialised flotillas supplying an inter-regional market and, on the other hand, opportunistic flotillas using various techniques to meet a localised, downscaled and changeable demand. The former operate out to sea on broad continental shelves and require significant technical and financial resources, whereas the latter fish in narrow coastal zones and steep-sloped non-trawlable areas, sometimes only using rudimentary means. This small-scale artisanal fishing on the coast often constitutes a "Sea fisherman incubator" for offshore specialised fisheries, but the scarcity of deep water resources combined with the limited continental shelf area and the low productivity of Mediterranean waters have restricted, more than elsewhere, this offshore expansion. Consequently, fishing in the Mediterranean essentially remains an activity of fresh fish landed daily, where "small profession" predominate in numerical and structural terms for the entire industry and its economy.

Today however, professions in the fishing industry are in crisis. They must overcome multiple threats to resources such as competition for the use of maritime space (especially from recreational uses), competition for putting products on the market, reduced stocks of certain species, the deterioration of coastal ecosystems as a result of anthropic pressure and the impacts of climate change (e.g. rising water temperature, acidification, and proliferation of invasive species). The need to define standards for the sustainable development of fishing activities in the Mediterranean therefore requires greater consideration of biological, historic and human data which influences the maintenance, adaptation and diversification of small-scale artisanal fishing occupations.

There is a need to assess the impact small-scale fishing occupations have on the resource and the ecosystems, to study with a historical perspective the adjustment of fishing communities to the fluctuations in the resource, the market demand and the changes in society, and to explore the opportunities offered by unexploited native, non-native and invasive species to help sustain the development of coastal fishing (food or biotechnological potential, creating value from products, resource management methods and professional training for fishermen, etc.). Heritage-related practices and

54. <http://faostat3.fao.org/home/E>

55. *Parliamentary Assembly of the Mediterranean, 2014. Role of fisheries and aquaculture in food security of the Mediterranean countries, 9 p.*

know-how linked to artisanal fishing have to be studied in order to enable ancient practices to adapt to the current context and promote the rich cultural heritage of Mediterranean fishing, especially in terms of eco-tourism and to develop methods geared to measuring the impact of recreational uses, especially the growth of leisure fishing which is starting to compete with small-scale artisanal fishing. From the governance point of view, regulations adapted to artisanal fishing have to be designed, enabling it to maintain its versatility while respecting sustainable fishing principles, especially by linking it with the development of marine protected areas.

Figure 16. Development of sustainable aquaculture and fisheries as an alternative food source.



Food chains

Mediterranean crops that are internationally recognised are subject to world-wide trade and support the industry (Figure 17). The value chain is well managed in selected crops and developed according to the changing consumer's preferences and demanded quality assurance systems. However, there are still high rates of crop losses due to pre- and post-harvest problems.

The socio-economic contribution of the agriculture and food sectors to economic growth, rural development and employment is important all around the Mediterranean. It is particularly strategic in SEMCs where agriculture is already providing employment from

The animal production challenge

- Mediterranean livestock farming systems need to adapt to the multiple and complex changes that occurred and will occur in the region. An important issue is that livestock management has been disconnected/separated (at least in some countries) from the cropping activities with subsequent negative impacts on the water and nutrient cycles and ecosystem services.
- Efforts are thus now required to encourage a greater integration of crop-livestock systems for a more appropriate land use of diversified ecosystems, the valorisation of manure, labour organisation, diversification of the products at the farm and the neighbourhood level in relation to the growing demography, rising pressure on land, increasing demand and strong international competition.
- Thus, the main perspectives are:
 - 1) Identifying efficient crop-livestock systems able to better utilise water, soil, rangelands, forages and crop residues, i.e. allowing to enhance resource use efficiency, and increase the production to meet the rising local demand for safe animal products (i.e. acting towards a greater socio-economic efficiency);
 - 2) Assessing their adaptive capacity, vulnerability and flexibility in the face of current stresses and changes;
 - 3) Assessing their 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.

20 to 40% of the population in Morocco, Egypt, Turkey or Tunisia. Thus, the role of agriculture and food industries to support employment in rural areas is crucial. Besides, Mediterranean countries are the first destination among all the EU countries in terms of touristic activities and retirement stays, which is expected to trigger new demands for quality food.

The consumption of Mediterranean food usually prepared at home or in a cottage industry setting is giving ground to fast food, subject to modern distribution models and often made from imported and subsidised raw materials. This not only contributes to poor nutrition, a source of significant health problems, but it also causes a decrease in agricultural activities and accelerates rural exodus and urbanisation and increases the market share of imported products. It also hinders the development of local food industries which generate employment and added-value.

The drivers of change or barriers to change in agricultural systems are often situated downstream in the food value Food security in a changing context can only be achieved if its determinants all along food value chains are carefully considered. contribution of food systems to economic development can best be assessed through a value chain analysis. The resilience of well-structured food supply chains is recognised to be critical for the stability of incomes for all stakeholders in the chain, which is particularly important to consider in a sector where recent crises show the importance of urgent short-term action to help economic agents overcome the crisis on markets while at the same time preparing long-term economic viability and overall sustainability.

Traditional and low-cost production and processing techniques are already embedded in the Mediterranean agriculture. PIn parallel with the increasing demand for typical and organic products, Mediterranean countries lead the way in the production and trade

of goods certified as organic or for their origin, and these certification schemes create an added-value. Nonetheless, there is a need to deliver scientific evidence for better quality and/or safety of the certified products. These practices, techniques or quality schemes should be assessed with respect to the current ecological and socio-economic challenges and scientific knowledge and best practices must be disseminated. In this respect, on-farm storage, processing and hygiene should receive priority to minimise losses and add value at farm level and to empower women. Certification schemes highlighting Mediterranean speciality should be worked out thoroughly.

Lifestyles, food, and health

In all Mediterranean countries, food security seems assured for now in quantitative terms, as less than 5% of the population is in a chronic malnourished state [in terms of energy input]. However, when it comes to food quality, not only there are still certain micronutrient deficiencies with relatively high prevalence in SEMCs, particularly affecting women, but also there is a massive emergence of diet- and lifestyle-related chronic diseases (e.g. heart disease, cancer, chronic respiratory disease and diabetes)⁵⁶. These diseases have become the leading cause of death both in the North and the South. While the traditional Mediterranean diet is considered particularly healthy (Figure 17), the Mediterranean is paradoxically one of the areas of the world where overweight and obesity are most prevalent, a clear sign of dietary shifts in progress: excess consumption of carbohydrates, sugars, saturated fat and salt, lower consumption of fruits, vegetables and fibre. These changes are largely correlated with the growth of retail and industrial products, whose price for urban consumers is lower than that of traditional products (Figure 18). The lack of interest is somehow leading to the unavoidable erosion of the Mediterranean diet and its associated cultural heritage, and this loss is more pronounced among the younger generations.

The human, social and economic costs of the epidemic of metabolic diseases are enormous, but policymakers have not always taken their measure. The challenges of research in this area are considerable: on the one hand, the complex relationship between diet and health in the Mediterranean context needs to be better understood, taking heed of genetic, epigenetic and behaviour determinants of chronic disease, and on the other hand, we must better understand eating habits, their heterogeneity and their determinants in order to inform and enrich the discussions on care and the prevention strategies and policies suited to the various contexts and populations around the Mediterranean.

Food industries and local conditions

The intense urban population growth calls for the organisation of supply chains which in many cases prove to be inefficient: the distribution of margins between producers, intermediaries and distributors and agents is rather unfair and poor quality signals do not allow adjusting the requirements of consumers to the characteristics of the products. The current business models of the small and medium enterprises are not able to adapt to changes in the demand

Figure 17. Different kinds of healthy food distribution and preservation forms.



Traditional fruit and vegetable markets, Morocco



Mediterranean supermarket

56. CIHEAM/FAO, 2015. *Mediterranean food consumption patterns: diet, environment, society, economy and health. a White Paper Priority 5 of Feeding Knowledge Programme, Expo Milan 2015. CIHEAM-IAMB, Bari/FAO, Rome, 76 p.*

Figure 18. Changes in the Mediterranean diet – from a traditional balanced diet to a carbohydrate-rich and saturated fat-rich fast food diet.



Typical components of a balanced Mediterranean diet, renowned for its health benefits – UNESCO Intangible Cultural Heritage of Humanity



Typical components of a carbohydrate- and fat-rich "fast-food" diet

and economic context. Small entities produce a high proportion of staple foods (milk, meat, fruits and vegetables and processed products), often with unique qualities derived from local tradition. Yet, most of these small companies operate in an informal setting, with recurrent food safety problems. Faced with a saturated Western market, the multinationals of the agro-industrial and agro-service sector (retail, foodservice), in search of new growth opportunities, are targeting developing countries. Suppliers of these downstream firms must meet longer payment deadlines and rigorous standards of quality, traceability and product homogeneity, on the one hand, and supply regularity, on the other. In the southern and eastern Mediterranean, however, upstream suppliers are usually widely dispersed, creating logistical difficulties in gathering raw materials (with significant post-harvest losses) and assessing their quality.

In this context, supporting competitive and innovative businesses, able to promote local products while proposing consumption models adapted to changing lifestyles, is a major issue for sustainable development in the Mediterranean region. Hence, food industry research faces a threefold challenge: technological innovation in the industrial development of traditional products, nutritional and health quality of processed foods, and competitiveness of local products vis-à-vis imports.

Progress in these areas will only be possible with the support of proactive policies linking regional development with the use of local production, the promotion of a healthy diet and the development of relevant research on: 1) Technological analysis of traditional food systems; 2) Characterisation of functional and nutritional properties of Mediterranean food commodities; 3) Development of technological processes that are more efficient as regards energy,

environment, nutrition and health, based on reverse engineering approaches; and 4) Improvement of the flexibility of production lines to accommodate the variability of raw materials and economic viability of processing methods through the enhancement of co-products, waste reduction, and market differentiation.

Smallholdings poorly integrated into formal supply chains

To meet retail or food industry requirements, local operators must reorganise, leading to a concentration of production and processing, as smallholdings (Figure 19) and small businesses have great difficulty in gaining access to commercial channels. As presented above, these small, low-cost entities nevertheless produce a high proportion of staple foods, often with unique qualities derived from local knowledge (local products). In addition, they create rural employment and provide environmental services. However, most of these small companies operate in an informal setting, with a very unfair distribution of the margins along the supply chain between producers, intermediaries and distributors and agents, and with recurrent food safety and quality problems. The integration of small producers into formal supply channels is a major challenge for research on agro-food systems, and thus the role of public and private standards, logistical infrastructure and public policies in promoting such integration will have to be looked at. Particular attention should be paid to maintaining the diversity of regional products and their economic use as a lever of territorial development, and to preserving peri-urban agriculture, which plays an important role in supplying cities with fresh food.

Post-harvest losses remain very high in many Mediterranean countries, representing up to 30% of the production in some of them. Globally, food losses and wastes are estimated to be around 280 kg and 215 kg per person per year in Europe and Northern Africa respectively⁵⁷. Reducing these losses can contribute significantly to improve food security. Transportation inefficiency has strong negative effects on this issue, and improved logistics can thus lead to a

57. FAO, 2011. *Global food losses and food waste – Extent, causes and prevention*. Rome, Italy, 37 p.

better marketing of products and contribute to opening up remote rural areas. In terms of food and water safety, the optimisation of the conveying of agricultural and agro-food products can significantly improve the quality of the products. Finally, transportation and logistics are of primary importance for the reduction of losses and wastes, and thus can contribute to increase availability of food and water for consumers⁵⁸.

This leads to develop research on: 1) Standards, logistical infrastructures, organisational forms, public policies and innovations in the banking and credit system to promote the integration of smallholdings and SMEs into modern distribution channels; 2) Reduction of post-harvest losses and wastes and development and valorisation of by-products; 3) Enhancement of regional products as a lever of territorial development; 4) Function of peri-urban agriculture in supplying cities; and 5) Health quality of food from smallholdings and informal channels.

The integration of small producers into formal supply chains is one of the major challenges, and the role of public and private standards, logistical infrastructure and public policies in promoting such integration is therefore crucial.

Food chains

- We witness the erosion of the Mediterranean diet and a massive emergence of diet- and lifestyle-related chronic diseases.
- The diversity of Mediterranean food products is an asset that could be better valorised.
- The integration of small producers into formal supply chains is a big challenge to address.

ARIMNET2 STRATEGIC PRIORITIES

To face these challenges, a tremendous nexus encompassing food security, poverty alleviation and renewable natural resources preservation must be considered and integrated into a systemic framework. The Mediterranean basin concentrates, in a quite small region and in one of the most politically unstable areas of the planet, a strong demographic growth, an increasing scarcity in land and water resources, a rise in social and economic inequalities and intense climate changes. All European countries - not only the southern ones - have to do with this crossroad which represents an important part of its historical cradle as well as geographical neighbourhood. Agricultural research can contribute to address these challenges as it is at the core of the interactions between technology, people and their environment.

The prioritisation process

While building this Integrated Strategic Research Agenda, two important challenges had to be addressed:

- 1) How to focus on the Mediterranean regional commonalities and specificities?
- 2) How to avoid formulations of issues and themes in terms which would be too general to be useful?

In order to set research priorities to face the above challenges, the defining strategy process made use of a brainstorming based on the combination of the three following elements:

Figure 19. Small producers using low-cost animal-pulled carts to transport their products.



Dairy family in Morocco



Farmer transporting straw with a traditional horse-pulled cart



Small-scale milk producer delivering his milk churns using a donkey-pulled cart

58. CIHEAM, 2014. *Méditerranée 2014 - Logistique et commerce agroalimentaire : un défi pour la Méditerranée*. Presses de Sciences Po, 556 p.

1. The challenges considering "Populations and societies", "Natural resources", "Crop production systems", "Animal production systems" and "Value chain management", **summarised into the food security, poverty alleviation and renewable natural resources preservation nexus** (outcome from section 2.2 (Figure 20);

2. The conclusions derived from the work entitled "Review of prospective studies for Mediterranean agriculture: implications for agricultural research"⁵⁹, the SCAR 4th Foresight exercise, and the FACCE-JPI agenda (outcome from section 1.3). The first lesson drawn from these reviews is the need to **integrate the diverse aspects within a systemic framework**. And indeed the Mediterranean specificity alluded to above may be the nexus of interrelated issues: rural poverty, import dependency and deterioration of natural resources in a situation where rural population will continue to increase. None of those aspects can be tackled without taking the others into account (outcome from section 2.1);

3. The 11 research topics outlined in the first ARIMNet2 call which ARIMNet2 partners agreed on (outcome from section 1.4).

The summarising table [Table 5] was built crossing both the economic and social challenges to be faced (i.e. food security, natural resources preservation and poverty alleviation/employment promotion) and the research topics selected by ARIMNet2 partners.

The results represent the level of contribution of each research topic to the challenges:

- +++ Very strong contribution
- ++ Strong contribution
- + Medium contribution

Three clusters were identified in defining three main priority areas, developed as below:




-  Increasing the efficiency and sustainability of production systems
-  Enhancing value chains
-  Promoting a balanced territorial development

Table 5. Research topics of the first ARIMNet2 call (2015) and their main contribution to Mediterranean social, environmental and economic challenges.

RESEARCH TOPICS	NATURAL RESOURCES PRESERVATION	FOOD SECURITY	POVERTY ALLEVIATION/ EMPLOYMENT
1. Increase in resilience, rusticity and productivity of Mediterranean agricultural production systems	++	+++	+
2. Improving input use management at the level of the production systems	+++	++	
3. Common Mediterranean challenges in animal and plant health	+	+++	
4. Sustainable Mediterranean aquaculture and fisheries	+	+++	++
5. Innovation in agroindustry		++	+++
6. Logistics, supply chain organisation, and transportation		+++	++
7. Food safety and food sanitary issues		++	+
8. Food consumption patterns: consumers' behaviour, quality of products, diet and nutrition		+++	++
9. Agricultural and food policies	++	+++	++
10. Sustainable management of water and other resources used by agriculture	+++	++	
11. Landscape and spatial management, competition with other land uses, peri-urban and urban agriculture	++	+	++

59. Prepared by Michel Petit and Fatima El Hadad-Gauthier and presented at the first SSAB meeting in Montpellier in June 2014.

Thematic priorities

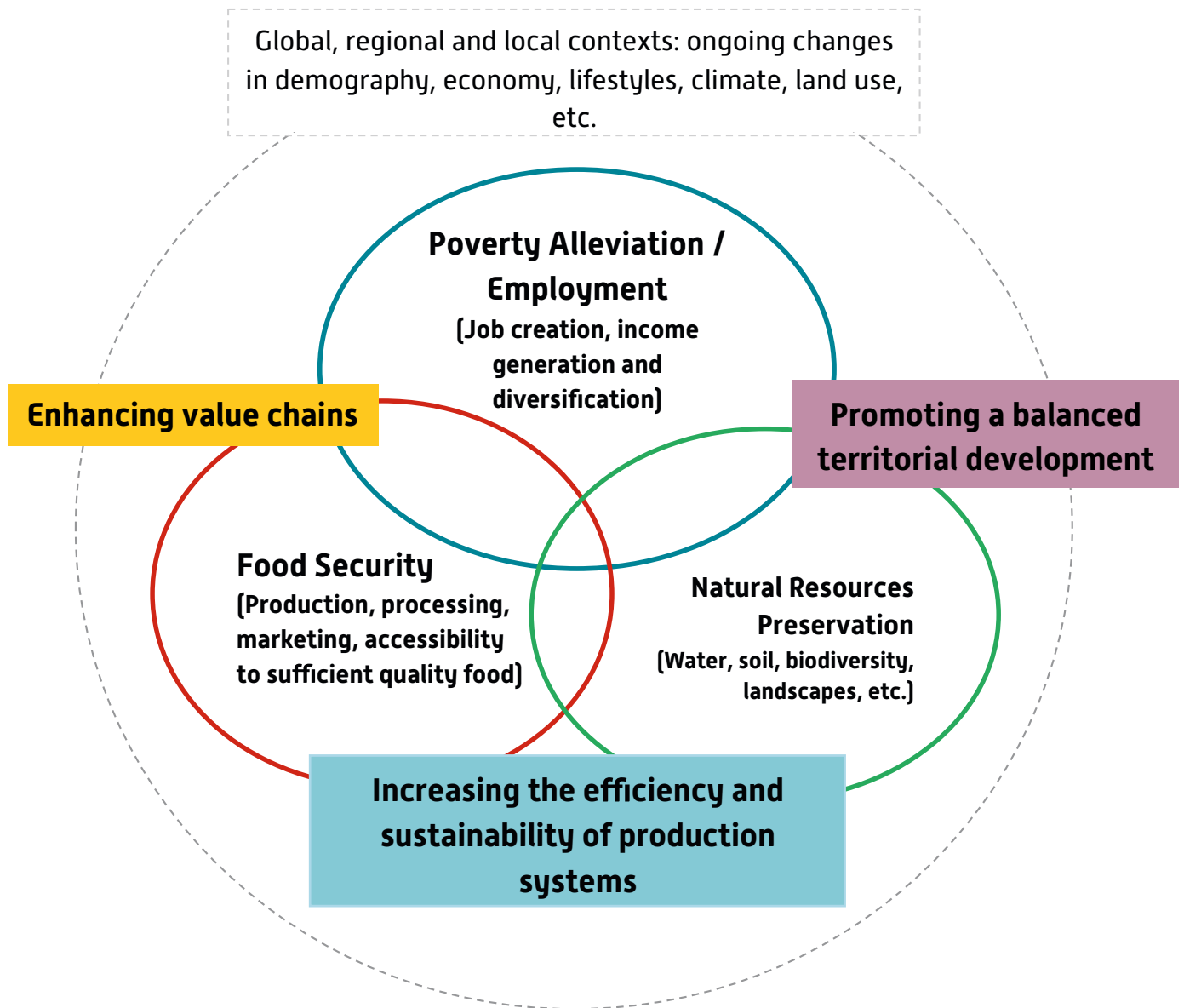
Based on the clustering presented in Table 5, three objectives emerge that constitute the core thematic priorities of the ISRA: 1) Increasing the efficiency and sustainability of production systems (in blue in Table 5 and Figure 20 below); 2) Enhancing value chains (in orange); and 3) Promoting a balanced territorial development (in purple).

Increasing the efficiency and sustainability of production systems

Agriculture delivers food and non-food commodities and moreover creates employment, sustains rural livelihoods and preserves landscapes. Today, there is a severe competition for agro-food products in the globalised market, whether being crop or livestock, that force to produce more at cheaper prices for distant markets despite the pressure of climate change. Agricultural systems are diverse and range from rain-fed low-input systems to highly-intensive systems

that rely on heavy input use and mechanisation. Aquaculture, as coastal or as integrated with farming, also plays an important role in generating income despite being controversial due to its polluting effect. This diversity leads to endless cases of best or bad practices. Production and distribution systems exert a significant impact on the environment not only at the farm level but also at the regional level as in the case of watersheds, and even at the global level through greenhouse gas emissions. However, the level of impact is closely linked to the target species, management system or technology chosen: e.g. impacts are reduced by a more effective control of plant pests and diseases (emergent and spreading) through the identification of plants' resistance capacity and the better management of cropping systems (e.g. through rotations and diversification). Research is needed both to develop new products, technologies and production systems for different farm types (family or commercial) taking into account simultaneously the farm level and the agro-industry perspective, and to assess their environmental, social and economic impacts.

Figure 20. The food security, poverty alleviation and natural resource preservation nexus.



The impacts of agricultural production systems on natural resources, soil, water and biodiversity require to assess their environmental, social and economic sustainability at the farm, regional, national, global or ecosystem levels. In this respect, the extent to which animal and plant production will be integrated and how this integration will influence the efficiency and sustainability of the agro-ecosystem is important [e.g. by designing complementarities between crop and livestock at different levels, from farming systems to the territories]. The methodology to be developed must be easy to apply and should produce reproducible, precise and quantitative/qualitative results.

The potential benefit of agriculture on employment and poverty alleviation orients research towards social aspects and supports the need for integrated and multidisciplinary approaches. The adoption of research results and innovative approaches is rather slow, therefore, efficient territory- or target group-specific extension methods are required to fasten implementation.

Enhancing value chains

Enhancing value chains is necessary because so much of what happens in agriculture and in rural areas depends on the collection, storage, transformation, processing of raw agricultural and natural products, and distribution of final products to consumers. Developing new technologies [e.g. simple and locally adapted technologies for on-farm processing] and improving supply chain organisation is needed to contribute to the development of the bioeconomy, to create new jobs and to boost overall rural economy. Furthermore, urbanisation and the changes in consumption habits and preferences raise new challenges with regards to the availability of nutritional and safe food for all, particularly for traditional retailing systems.

Research has an important role to play in this diverse domain. It is indeed critical to understand well the rapid evolution of consumers' feeding habits and the reasons for these changes. It is also necessary to understand the processes leading to the transformation of the Mediterranean diet in order to design public policies successful in improving nutrition and health.

In addition, two specific domains need to be worked on:

- 1) The design of innovative quality-oriented food systems and food business models which boost the competitiveness of specific value chains and generate employment, notably in rural areas [e.g. implementation of certification schemes as a lever of territorial development, linking particular geographical areas with specific local/regional Mediterranean products and highlighting their uniqueness; improvement of on-farm storage, processing and hygiene to minimise losses and add value to the products];
- 2) The analysis of the whole logistics, supply chain organisation and transportation system in order to help public and private actors to improve their performance [e.g. analysis of standards, logistical infrastructures, organisational forms, public policies and innovations in the banking and credit system to promote the integration of smallholdings and SMEs into modern distribution channels, and survey of the impact of Foreign Direct Investment (FDI) on employment, income and international trade.

60. JPIs TO CO-WORK1 has developed a framework tailored to the specific character of JPIs and JPND [Neurodegenerative Diseases] has developed another framework based on the Logical Framework Analysis 2.

Promoting a balanced territorial development

Promoting a balanced territorial development is a priority research area because the economic, social and environmental stakes are very high.

The growth of rural employment is critical to fight rural poverty. Thus, research should support the potential synergies among activities of the various economic sectors in rural areas, as well as rural/urban synergies, notably to exploit the potential contributions and to minimise the risks linked to the close rural/urban relationships existing in many places. Research should also investigate the development of labour-intensive agricultural activities and design labour-intensive and profitable farming systems for small scale agriculture in marginal areas. It should also look at the way to enhance the development of food industries suited to local conditions, able to valorise the local productions and traditional know-how [e.g. how to promote small scale food industries able to contribute to rural development and to analyse the role of large scale ones?]. In addition, research must provide the intellectual tools and approaches necessary to take into account the diversity of local development situations, in particular the specific dimensions of the potential synergies just alluded to. This can only be done at the territory level. The diversity of production systems can help to valorise the diversity of soils, slopes and wet areas but can also play a non-negligible role in water circulation, fauna and flora dissemination or soil distribution: but what are then the technical, economic and environmental factors that affect the compatibility of diverse agricultural models [industrial/small scale, irrigated/rainfed, food/non-food] in the same areas?

This leads to understand the role played by the spatial organisation of land and field patterns, the networks of hedges, fields and woods, etc., in the conservation of natural resources and the environment. At a higher level, the spatial organisation of agriculture, forest and pastoral areas, has a strong influence on soil quality, water resources and biodiversity. The current dynamics in land uses produce new spatial patterns and new relationships between urbanised areas, agricultural areas, hybrid spaces between city and countryside [rural-urban interface], intensive and extensive agricultural land, pastoral areas and uncultivated zones [e.g. this implies to improve the integration between agriculture, forests, wetlands and urban areas in coastal zones, and to find ways to manage this development and the relationship between coastal areas and hinterlands]. This has to be analysed in a perspective of landscape and land use regulations inside the farm and through the spatial organisation of farming systems, addressing the issue of the coexistence among a diversity of production models.

INSTRUMENTS TO IMPLEMENT THE ISRA

Many joint activities support the implementation of this ISRA, including the promotion of researchers' mobility and exchange, the organisation of training, the development of the networks and partnerships and the opening of transnational calls for research and collaborative projects.

Instruments to strengthen capacities

- Annual summer schools for researchers, 3 to 5-day-long, in a different country every year, on general or specific thematic areas and combining both theoretical and practical [field visits] training;
- Mobility programmes for the exchange of researchers, PhD

students, post-docs, etc., to earn new competences or use specific devices and protocols.

- **Specific seminars addressed to young researchers** (e.g. with less than 5 years of experience after their PhD) to favour interactions and create a transnational community of researchers sensitive to the issues of stakeholders' involvement and innovation promotion in applied research projects (e.g. ARIMNet2 Young Researchers Seminar, 29 May – 3 June 2016, Montpellier, France).

Instruments to develop shared equipment

- **Specialised platforms** (5-6 for the region) with outstanding infrastructure covering several high-level technologies (genotyping, phenotyping, bioinformatics, data mining, remote sensing, spectroscopy, etc.) to carry out any possible joint activities (i.e. collaborative projects, host colleagues, organise courses);
- **Network of greenhouses** sharing compared trials as well as shared experiments on several pathologies in safe conditions;
- **Virtual network of common databases** in order to monitor surveys across the region, share data and improve their compatibility, operability and reliability.

Instruments to enhance collaborative projects

- **Thematic transnational calls** launched every 1-2 years grounded on the priorities highlighted by the ISRA and encouraging, through the use of relevant criteria, a wider cooperation, e.g. by setting the most suitable minimum number of countries involved to ensure a broad but efficient cooperation;
- **Support given to groups of researchers** from different Mediterranean countries aiming to submit a bid to an international call (e.g. European Commission, Global Environmental Fund) by small grants of seed money to support them in all their activities, e.g. meetings/networking, literature review, project design and write up, dissemination and valorisation activities, etc.;
- **PhD grant programmes supporting theses** co-supervised by experienced researchers from different countries familiar with current collaborative projects, in order to build an active and productive transnational community of researchers.

ISRA MONITORING AND EVALUATION

The ARIMNet2 monitoring and evaluation framework is the outcome of an analysis of the most suitable procedures and tools for monitoring and evaluating the joint activities launched by the action (transnational calls for project proposals, young researchers' seminars, working groups, etc.).

A starting point to define a monitoring and evaluation strategy for ARIMNet2 in implementing the ISRA is the analysis of the existing guidelines and procedures for some other similar joint actions, such as JPIs, ERA-NETs, etc.⁶⁰. However, at the time being, none of these evaluation/monitoring systems has been concluded. For this reason, ARIMNet2 wanted to figure out its own monitoring and evaluation framework based on its specific characteristics.

The ARIMNet2 monitoring and evaluation framework embraces several objectives:

- To raise the awareness from the Mediterranean population of the issues related to agriculture, food security, natural resources management and rural development;

- To increase the societal impact of research and innovation with regard to the current and future agricultural and ecological challenges that the Mediterranean area has to face;
- To stimulate the debate on the Mediterranean issues related to agriculture and research in the primary sector at the European and global level;
- To encourage collective reflexions on how to boost innovation by promoting a constructive dialogue among all stakeholders and the greater involvement of end-users in research, development and innovation processes (e.g. AKIS Conference, October 2016, Turkey).

To evaluate the ISRA implementation and ARIMNet2 efficacy and success, the evaluation activities cover both the short- and medium/long-term:

In the short-term, activities consist in:

- Informing all the possible stakeholders about the ISRA and ARIMNet2 scope and objectives, not only across Mediterranean countries, but also at the European and international levels. For this purpose, we rely on the cooperation of all ARIMNet2 partners and of their collaborators.
- Monitoring the results and effects of the projects financed by the ARIMNet Call launched in 2011.
- Closely monitoring all ARIMNet2 joint actions, in particular the calls for proposals, the young researchers seminar and others.

In the medium and long-term, activities consist in:

- Promoting universities and other institutions offering post-graduate studies, and the implementation of theses and research activities on the issues pointed out in the ISRA.
- Evaluating national research and innovation programmes in Mediterranean countries.
- Monitoring the results and effects of the projects financed through the ARIMNet2 Calls (launched in September 2014 and April 2016) in order to compare the two lots of projects (ARIMNet and ARIMNet2) and evaluate the improvements made.
- Carrying out surveys of published articles on topics prioritised by Mediterranean countries in the ISRA during the implementation of ARIMNet and ARIMNet2 projects.

The added-value of transnational cooperation

- Under the current economic conditions, there is a greater need to enhance multilateral cooperation for research and innovation to strengthen Mediterranean economies and to help finding solutions to local, regional and global challenges.
- Research targeting agriculture and related fields must possess multi-dimensional facets based on societal, political, environmental, technical (basic and applied sciences), economic and/or management aspects.
- The ISRA highlights the need for a systemic approach that should be implemented in defining the priority thematic areas, including food chains, policies and territorial development. This approach is expected to deliver high-impact results.
- The ISRA expects not only to contribute to current ARIMNet2 activities but also to support the emergence of an enlarged multilateral cooperation initiative in the future.



ARIMNet2 PERSPECTIVES

CONTRIBUTION TO THE IMPLEMENTATION OF THE FACCE-JPI STRATEGIC AGENDA

As explained, the FACCE-JPI Strategic Research Agenda (SRA) addresses five core themes, at the scale of farming systems, landscapes and value chains: 1) Food security under climate change; 2) Sustainable intensification of agriculture; 3) Assessing trade-offs between food supply, biodiversity and ecosystem services; 4) Adaptation to climate change; and 5) Mitigation of climate change.

It addresses eight major domains: 1) Scenarios of global change and adaptive strategies; 2) Food systems and food security; 3) Land use and sustainable management of biodiversity and natural resources; 3) Crops: production, health and breeding; 4) Livestock: production, health and breeding; 5) Greenhouse gases mitigation and carbon sequestration by agriculture; 6) Bioenergy and biofuels; 7) Forestry as related to agriculture and food security.

While the FACCE-JPI SRA identified research needs in response to given European challenges, ARIMNet2 addresses those needs within the more specific context of the Mediterranean region.

Animal and plant health

Considering the significance of the emergence/re-emergence of pests and diseases in the Mediterranean region and its associated negative health and economic impacts, as the FACCE-JPI SRA, our ISRA gives priority to research and innovation efforts seeking to develop integrated resilient animal and crop health management systems adapted to climate and socio-economic changes. The ISRA includes issues dealing with: 1) Emerging pests and diseases; 2) The links between pests/diseases, farm management, biodiversity and landscape composition and structure. Research and development activities involving farmers and other stakeholders will produce innovative and effective strategies and practices that will foster integrated and sustainable pest and disease management in crop-

ping and livestock systems across Mediterranean countries, and will subsequently lessen production losses.

Adaptation to climate change

The ISRA embraces a very relevant topic also identified by FACCE-JPI, which concerns the role that plant and animal breeding can play in our efforts towards climate change adaptation and mitigation. ARIMNet2 supports indeed the activities related to phenotyping, genotyping, breeding and reproduction to adapt crop, pasture and livestock species to climate change, together with the evaluation of alternative species. It encourages the preservation of genetic resources, the definition of new breeding targets in response to elevated air CO₂ concentrations and to abiotic (e.g. high temperatures, water deficit, ozone, salinity, etc.) and biotic stresses (e.g. emerging pests and diseases) as well as the development of advanced infrastructures for plant and animal breeding. The ISRA also includes a climate change risk assessment for agricultural production systems (plant and livestock) and food supplies.

Sustainable agriculture intensification

The high vulnerability of Mediterranean ecosystems and the need to increase food production place the sustainable agriculture intensification topic at the heart of ARIMNet2 priorities, reinforcing FACCE-JPI efforts on that aspect at the European level. ARIMNet2 specifically fosters research activities that contribute to improve natural resource use efficiency (water, soils, etc.) and to reduce and/or manage potentially polluting chemical or organic inputs (e.g. pesticides, fertilisers, heavy metals, pathogens) in a changing context of environmental stresses and natural risks, with the aim to develop more efficient agroecosystems. In addition, a better understanding of the value of specific ecosystem services helpful to enhance in a sustainable way agroecosystems' productivity is also considered. Research and innovation in this field will assist the stakeholders from the agricultural sector (farmers in particular) and policy-makers in their efforts towards enhancing the multifunctionality, resilience and sustainability of agricultural systems and landscapes.

Contribution of agriculture and food systems to socio-economic development

Fully aware that societal factors underpin every aspect of agriculture and food security and play a critical role in both mitigation and adaptation to climate change at all scales, the ISRA and ARIMNet2 activities in general support the projects that foster the participation and involvement of stakeholders, for example farmers and policy-makers, all along the research and innovation process. It also underlines the importance to better understand how different policies evolve and how farmers' and consumers' behaviour changes over time. It thus supports FACCE-JPI efforts in those directions. Finally, as recommended by the FACCE-JPI, ARIMNet2 ISRA encourages the integration of biophysical and socio-economic models to analyse the potential impacts of changes in agricultural policies and in other parts of the bioeconomy sector in the Mediterranean, under different climate change scenarios.

CONTRIBUTION OF ARIMNet2 TO THE EURO-MEDITERRANEAN RESEARCH AND INNOVATION POLICY

In April 2012, the "Euro-Mediterranean Conference on Research and Innovation" organised by the European Commission in Barcelona, stressed the need for a renewed partnership in Research and Innovation. The idea was to promote cooperation among EU Member States and Mediterranean countries based on the principles of co-ownership, mutual interest and shared benefit. In this respect, the Commission gave a decisive impetus by highlighting the potential of using Article 185 of the Treaty on the Functioning of the European Union (TFEU) for implementing this partnership between the EU and its Southern Neighbourhood. This idea immediately received support from a significant number of Euro-Mediterranean countries.

On 22 December 2014, nine EU Member States – Czech Republic, Cyprus, France, Greece, Italy, Luxembourg, Malta, Portugal, and Spain – submitted a proposal for the participation of the EU in a joint research and innovation programme named PRIMA (Partnership for Research and Innovation in the Mediterranean area), focused on the development and application of innovative solutions for food systems and water resources in the Mediterranean basin. Seven non-EU countries are also taking part in PRIMA: Algeria, Egypt, Jordan, Lebanon, Morocco, Tunisia and Turkey. More than two hundred million euros have been committed for this initiative over a ten-year period starting in 2018. Other countries interested in the PRIMA Initiative include Croatia, Germany, Israel, Romania and Slovenia.

Today, PRIMA is a proposal supported by more than 20 countries with the objective to implement joint actions and to move towards a strong and long-lasting cooperation for research and innovation in the Mediterranean. The two most pressing key socio-economic issues of the Mediterranean area that have been retained by the participating countries are food systems and water resources, in a multidimensional and integrated approach. Eight objectives have been identified as priorities, structured into three pillars: 1) Sustainable management of water in arid and semi-arid areas, 2) Sustainable farming under Mediterranean environmental constraints, and 3) Mediterranean food chains for regional and local development.

The ARIMNet2 ISRA and actions intend to contribute to the implementation of PRIMA in two ways:

- In the identification of thematic priorities and actions to be implemented. There is already a clear connexion between the three priorities of the ARIMNet2 ISRA and PRIMA pillars. The ISRA highlights the importance to consider the links and the interactions between the agriculture and food nexus (natural resources, poverty alleviation and food security). The challenges and actions that have been identified in the ISRA go largely beyond the framework and lifetime of ARIMNet2. To be implemented, they need a stronger action in terms of funding commitments on the one hand and sustainability and continuity on the other. That is what PRIMA will be. After 2017, it will allow to build an integrated funding programme based on the principles of co-ownership, co-decision and co-funding.

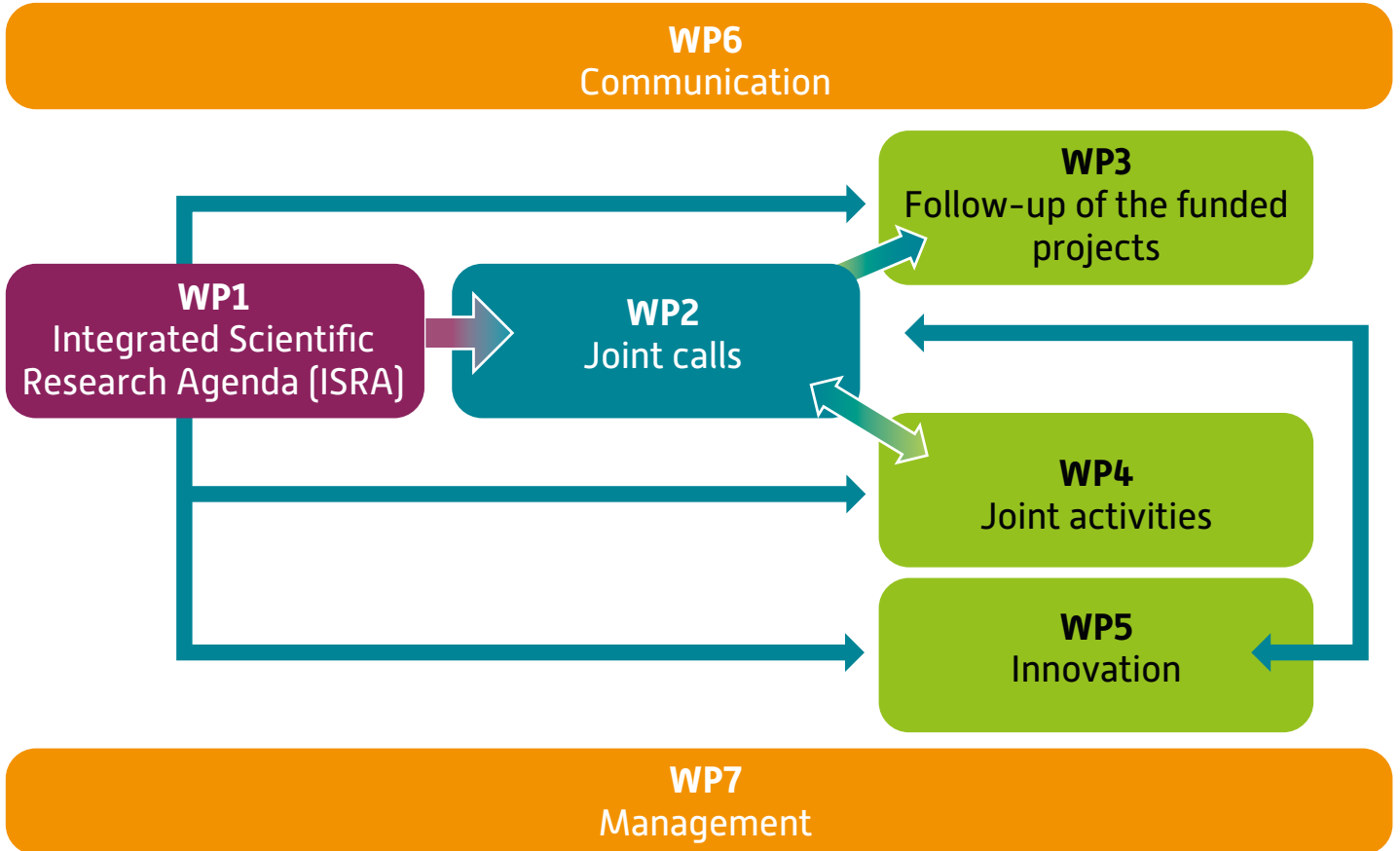
- In paving the way for a broader initiative by implementing trust and collaboration among funding agencies. ARIMNet and ARIMNet2 have launched three transnational calls for research proposals that are co-funded and co-decided among all participating countries, no matter if they are EU Member States or Mediterranean participating countries. Together with other initiatives, namely ERANETMED, they have established good practices among Mediterranean countries to this respect. These initiatives have also promoted networking in research and innovation programmes within the Mediterranean region among different stakeholders. Therefore, they prepare the ground and practices in line with the principles that PRIMA has retained. Thus, ARIMNet2 ISRA could represent a first step in building an ambitious research agenda for agriculture and food at the Euro-Mediterranean level.



ANNEX 1: ARIMNet2 PARTNERS

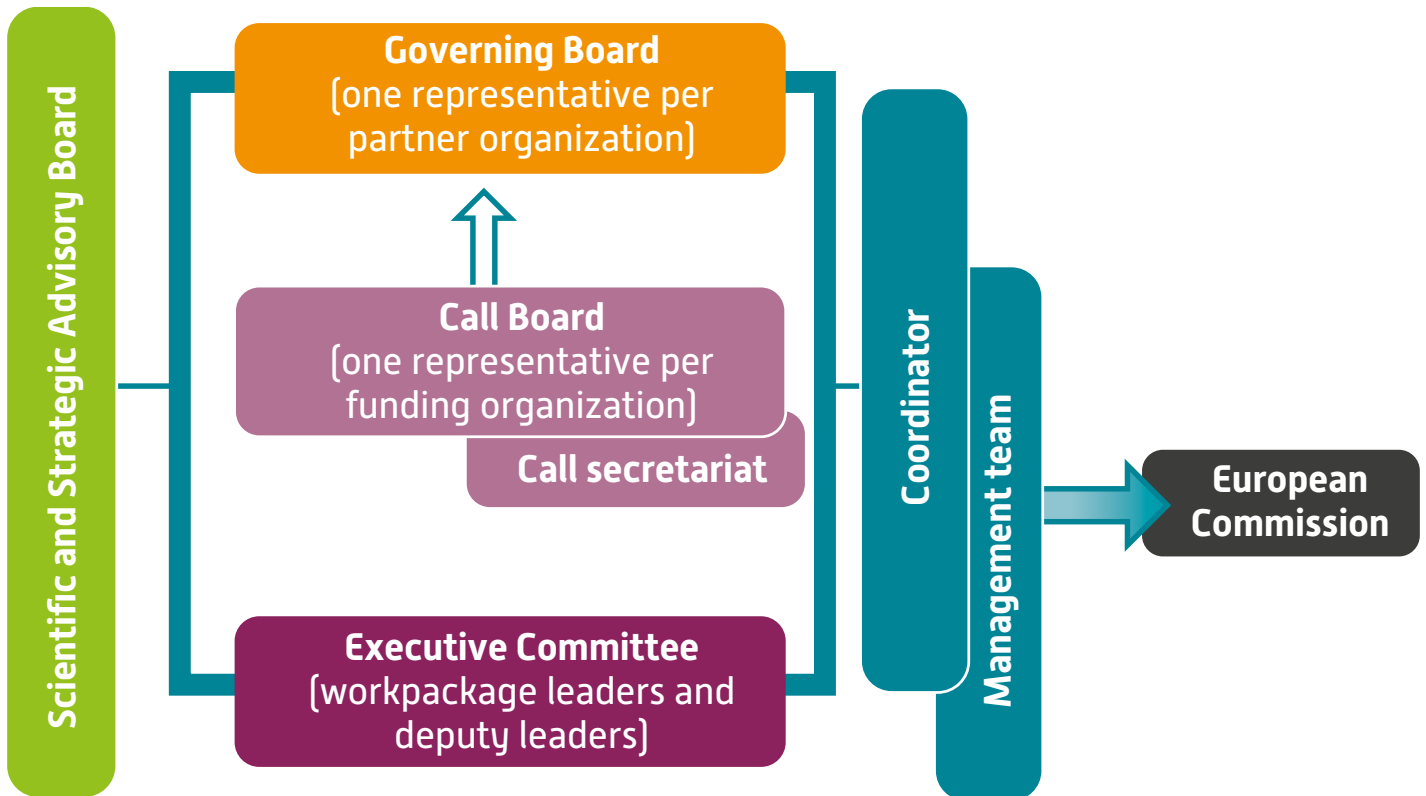
- Institut National de la Recherche Agronomique (INRA) – France
- Academy of Scientific Research & Technology (ASRT) – Egypt
- Agence Nationale de la Recherche (ANR) – France
- Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) – France
- Centre International de Hautes Études Agronomiques Méditerranéennes – Institut Agronomique Méditerranéen de Montpellier (CIHEAM-IAMM)
- Fundação para a Ciência e a Tecnologia (FCT) – Portugal
- Hellenic Agricultural Organization DEMETER – Greece
- Institut Agronomique et Vétérinaire Hassan II (IAV) – Morocco
- Institut National de la Recherche Agronomique d'Algérie (INRAA) – Algeria
- Institut za jadranske kulture i melioraciju krša (KRS) – Croatia
- Institution de la Recherche et de l'Enseignement Supérieur Agricoles (IRESA) – Tunisia
- Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA) – Spain
- International Center for Agricultural Research in the Dry Areas (ICARDA)
- Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA) – Italy
- Ministère de l'Enseignement Supérieur et de la Recherche Scientifique (MESRS) – Algeria
- Ministero delle Politiche Agricole Alimentari e Forestali (MIPAAF) – Italy
- Ministrstvo za izobraževanje, znanost in šport (MIZS) – Slovenia
- Ministrstvo za kmetijstvo, gozdarstvo in prehrano (MKGP) – Slovenia
- Ministry of Agriculture and Rural Development (MOARD) – Israel
- Ministry of Agriculture, Rural Development and Environment - Agricultural Research Institute (ARI) – Cyprus
- Ministry of Food, Agriculture and Livestock - General Directorate of Agricultural Research and Policies (GDAR) – Turkey
- Ministère de l'Enseignement Supérieur et de la Recherche Scientifique (MESRS) – Tunisia
- Ministry for Education and Employment - Malta Council for Science and Technology (MCST) – Malta
- The Agricultural Research Centre (ARC) – Egypt

ANNEX 2: ARIMNet2 WORK PACKAGES



- **WP1: Developing an Integrated Strategic Research Agenda**
Leader / Deputy Leader: MIPAAF-IT / GDAR-TR; Main contributors: INRA-FR, IAV-MA, IRESA-TN
- **WP2: Preparation and launching of Joint Calls for transnational research projects**
Leader / Deputy Leader: IAV-MA / ANR-FR; Main contributors: MESRS-TN
- **WP3: Monitoring, follow-up and impact assessment of calls and funded research projects**
Leader / Deputy Leader: INIA-ES / FCT-PT, IAV-MA; Main contributors: ANR-FR, IRESA-TN, MESRS-TN
- **WP4: Implementing joint activities to support cooperation in research**
Leader / Deputy Leader: DEMETER-GR / CIRAD-FR, ARC-EG; Main contributors: INIA-ES
- **WP5: From Research to Innovation**
Leader / Deputy Leader: GDAR-TR / INRAA-DZ, INEA-IT; Main contributors: IRESA-TN, INIA-ES, MESRS-DZ
- **WP6: Outreach and Communication**
Leader / Deputy Leader: IRESA-TN / INRA-FR; Main contributors: CIRAD-FR, MIZS-SI
- **WP7: Management**
Leader: INRA-FR

ANNEX 3: ARIMNet2 GOVERNANCE



Coordination: Florence Jacquet (INRA-FR, coordinator), Marie Ollagnon (INRA, assistant coordinator), Fabrice Gouriveau (INRA-FR, assistant coordinator).

Governing Board: Florence Jacquet (INRA-FR), Adel Aboulnaga (ARC, EG), Allannah Bonnicci (MCST, MT), Anabel De la Peña (INIA-ES), Mohamed Aziz Dargouth (IRESA-TN), Diana Spiteri (MCST-MT), Foued Chehat (INRAA-DZ), Aristotelis H. Papadopoulos (Demeter-GR), Jana Erjavec (MKGP-SI), Jean-Luc Battini (CIRAD-FR), Kim Turk (MIZS-SI), Mohammed El Mourid (CGIAR), Marina Montedoro (MIPAAF-IT), Maria João Maia (FCT-PT), Marinos Markou (ARI-CY), Maurice Héral (ANR-FR), Sahin Anil (GDAR-TR), Fabrice Dentressangle (ANR-FR), Maria Bertaki (Demeter-GR), Moez Jebara (MESRS-TN), Anna Vagnozzi (CREA-IT), Sanaa Zebakh (IAV-MO), Pascal Bergeret (IAMM-FR), Rachida Yahiaoui-Zaidi (MESRS-DZ), Amr Radwan (ASRT-EG), Samira Chader (MESRS-DZ), Slavko Perica (KRS-HR), Yuval Eshdat (MOARD-IL).

Executive Committee: Florence Jacquet (INRA-FR, WP7-L), Sahin Anil (GDAR-TR, WP5-L, WP1-DL), Anis Ben Rayana (IRESA-TN, WP6-L), Foued Chehat (INRAA-DZ, WP5-DL), Anabel De la Peña (INIA-ES, WP3-L), Maurice Héral (ANR-FR, WP2-DL), Fabrice Dentressangle (ANR-FR), Adel Aboulnaga (ARC-EG, WP4-DL, WP6-DL), Aristotelis H. Papadopoulos (Demeter-GR, WP4-L), Maria João Maia (FCT-PT, WP3-DL), Marina Montedoro (MIPAAF-IT, WP1-L), Jean-Luc Battini (CIRAD-FR, WP4-DL), Anna Vagnozzi (INEA-IT, WP5-DL), Sanaa Zebakh (IAV-MA, WP2-L, WP3-DL).

Strategic and Scientific Advisory Board (SSAB): Uygun Aksoy (chair, Turkey), Bernard Hubert (vice-chair, France), Mohamed Badraoui (Morocco), Mohamed Ben Hamouda (Tunisia), Dunja Bandelj (Slovenia), Marcello Pagliai (Italy), Maroun El Moujabber (ERANETMED), Egizio Valceschini (SCAR), Reinhart Ceulemans (FACCE-JPI).







www.arimnet2.net

ARIMNet2

Coordination of Agricultural Research
In the Mediterranean

Coordination:
Dr Florence Jacquet,
Institut National de la Recherche Agronomique
(INRA, France)



ARIMNet2 (2014-2017) has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 618127