Priority 1: Sustainable management of natural resources

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Priority 1:
Sustainable management of natural resources

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"Human beings are all interlocked with plants, animals, soils and waters, in one humming community of cooperation and competition: one biota! They are related and bound into a seamless fabric"

(A. Leopold, 1949)

I – Abstract (including aim and sub-priorities)

The Mediterranean region is undergoing tremendous political, economic, social and environmental changes and many challenges lie ahead. Within the endless myriad of problems, fears are that food security[1] may be the next major "trouble" for a region that historically has left behind many of such worries. The Arab Spring is turning into a "hot summer" and its impacts on natural resources management and food security are yet to be seen, but there are reasons for concern. The Mediterranean is unique for its geographical position where Europe, Africa and Asia meet and for the distinct differences between the Southern and Northern countries of the region. There are considerable economic disparities between Mediterranean EU countries with an average Gross Domestic Product, or GDP per capita in the range of €16,000 while in North Africa the average GDP per capita is only €1,600 reflected with a significant migration flow from the poorer south to the richer north. Consequently, issues related to food should be dealt differently: food safety and waste of food for the North and food security for the South. We focus in our analyses mostly on the South.

The region is best described for its limited natural resources especially land and water, its rich biodiversity and by high population growth rates in the Middle East North Africa (MENA) region[2]. Paradoxically, shortages of suitable land for crop production and water for irrigation or urban use are much severe in the MENA. Climate change effects are already taking their toll as the region is becoming drier and hotter imposing considerable negative consequences on crop production, biodiversity loss, reduction of ecosystems services and overall compromised environmental sustainability. On the other side, the MENA region posses considerable fossil fuel reserves (Egypt only has proven oil reserves of 4.4 billion barrels and proven natural gas reserves of 78 trillion cubic feet) and large potential for renewable energy production such as solar, even though this last source is yet in the early stages of development and it is not clear what impact could have on food security.

In 2004, the overall ecological footprint in the Mediterranean Basin countries reached 1.3 billion global hectares (gha), almost 10 percent of the worldwide footprint, while the Mediterranean population represent less than 7 percent of the world's population. The ecological footprint of 3 gha/inhabitant is higher than the world's average ecological footprint of 2.2 gha/inhabitant and the region's ecological deficit (*i.e.* 1.7 gha/inhabitant) is more than four times greater than the world's ecological deficit of 0.4 gha/inhabitant indicating that current economic development trends in the Mediterranean are not sustainable.

One thing is sure however: the MENA countries, even by the most optimistic scenarios, not only today, but also on the medium and long term periods can't meet the goal of being food self sufficient via their own agricultural production and hence food-safe. They will continue to rely on food imports compensated largely from their fossil fuel sources and tourism revenues as long as these sources would be available. This conclusion conforms predictions of international research institutions and UN organisations and fits well with the new concept that *food security is not necessarily equal to self-sufficiency* in food production. However, it is closely related to political and social stability of a country and hikes in global food prices could provoke "food scarcity shocks" and social unrest as it happened in Egypt and Algeria in 2008. Widespread land degradation and desertification but especially the inefficient and inequitable use of water, lie at the roots of many problems the region is facing, and yet, effective solutions remain elusive.

This first priority of the Feeding Knowledge project describes the links between natural resources status and management and their inter-linkages with food security by analysing five important components that include land, water, climate change, biodiversity, and energy. Natural resource degradation is not a fate but often receive a "back seat" position in the Governmental agendas. It can be reversed however, if it is caught up early and there is a political will to stop it. Research results show that there are many options available for its recovery through sustainable land and water management, biodiversity conservation, efficient use of energy sources and mitigation/ adaptation actions to climate change.

Map 1. Prevalence of undernourishment in the World

This interacti ve map developed by the FAO to show the level of undernourishment in the World for the period 1990-2012 indicates that the situation in the MENA region has either remained stable or improved with Algeria moving at the same level as all other countries and only Morocco remaining at the lower level.

Source: http://www.fao.org/hunger/en/

Sub-priorities at the glimpse

Land	Water	Climate change	Biodiversity	Energy
Globally, the Mediterranean land area covers 6.3 per cent of the Earth's land mass, 3.7 per cent of natural pastures and rangelands, 1.9 per cent of forests and woodlands, 8.6 per cent of areas with limited biomass potential or sealed by urbanisation and only 7.9 per cent of total agriculture lands. Region-wide, agricultural land cover 14 per cent (in MENA 5), natural pastures 15 per cent, forest and woodlans 8 and the remaining 63 per cent represent areas sealed by urbanisation or with limited biomass production capacity. Soil sealing is a big issue all over the Mediterranean and data show that 40 per cent of the Mediterranean cost is already urbanised and by 2050 that area will be as high as 50 per cent. Still, 41 per cent of the population in the MENA lives in rural areas and these people rely heavily on their local natural resources for their very survival. Major land degradation processes include water and wind erosion, salinisation, organic matter and soil fertility decline, landslides, flooding, overgrazing, and wild fires. Salinisation and alkalinisation alone cover about 10 million ha. Desertification affects more than 40 per cent of the region's territory and 31 per cent of the population, but such process is particularly widespread in the MENA region. If present rates of land degradation and urbanisation will remain unchanged, the region will lose an additional 8,3 million ha by 2020. Still 60 per cent of the local food production comes from the reinfed agriculture. These figures reinforce the need for immediate action in endorsing and implementing sustainable land management techniques and soil conservation practices.	The region is home to 6.3 percent of world's population but has access to a measly 1.4 percent of the world's renewable fresh water. The average water availability per person in other geographical regions is about 7,000 m^3/year, whereas water availability is merely 1,200 m^3/person/year in the MENA region. The region has the highest per capita rates of freshwater extraction in the world (804 m^3/year) and currently exploits over 75 per cent of its renewable water resources. Due to burgeoning population and rapid economic growth, the per capita water availability is expected to reduce to alarming proportions in the coming decades. By the year 2050, two-thirds of MENA countries could have less than 200 m^3 of renewable water resources per capita per year. Around 85 per cent of the water in the MENA region is used for irrigation. MENA's average water use efficiency in irrigation is only 50 to 60 percent, compared to best-practice examples of above 80 percent efficiency under similar climate conditions in Australia and southwest US. Similarly, physical water losses in municipal and industrial supplies in the region are way above world averages, around 30 to 50 percent in some cities, compared to global best practice of approximately 10 percent. In general, MENA countries are beginning to recognize the importance of an integrated approach to water management. The demand for water will continue to rise across the region, due to population increase and economic growth.	Climate, water and land management are intrinsically linked and shaped the characteristics of natural and agricultural systems. The vulnerability of the systems strongly relies on the actual state of availability and exploitation of resources and capability to response to variability and changes of climate over various time spans. Certainly, many areas in the Mediterranean might be a particularly vulnerable due to the scarcity of resources and pronounced degradation of both water, land and environment. In particular, climate changes implications on agriculture and food security could be relevant with interrelated effects on the biophysical factors (physiological effects on crops, pasture, forests and livestock; changes in water, land and soil availability; increased weed and pest challenges) and socio-economic impacts (changes in yields and food production; fluctuations in world market prices; increased number of people at risk of water and food insecurity; human health, products distribution channels, market flows, etc.) (FAO, 2007). Focusing primarily on the agricultural sector, the climate change implications could be twofold: 1) causing permanent structural changes of cropping pattern and agricultural vocation of an area due to expected trend of main climate factors (precipitation, temperature and CO_2 concentration), and 2) increasing vulnerability to transitory extreme events as prolonged hot spells, droughts and floods difficult to predict . The adaptation/mitigation measures should consider the capacity of each specific area/country and could have greater success in the Northern than in the Southern Mediterranean countries.	The importance of biodiversity in the frame of food security and global sustainability is optimally shown in the report about the state of environment of the Millennium Ecosystem Assessment that describes the relationship between biodiversity and eco-system services (MEA, 2005). Food provisioning is the first typology of service delivered by ecosystems and in terms of importance it is closely followed by all the services related to ecosystem's ability in supporting life on Earth. Key functions of the ecosystems are linked to biodiversity for provision of basic materials for life (adequate livelihood and sufficient nutritious food) or for health (strength, feeling well, access to clean air and water). There are even many other important ecosystem services deriving from it that are more related to environmental aspects such as regulating ability (climate, flood, disease regulation and water purification) that relate to public security (i.e. security from disasters), or to health, and to good social relations.	Energy is needed in all steps along the agrifood chain: in the production of crops, fish, livestock and forestry products; in post-harvest operations; in food storage and processing; in food transport and distribution; and in food preparation. Historical trends indicate an evident link between food prices and energy prices and the higher fuel costs increased the cost of producing and transporting agricultural commodities. Energy is one of the key drivers that cause food prices to surge to their highest levels in nearly 50 years. Moreover the higher food prices affects food access, which drove millions of people into food insecurity. In Mediterranean countries for rural development, the access to energy is fundamental for the provision of goods and services that can improve agricultural productivity and bring new opportunities for generating income. Increasing the energy services in Mediterranean rural areas could have the potential to spur agricultural development by increasing productivity, for example through irrigation, and improving crop processing and storage. It could also strengthen the development of non-farm commercial activities, including micro-enterprises, and create opportunities for other livelihood activities beyond daylight hours. Renewable energies such as bio energy, solar, wind, hydro and geothermal could be used in Mediterranean countries in agrifood systems as a substitute for fossil fuels to generate heat or electricity for use on farms or in agriculture-related operations. If excess energy is produced, it can be exported off the property to earn additional revenue for the owners. Such activities can bring benefits for farmers, landowners, small industries and rural communities.

II – State of the art

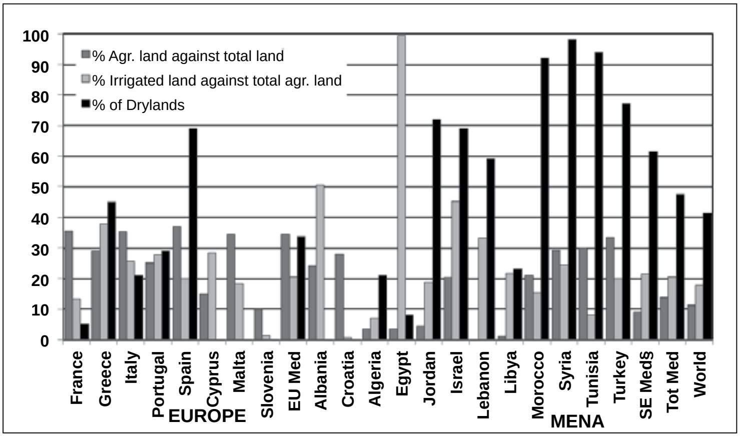
1. The Land issue

How much land is available for crop production? Is it of good quality? What is the role of agriculture in overall economic development and food supply?

The Mediterranean region posses about 854 million ha of total land resources but only 118 million ha of them (or 14 per cent) are suitable for agricultural production while the MENA countries cultivate on average only 5 per cent of their total area. The most land constraint countries are Libya (less that 2 per cent), Egypt and Algeria with less than 4 per cent and Jordan with less than 5 per cent of its land fit for agriculture production. Region wide land cover patterns include also natural pastures and rangelands (15 per cent), forests and woodlands (8 per cent) and the remaining 63 per cent (or about 538 million ha) represent areas with very limited or no biomass production capacity while coastal wetlands cover about 1 million ha throughout the region. Contrary to tropical countries, options for agricultural expansion are extremely limited and if land is reclaimed for agriculture, costs are high and the newly reclaimed soils often result in poor quality needing further investments to keep (or increase) their productivity level. If water would be available, options for growing crops could be largely increased, but one must consider however that irrigation necessitates additional energy sources and investments that in addition to water, may be shortcoming.

Drylands (as described by the United Nations Convention to Combat Desertification UNCCD)[3] are spread over 33.8 per cent of the Northern Mediterranean countries while in the MENA they reach as much as 61.3 per cent (Graph 1). Desertification affects 30 per cent of the semi-arid drylands (Rubio and Recatala, 2006) and 31 per cent of the region's population (Safriel, 2009). Compounding the many natural disadvantages and the rugged topography are the long periods of soil exploitation and mismanagement, overgrazing, deforestation and wild forest fires (Zdruli, 2012). Land degradation in the form of salinisation, water and wind erosion, sand encroachment, compaction, organic matter decline, sealing, and coastal littoralisation are severe in many countries.

Desertification is also a man-made water scarcity regime, which requires appropriate water conservation and saving, and relates to great social challenges (Pereira, 2005; Pereira *et al.*, 2006; 2009).



Graph 1. Comparison between agriculture land, total land area, irrigated land and distribution of drylands in Mediterranean Europe and MENA. *(Source: Zdruli, 2012)*

A GIS-based approach for desertification risk assessment in Apulia region, SE Italy

An assessment of the desertification risk was carried out for Apulia region (south-eastern Italy), a typical example of many Mediterranean areas affected by land degradation. The presented approach represents a modification of the ESAs model (Environmental Sensitive Areas to Desertification; Kosmas *et al.* 1999), applied in the MEDALUS (Mediterranean Desertification and Land Use) project funded by the European Commission. A set of new indicators was developed to account for the regional-specific environmental features as well as for the socio-economic parameters relevant to land use planning and control measures. GIS analysis was done including the whole set of indices (the Soil Quality Index, the Climate Quality Index, the Vegetation Quality Index, the Land Use and Management Quality Index and the Human Pressure Index), at both regional and administrative scales that constitute the principal territorial units for natural resources management and for the implementation of mitigation policies. The sensitivity of the areas to desertification risk was determined using (i) only bio-physical factors of the territory by means of soil, climate and vegetation quality indices, and (ii) both biophysical and human-induced factors, i.e. including also land use and management practices and human pressure. The estimation of desertification risk by means of bio-physical factors (soil, climate, vegetation) shows that more than half of the territory (51.7 per cent) could be classified as critical, 27.7 per cent as fragile, 8 per cent as potentially affected by desertification processes, 7.3 per cent as non-affected land, while 5.3 per cent represents urban and industrial areas and water bodies. The inclusion of human-induced factors (land use and management, human pressure) significantly changes the situation about desertification risk in Apulia region by describing 80 per cent of the territory as critical, 12.9 per cent as fragile, 1.2 per cent as potentially affected and 0.5 per cent as non-affected land (5.3 per cent represents artificial areas and water surfaces). The results of this study have shown how the effect (not in all cases negative) of human activities and pressures can trigger factors that move sensitive areas from a marginal steady state to an actively unstable state. The results showed good performance of the proposed approach that permits not only to identify and refine different degrees of vulnerability to land degradation, but also to analyse specific factors affecting desertification as well as their evaluation in terms of spatial and temporal distribution. The presented method can be easily implemented at different spatial scales (from watershed to regional level) and might represent a benchmark methodology to identify priority measures for mitigation of desertification risk in semi-arid Mediterranean environments.

Ladisa, et al,. 2012

Soil salinisation and alkalization are regarded as major causes of desertification and are serious forms of soil degradation in the Mediterranean (Zdruli *et al.*, 2007). Human-induced salinisation has expanded mostly due to poor quality irrigation water and irrigation management, especially along the coasts where seawater intrusion into the fresh water aquifers is a common problem. Almost all the saline soils of Egypt (1 million ha) for instance are human-induced (Gomaa, 2005) and in Algeria in 2011 the area of secondary salinisation was estimated to cover 15 per cent of all irrigated lands. A decade ago, estimates of the economic costs of environmental degradation in Egypt ranged between €2.7 billion to €5.1 billion per year (or 3.2-6.4 per cent of GDP), €1.5 billion per year (or 3.6 per cent of GDP) in Algeria and €1.2 billion per year (or 3.7 per cent of GDP) in Morocco (Montanarella, 2007). No one expects that the situation has improved since these data were published.

> *What now remains of the formerly rich land is like the skeleton of a sick man. . . . Formerly, many of the mountains were arable. The plains that were full of rich soil are now marshes. Hills that were once covered with forests and produced abundant pasture now produce only food for bees. Once the land was enriched by yearly rains, which were not lost, as they are now, by flowing from the bare land into the sea. The soil was deep, it absorbed and kept the water in loamy soil, and the water that soaked into the hills fed springs and running streams everywhere. Now the abandoned shrines at spots where formerly there were springs attest that our description of the land is true.*
>
> **Plato (427-347 BC)**

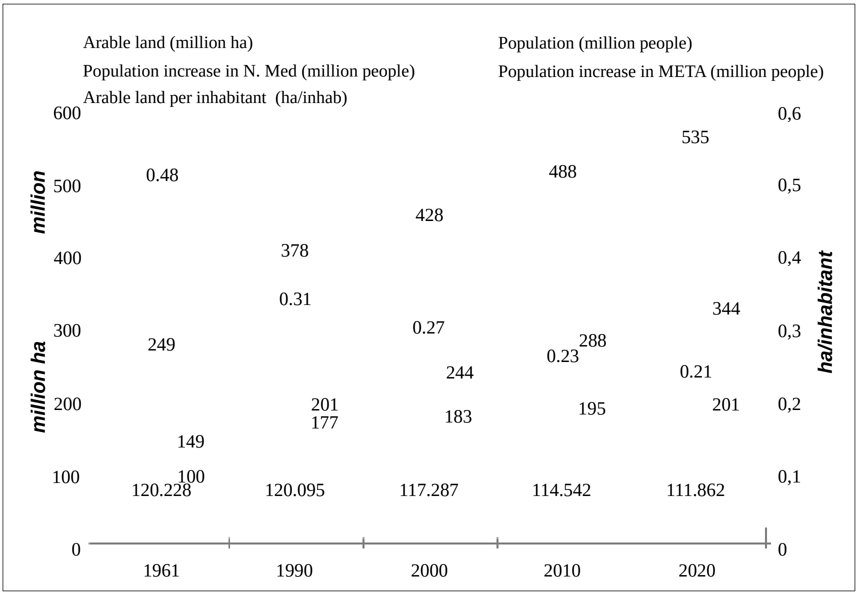
Land degradation in the Mediterranean is as old as its history. There is ample evidence for instance showing that ancient Greeks (Runnels, 1995) cut their forests to expand cultivation on the sloping lands causing thus extreme erosion and leaving behind abandoned badlands. In the area of Aleppo, in Syria called “hundred dead seas” archaeological surveys demonstrate that 1-2 metres of soil was washed away during the first century AD following invasion of several armies and massive deforestation. The same is true for eastern Turkey, Jordan and Lebanon showing evidence of forest clearing since Roman times. Lebanese cedars reached not only the Egyptian Pharaohs but they were used even in the Balkans for building deluxe homes.

Figure 1. Natural erosion in sedimentary claystone/siltstone/sandstone/ formations in Calabria, Italy, locally known as *calanchi*. *(Photo credit: Zdruli, 2012)*

Forest fires in Spain and gully erosion due to land abandonment in Albania

Figure 2. Man made land degradation. *(Photo credit: Cerda and Zdruli)*

While analysing the status of land resources, particular attention is given to agriculture land and not only to the total land area a country has. In the Mediterranean EU countries the average agricultural land per capita is 0.30 ha and the agricultural land per agricultural worker is 11.4 ha, while in the MENA countries (including Turkey) the first value is 0.25 ha and the second is only 1.9 ha, indicating that land available for agriculture is much less and still larger portions of the population (on average 41 per cent) live in rural areas. Other indicators link population increase with availability of agricultural land and predictions show that Mediterranean population by 2020 could reach as much as 535 million people and the largest increase will be in the MENA over passing 300 million people. Contrary, agricultural land area may further shrink by losing 8.3 million ha (or 7 per cent) if the actual rates of urbanisation and land degradation will remain the same (Zdruli, 2012). Consequently the agricultural land (ha/capita) region wide would drop from 0,48 ha in 1961 to 0,21 ha in 2020 (Graph 2). Unless these rates are reversed, the situation in the MENA region could become particularly critical.



Graph 2. Relationships between availability of land resources and population trends. *(Zdruli, 2012)*

Agriculture remains an important economical sector for the MENA economies and its share on the national GDP varies from country to country. In Egypt for example the sector provides 13.4 per cent the country's GDP and must be noted that Egypt is one of world's largest producers of rice and cotton and in 2011 produced about 5.67 million tons of rice and 635,000 tons of cotton. On the other side Egypt is the world's largest wheat importer!!

Despite the fact that MENA is one of the most land and water scarce and dry region in the world, many of these countries, especially those around the Mediterranean Sea, are highly dependent on agriculture. For example, the Oum Er Rbia River basin contains half of Morocco's public irrigated agriculture but produces 60 per cent of its sugar beets, 40 per cent of its olives, and 40 per cent of its milk.

Agricultural output is central also to the Tunisian economy. Major crops are cereals and olive groves, with almost half of all the cultivated land sown with cereals. Tunisia is one of the world's biggest producers and exporters of olive oil, and it exports dates and citrus fruits that are grown mostly in the northern parts of the country. Agriculture in Lebanon is the third most important sector in the country after the tertiary and industrial sectors. It contributes nearly 7 per cent to the GDP and employs around 15 per cent of the active population. Main crops include cereals (mainly wheat and barley), fruits and vegetables, olives, grapes, and tobacco, along with sheep and goat herding. These figures indicate the importance of the agriculture sector in the overall economical activities of the MENA countries and the impact the sector has in partially fulfilling the population's food needs.

Figure 3. Extensive olive groves in Tunisia, world's largest olive oil producer and exporter

2. The Water issue

Water and food security are highly interconnected. Many of the over 800 million people in the world who still go hungry live in water scarce regions (FAO, 2008a): a limited and insecure access to water resources is often one of the main factors threatening food production (UNDP, 2007). Since water is a key factor for agricultural development, water scarcity can endanger food production and food security (Pereira *et al.*, 2009).

According to the World Bank, water withdrawals in the MENA region represent 67 per cent of renewable water resources and 85 per cent of the water used in the region is for irrigation. As expected, the demand on water for irrigation is considerable, especially because of climate features: a long dry summer, relatively low rainfall and very high evapotranspiration rates. In addition, irrigation systems and practices are often less appropriate to minimise non-beneficial water uses (Pereira *et al.*, 2012).

Besides water scarcity, problems of poor water quality and water pollution are also expected as a result of increasing salinity due to over-abstraction and inadequate irrigation management, pollution from agricultural run-off and uncontrolled discharges of wastewater and effluents. The latter take a great importance as causing public health problems. A point that cannot be ignored is for example the damage coming from fertilisers contaminated water runoff into lakes, rivers and the sea. Egypt is now the largest user of fertilisers in the region that, in addition to less efficient agronomic practices, also relate with the construction of the Aswan High Dam and the consequent Nile floods termination (along with their fertilising silt).

In some cases the irrigated agriculture has changed the dynamics of discharge and recharge to groundwater. The current water conveyance and distribution system leads to recycling of surface water through the aquifer, thus increasing salt concentration in the groundwater used for irrigation. Salt loads of drainage water flowing back to the rivers or groundwater can considerably exceed those projected to occur from irrigation alone. Such waters obviously are an economic burden to those downward in the basin who have to use waters into which such exceeding salt loads have been disposed (note for example the case of the Euphrates river in Syria) (Coppola, 2010). In other cases, degradation of water quality for irrigation may be related to the specific transboundary characteristics of the water resources. For example, in the Syrian area at the Turkish-Syrian boundary the water table has fallen due to the over-pumping and less water flows of the Euphrates river into Syria. It seems plausible that such a dropping is especially due to the strong water abstraction policy actuated by the Syrian government in order to supply water to the dams near the boundary, as well as directly to the El Khabour River and its affluents. This induces farmers to deepen their pumps thus frequently pumping more saline water from gypsiferous porous formations (Coppola, 2007). For more on water quality issue and its relation with land salinization and pollution see also sub-priority 1: the land nexus.

The Mediterranean receives on average only 3 per cent of global freshwater resources. In some countries, these mainly come from transboundary water resources: 97 per cent in Egypt (Nile), 55 per cent in Israel (Jordan River and Mountain Aquifer) and 43 per cent in Syria (Euphrates) (UNEP/MAP-Plan Bleu, 2009). Transboundary water issues (surface and groundwater) are cause for political disputes among the Mediterranean countries and with the impacts of climate change, most likely they will further deepen.

Half of the “water poor” world population (i.e. less than 1,000 m^3 per capita per annum) is concentrated in the Southern Mediterranean region (Mediterra, 2008) and it has been estimated that by 2025 potentially 180 million people will be affected by water problems, 60 million of whom will suffer water shortage of less than 500 m^3 per capita per annum (UNEP/MAP-Plan Bleu, 2009). Demographic pressures together with the economic development of non-agricultural sectors will further deteriorate the water balance in many Mediterranean countries where the water exploitation index is already a matter for serious concern. Pressures will become more severe for the agriculture sector that consumes the largest volume of all water users since it accounted for 64 per cent of overall demand in the period 2005-2010 (49 per cent in the North, 74 and 81 per cent in the South and East), (Blinda, Plan Bleu, 2011). The irrigated area in Mediterranean countries has more than doubled over the last 40 years, totalling 24,200,000 ha in 2009 (17,8 million in the Mediterranean Europe and 6,4 million in Northern Africa). Irrigated land accounts for 20 per cent of all arable land and produces 40 per cent of food production while rain-fed agriculture and pastoralism still occupy an essential place in Mediterranean countries producing around 60 per cent of all the food needs (Molden *et al.*, 2007). In arid and semi-arid Mediterranean countries, irrigation contributed to boost agricultural yields and outputs, stabilized food production and prices and improved farmers' income and economic welfare of rural population (Hanjra *et al.*, 2010; Rosegrant and Cline, 2003).

Nevertheless, the effects of global climate change on the water cycle- rainfall, evaporation, run-off- are expected to deplete water resources (see sub-priority 3: the climate change nexus). Some countries have already revised their resources estimates downwards (Algeria by 20 per cent and Morocco by 25 per cent).

3. The Climate Change issue

Climate Change (CC) refers to any change in climate over time which, triggered (and triggering) with other expected and plausible changes (e.g. population growth and migrations, social, economic and technological development, political, financial and cultural setup, consumption and living habits, dietary preferences), will create new scenarios that will affect the availability and quality of water and land resources used in agricultural production and the biodiversity of ecosystems, thus creating new challenges in water resources management and use (Pereira *et al.*, 2009; 2012). In turn, it could likely affect the availability and spatial distribution of food over the planet and cause concatenated effects throughout the water, land, energy and food security nexus (Fig. 4).

The observations of climate in the past together with the future projections (Bates *et al.*, 2008; IPCC, 2007; Jones and Moberg, 2003) provide a quantitative basis for estimating the likelihoods for many aspects of future CC: continuous warming and increase in mean air temperature of 1–3℃ by the middle of 21 st Century (Nakićenović and Swart, 2000; Giannakopoulos *et al.*, 2005) are expected to occur whereas, by the end of the Century, the increase of temperature could reach between 2.1 and 5.2℃ (IPCC, 2007). It appears that these global projections match in a remarkable agreement with the Mediterranean region, perhaps better than with many other areas. However, warming in the Mediterranean is expected to be higher than the global average, precipitation much reduced in southern areas (Map 2) and frequency and intensity of extreme events and inter-annual variability to increase notably (Giorgi, 2006; Norrant and Douguédroit, 2006; Giorgi and Lionello, 2008; Giannakopoulos *et al.*, 2009; Ferara *et al*., 2010).

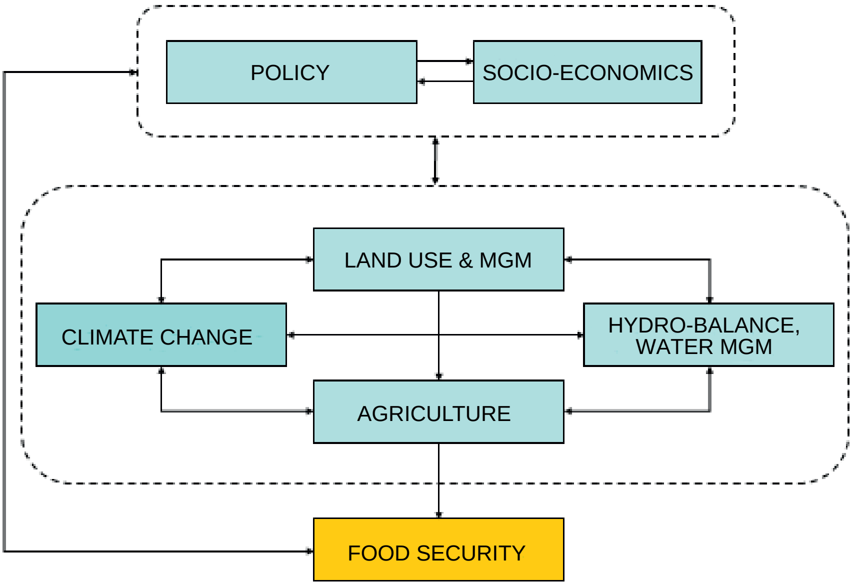
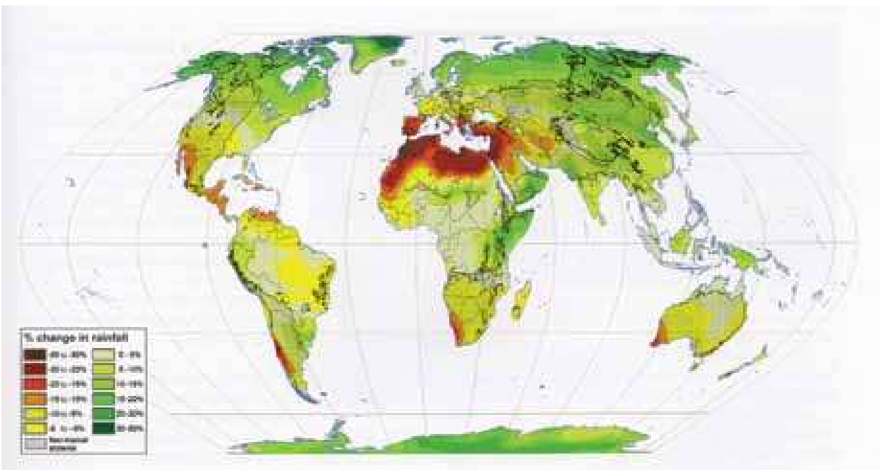


Figure 4. Climate change and its interactions within a larger context of land and water management, agricultural production and food security



Map 2. Projections of precipitation change (in %) for the period 1989-2099 (SRES, A1B) (IPCC, 2007)

Many drylands may be severely affected by climate change. The Scenario A1B of the IPCC predicts an increase in average temperature between 2-4° C for the period between 1980/89 and 2080/99, and especially vulnerable are the regions of non-tropical drylands characterized by higher temperatures and lower rainfall. The WANA (West Asia and North Africa) region is already adversely affected by severe drought stress in cropland with strong repercussions to global food security. Other regions (i.e., Southern Europe, parts of western US and Central America, Northern and Western Latin America and parts of South Western Africa and Australia) are also projected to experience reduced rainfall by as much as 20-50 per cent.

Source: Scenario A1B, IPCC, 2007

The most typical part of the Mediterranean region, i.e. its coastal zone, is characterized with a specific “Mediterranean” type of climate indicating dry and hot summer season and mild and rainy winters which coincides mainly with semi-arid conditions. However, considering the continental areas neighbouring the coastal zone and intrinsically linked with it, the Mediterranean presents a transition area between the arid climate of North Africa and the temperate and rainy climate of central Europe (Map. 3). Hence, due to its specific geographical location, the Mediterranean region is affected by interactions between mid-latitude and tropical processes which makes the region potentially highly vulnerable to climatic changes as it has shown large climate shifts in the past (Luterbacher *et al.*, 2006) and has been emphasized in recent climate change projections (Giorgi, 2006; IPCC, 2007).

Map. 3. Climatic zones in the Mediterranean Region according to the global aridity index (UNEP, 1997) on the basis of the ratio between precipitation and reference evapotranspiration. *(Todorovic et al., 2013)*

The recent analyses, based on A1B scenario and carried out within the WASSERMed project[4] ave shown that, in the Mediterranean region, annual mean temperature over the period of 50 years (2000-2050) would increase in average from 0.8°C in Spain to 2.3°C in Morocco. The overall raise of air temperature would be the greatest in some areas of Northern Africa and the Middle East, and in Southern Turkey. Seasonal patterns indicated that, in winter, the continental interior of South-eastern Europe and Eastern Mediterranean would warm more rapidly than elsewhere. Differently, in summer, the western Mediterranean would warm more than the other parts (Todorovic *et al.*, 2012).

For the same time span (2000-2050), the average annual precipitation could have a decreasing trend of around 6 per cent for the whole region, while the expected range of variation at country level would be between -21 per cent (for Cyprus) and +1 per cent (for France and Slovenia). The spatial pattern of annual precipitation indicates an increase over most of France and Alps, while a decrease is observed in almost all the other regions. There is a marked contrast between winter and summer patterns of precipitation change. Most of Europe could get wetter in the winter season with the exception of Greece, Southern Italy and Turkey. In summer, an overall decrease of precipitation could be expected in Europe, while an increase is foreseen in some areas of Northern Africa and the Middle East (Tanasijevic, 2011; Saadi, 2012; Todorovic *et al.*, 2012).

Therefore, the Mediterranean might be a particularly vulnerable region to CC and especially in the areas already characterized by water scarcity and land degradation. In fact, the warming trend and changes in precipitation pattern might further affect the water balance and composition and functioning of natural and managed ecosystems. In particular, CC impacts on agriculture could be relevant with interrelated effects on the biophysical factors (physiological effects on crops, pasture, forests and livestock; changes in land, soil and water resources; increased weed and pest challenges; etc.) and socio-economic impacts (changes in yields and food production; fluctuations in world market prices; increased number of people at risk of food insecurity; human health, distribution channels, market flows, etc. (FAO, 2007). Moreover, besides the changes in food availability, the collateral effects of CC could be expected over the whole chain of food system stability, accessibility and utilization, including the water and energy used in food processing, storage and transport, as well as the consideration of environmental services (FAO, 2008b). Certainly, these effects will be redistributed in a different way at the global level, with economically advanced regions more capable to adapt to changes opposed to areas penalized because of the scarcity of economical and natural resources, as they are the Southern parts of the Mediterranean.

4. The Biodiversity issue

Biodiversity is not just the direct expression and the term of evaluation of the state of conservation of an environmental system, but it means, even and overall, that it expresses system's productivity, stability and the ability of being self-supporting and self-perpetuating in the long run. Biodiversity loss with consequent reduction of delivery of ecosystem services, has very high economic and social costs not only in terms of environmental sustainability but also to reduce poverty, hunger and diseases all over the world. That's why stopping or reducing biodiversity loss was and still is one of the main Millennium Development Goals (the 7b) replaced by Sustainable Development Goals after Rio+20 and in this regard the Mediterranean region is particularly sensitive.

Due to its location placed in the middle of two major terrestrial land masses (Eurasia and Africa), its climatic characteristics, differences in altitude level (ranking from below sea level - with the Dead Sea 420 meters b.s.l.- to the 4,165 meters of the Atlas in Morocco) and to the variations in rainfall (going from 100 to 3,000 millimetres), the Mediterranean Basin is a real biodiversity hotspot. This is well represented by the high level of endemic species (10 per cent of the world's endemic plants located in only 1.6 per cent of the world's surface). Above all, the region scores third in biodiversity richness at world level (CEPF, 2010) as it hosts 60 per cent of all unique flora species, 30 per cent of endemic fauna and about 7 to 8 per cent of the known marine species. However, nearly 19 per cent of the hosted species are considered as threatened by extinction.

Much of the original vegetation cover of the Mediterranean hotspot has been altered by millenary human induced activities and many of them include conversion of forests and scrubs into agriculture use reducing thus existing natural cover to just about 5 per cent, which is the lowest in respect to any other hotspot in the world. Less than half of this area is actually under protection but the high increasing population trend in the MENA is continuously threatening the remaining biodiversity wealth and its habitats.

In the Apulia region in southern Italy agriculture cover 81 per cent of the territory and only limited patches of shrubs, natural pastures and forests remain untouched

Figure 5. Typical Mediterranean landscapes of Mediterranean Europe showing cereal cultivation surrounded by natural vegetation. *(Photo credit P. Zdruli)*

According to the International Union for Conservation of Nature (IUCN) Red List there are 555 threatened species in the terrestrial area of the Mediterranean hotspot, 336 of these are endemic and 100 are plants. In total 1,110 key biodiversity areas have been identified for the Mediterranean hotspot (CEPF, 2010). Of these key areas, 79 are totally irreplaceable because they contain the entire range of globally threatened species. The Mediterranean Basin is crucially important also for the migratory birds, because it lays along the major migratory bird flyways and it harbours even many critical wetland sites of international importance as described by the Ramsar Convention[5].

Figure 6. Wetlands in the Marine Protected Area of Torre Guaceto in the Province of Brindisi in Italy. *(Photo credit P. Zdruli)*

The Mediterranean sea represents 0.8 per cent of the global ocean surface area, 0.3 per cent of the global water volume but as biodiversity hotpot, on average, it is home to 7 – 8 per cent of all the known marine species accounting with more than 12,000 described species. Its geo-morphological and geological history and the position of the biomes from temperate to tropical, enable it to accommodate both species affinities hot and cold (Pergent Martini, 2009) and to host a strong proportion of all endemic species (over 25 per cent), existing only in the Mediterranean. A higher diversity is observed in the western part of the basin, where almost 90 per cent of the known plant benthiques and more than 75 per cent of fish species are found in the shallow waters (0 to 50 m) although they represent only 5 per cent of the Mediterranean waters.

Apart from the coastal habitats, available knowledge is extremely fragmentary and vary from one sector to the other. At regional level, the latest edition of the IUCN red lists shows that among the Mediterranean marine species the most endangered taxonomic groups are the monk seal (*Monachus monachus* with only 350 - 450 individuals left) and cartilaginous fish (chimaera, rays and sharks; almost 42 per cent of the Mediterranean shark species are at risk of extinction, as opposed to only 17 per cent at global level). Other species of concern at risk of extinction are: the Atlantic blue-fin tuna (*Thunnus thynnus*, because of over fishing) and two turtles species *Caretta caretta* and *Chelonia mydas* (CEPF 2010). According to Annex II of the Protocol concerning Specially Protected Areas and Biodiversity (SPA/BD), the situation is extremely worrying at least for three fish and one mammal species. For the other groups of species, it is difficult to provide a clear diagnosis in the absence of any up-to-date assessment at regional level or as a baseline concerning the state of these species now and in the past.

The straits of Sicily divides the Mediterranean Basin into two main sub-basins, the Western one with a strong influence from the Atlantic ocean, and the eastern one that is characterized by higher productivity and mostly concentrated over the continental shelf. Many other species contribute to ecological functions from which agriculture depends, including soil services and the water cycle.

Biodiversity is the origin of plants and animals that form the basis of agriculture and the immense variety within each crop and livestock. Biodiversity has enabled farming systems to evolve since agriculture was invented about 10,000 years ago in many parts of the world, including the Mediterranean, the birthplace of European agriculture. Presently, all around the world a great diversity of agricultural systems with many different crops and diets are available.

Of the approximately 15,000 species of mammals and birds, only 30 to 40 were domesticated for food production and fewer than 14 species-including cattle, goats, sheep and chicken provide 90 per cent of global trade in livestock production at present (FAO, 2010). According to FAO, about 7,000 species of plants have been cultivated since man began farming, but today, only 30 crops provide 90 per cent of dietary needs of the world’s population, with wheat, rice and corn providing about half of the food globally consumed (FAO, 2010). In recent decades, there has been an alarming genetic erosion of these species. Loss of genetic diversity can occur through poorly planned replacement of local varieties of crops. Genetic erosion can also result from intruding invasive alien species, pests, weeds and diseases, land use changes and environmental degradation.

Since agricultural biodiversity is both the result of natural and human selection its conservation and sustainable use is essential for the future of agriculture production and humanity well being.

5. The Energy issue

Energy inputs are essential to create employment in many productive sectors such as industry, transportation, commerce and agriculture. Water management and use for agriculture is closely related to reliable access to energy. Water resource management, irrigation, urban and industrial water supply, and water and wastewater treatment all place demand for energy to be able to operate on the local level[6].

The type of energy we use in the agrifood chain and how we use it will in large part determine whether our food systems will be able to meet future food security goals and support broader development objectives in an environmentally sustainable manner. As shown in Figure 7, agrifood systems not only require energy, they can also produce energy.

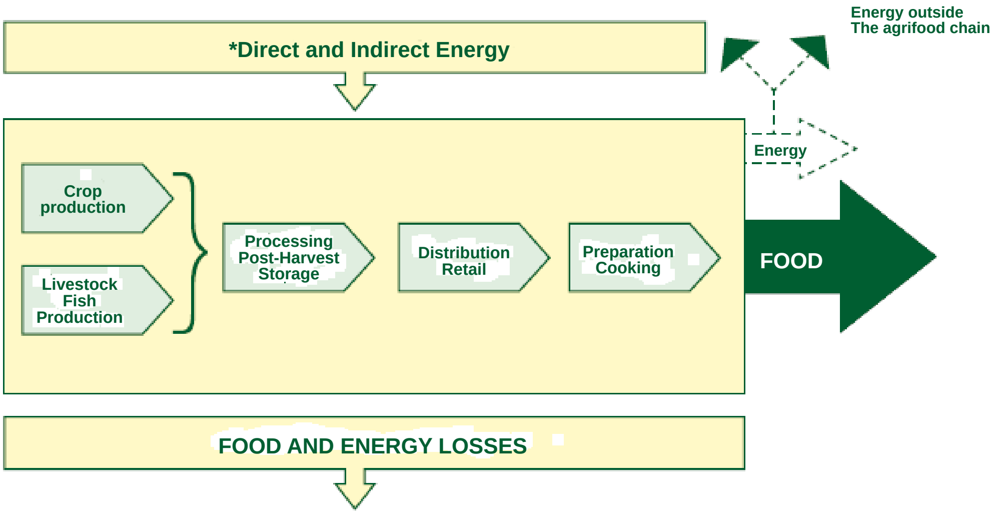


Figure 7. Energy for and from the agrifood chain

Population growth rates (the fertility levels in the MENA are significantly higher than in the wealthy, fully-industrialised nations of the northern Mediterranean) are expected to have an obvious impact on energy consumption in the region. Such a condition is very relevant with regards to energy infrastructure, which requires large investments and long-term planning. The present situation implies that much more energy will be needed especially in the MENA nations, to maintain or increase the present level of per capita energy consumption, notwithstanding the relatively large population growth.

According to projections by the Mediterranean Energy Observatory, primary energy demand of the MENA countries will increase from 33 per cent of the total demand in 2010 to 40 per cent in 2020 and 42 per cent in 2030. In this analysis, it has also been considered that the economies of the MENA countries are at a different stage of maturity compared to those of the European Mediterranean edge. While the EU countries have shifted much of their economies from production to the less energy-intensive service sector, the MENA regions currently tend to developing of a classical manufacturing production.

Energy security is associated with social security, economic security (besides military security), but also refers to food security. Traditional agriculture simply converts solar energy into food for humans and livestock. Nevertheless, as argued by Weissenbacher (2012), societies evolution has turned agriculture, their first great source of energy, into an energy sink. It is expected that the agriculture development in the Mediterranean to fulfil population growth will require much larger inputs of technical energy into food production. The enormous energy inputs for fertilizer production are a major factor in this system. Natural fossil fuels prices have a strong influence on fertilizers and thus on food prices. On the other side, the energy-water nexus is very much interlocked as both components of the equation rely heavily on each other.

Boosting irrigation for enhancing food production also tends to increase the energy demand. In various South-Eastern Mediterranean countries, the demand for energy for irrigated agriculture is expected to increase considerably (see sub-priority 2: the water nexus) because of the increasing water pumping that is necessary to run irrigation schemes. This situation is expected to worsen where desalination plants need to be implemented.

As a consequence, feeding the world in the coming decades will require the gradual decoupling of agricultural intensification from its dependency on fossil fuels, in order to make inputs affordable – hence contribute to both climate and food security. This requires more **energy-smart food systems**, which means:

- increasing the efficiency of direct and indirect energy use in agro-food systems, without lowering productivity (Lamaddalena and Khila, 2012);
- using more renewable energy as a substitute for fossil fuels in the agro-food chain and irrigation;
- improving access to modern energy services (FAO, 2012).

III – Problem analyses

1. Land and Food Security Nexus

The Mediterranean region covers 6.3 per cent of the global land area, contains 7.9 per cent of the agricultural land, 3.7 per cent of natural pastures and rangelands, but only 1.9 percent of forests and woodlands. Noteworthy however, is that urban settlements, deserts and areas with minimal photosynthetic potential cover about 8.6 per cent of world's land area. It is significant that only this last figure ranks higher in a region of land scarcity!

Competing interests for land in the region identify agriculture as the major looser. Built-up areas now cover nearly 40 per cent of the Mediterranean coastline and by 2050, provided the present sealing (urbanization and land take) rates will remain similar, it will reach at 50 per cent spurred also by the tourism industry that brings into the region about 300 million tourists each year. Urban expansion has often happened at the expense of prime soil and major cities like Alexandria, Cairo, Tripoli, Beirut, Casablanca, Istanbul, Barcelona, Marseilles, Athens and many others have been established where the best soils are. Data from Italy show that during the period of 2000-2010 more than 300,000 hectares of agricultural land were lost to urbanization. This is translated with the loss of 1,500,000 tons of wheat per year. Similar "disturbing" data are available also for Spain (Barbero-Sierra, *et al.*, 2013).

Fertile soils could not be converted to non-agricultural uses either for installation of solar panels or windmills mushrooming in many European Mediterranean countries. Good soils and the rural agricultural landscapes should not be threatened by ill-implemented renewable energy initiatives camouflaged with environmental concerns. Soil sealing is one of the major soil degradation problems in the EU that losses as much as 275 ha day^{-1} of agricultural land (JRC-EEA, 2012) or for every 3 seconds an area equal to one football field size. This is a very significant figure since for every hectare of fertile arable land lost in Europe it would be necessary to bring into production elsewhere outside the continent an area up to ten times larger (Gardi *et al.*, 2011), accelerating thus the process of land grabbing in Africa or other world regions.

Figure 8. Solar panels replacing olive groves in the Apulia Region, Southern Italy
Source: Salviamo il paesaggio difendiamo i territori. Italian Forum Movement for Land and Landscape www.salviamoilpaesaggio.it

The Southern Mediterranean experience similar problems. In Egypt, Morocco, Tunisia, and Syria thousands of hectares of valuable agricultural land were lost to urbanization especially during the period 1975-1985. A typical example is Egypt where even 110 km^2 of desert lands were urbanised between 1995 and 2007 (UN HABITAT 2012). Prior annual land transformations (1960-1990) in Egypt, the most populated Mediterranean country have been 10,000 ha $year^{-1}$, increasing to 12,600 ha $year^{-1}$ after 1990 (Plan Blue, 2003) but the land take rates for the surroundings of Cairo were much larger (Chaline, 2001). In 2012 the Greater Cairo area accounting for about 20 million people, 65 per cent of them living in the so-called informal areas, was ten times bigger than in 1950. It is also for these reasons that Egypt, a country expected to have 101 million by 2020 and 150 million by 2050 is making land acquisitions in the nearby Sudan or expanding irrigated crop production in the arid areas as it is happening between Cairo and Alexandria crossed by the famous Desert Road. Similarly, in the region of Algiers in Algeria about 140,000 ha of fertile lands have been affected by urban sprawl and other forms of land take (Chaline, 2001) and in Lebanon 30,800 ha of productive lands have been lost to urbanization for the period 2000-2010. Data for Turkey show that this country too lost to sealing 827,000 ha only for the period 2001-2010.

Outside the arable lands, there are the categories of natural pastures and rangelands that along with rainfed agriculture and pastoral activities produce the largest share of the food supply in the Mediterranean. In the MENA region, pastures and rangelands cover 95,275,000 ha or 13.8 per cent of the whole area, which is almost triple the surface area covered by this type of land cover in the Northern Mediterranean countries. This land use category is important also for the preservation of biodiversity and global life support and ecosystem services, especially as potential pools for carbon sequestration and mitigation of climate change, hence deserves protection. Forests and woodlands cover only a small portion in the region and are best preserved in the Mediterranean EU countries, where almost one third of the land is under forest or woodland. The MENA countries have only 2.9 per cent of their territory covered by forests and shrubs many of which have either been damaged by wild fires, exploited for fuel wood, overgrazed, converted to cropland or consumed by urbanization. It is concluded that despite land scarcity is evident throughout, actions to prevent or restore degraded lands are only marginal.

2. Water and Food Security Nexus

Water scarcity and associated water quality degradation are expected to become the main environmental and social problems for all the countries in the Mediterranean region, particularly those in the MENA region. Due mainly to the increasing population, demand for water has increased as well and many countries are currently facing water shortages and forecasting future water resource scarcity. This is a problem not only for countries located in the arid areas, but also for those outside such areas which are over using and deteriorating their water resources. A number of Mediterranean countries regularly experience severe water supplies and demand imbalances, particularly in the summer months. Water shortages are also frequently affecting regions less used to such events, where dry spells are becoming more frequent and long lasting. Due to resource scarcity, agricultural activities are especially penalized, while higher priority demands for urban and industrial uses are satisfied. Notice should be taken that agriculture in MENA is responsible for more than 50 per cent of total groundwater abstraction, reaching values superior to the natural recharge, thus leading to the mining of groundwater resources.

Water scarcity and water quality degradation in most of the MENA countries are aggravated by relatively low beneficial water uses as a fraction of total uses, as well as water over-abstraction. According to UNEP/MAP - Plan Bleu (2009), in the Mediterranean region, total (for all uses) losses, leaks and wastage sum up to about 40 per cent of the total water demand. Such losses come partly from dilapidated water distribution networks and limited funds for network maintenance, but also results from high levels of wastage due to less efficient irrigation systems.

On the other side, the growing demand for water to meet agricultural needs is largely met by an increasing over-exploitation of both the renewable and fossil groundwater. Over-exploitation of groundwater, in addition to mining, leads to degradation of the resource (Pereira *et al.*, 2009). UNEP/MAP - Plan Bleu (2009) estimated that this way 16 km^3/year of so-called «non sustainable» water is produced, two thirds of which comes from the abstraction of fossil water and the remainder from the over-use of renewable resources or the re-use of drainage water. In some cases (e.g., Egypt) abstractions exceed the primary renewable resources.

It is clear that water quality and water scarcity are strictly related, as water degradation in the region mainly results from high salinity due to over-abstraction and contamination. Thus, since water in the Mediterranean serves largely for producing food needed to feed its population, the combined effects of shortage and degradation of water resources may lead to reduce agriculture's capability to maintain its per capita agricultural output and to contribute towards achieving food security objectives.

3. Climate Change and Food Security Nexus

Precipitation pattern (spatial intensity and variation), air temperature increase and higher atmospheric CO_2 concentration are three major interconnected CC parameters that will influence agricultural production in the future. Most plant processes related to growth and yield are highly temperature dependent and a shifting of agro-ecological zones (from lowland to upper altitudes and from Southern to Northern areas) is expected. Certainly, this will create new conditions related to land and water availability for agricultural production and modification of agro-ecosystems. On one side, higher temperature will decrease the growing cycle of plant species; on the other, it will extend the overall period suitable for cultivation and allow, in some areas, for more than one cropping in the same year. Nevertheless, the duration of optimum temperature range for obtaining maximum yield could be compromised in many regions. Moreover, it should be recognized that the effects of elevated CO_2 on crop yields could be strongly different among crop type and location. Recent studies confirmed that the effect of elevated CO_2 on plant growth and yield depend on photosynthetic pathway, species, growth stage and management regime (Pereira and de Melo-Abreu, 2009). Furthermore, the increase of CO_2 concentration would affect also the level of stomata opening and transpiration process.

Therefore, in the future, crop yields affected by climate change are expected to be different in various areas: in some areas crop yields will increase, and for other areas it will decrease depending on the latitude, soil characteristics and water availability for irrigation. In general, crop yield is more sensitive to precipitation than temperature. If water availability is reduced, the soils of high water holding capacity would attenuate better the impact of drought. In general, with the increase of temperature and overall water demand, it is likely that water availability and crop production could decrease in the future. However, the results of investigations are contradictory due to use of different scenarios, various scales of study, difficulties to interact with many correlated parameters, etc. (ISMEA-IAMB, 2009).

In the Mediterranean, the impact of CC on agricultural production could be negative for most areas with a large variability and reduction of crop production (Olesen and Bindi 2002; Ewert *et al.*, 2005; Olesen *et al.*, 2007). No changes or slight increase in yield are expected for autumn and winter crops while, for summer crops, a remarkable decrease of yield is predicted due to a lengthier drought period during this season (Giannakopoulos *et al.*, 2009). The possible increase in water shortage and in frequency and intensity of extreme weather events may cause lower harvestable yields, higher yield variability and a reduction in suitable areas for traditional crops (Maracchi *et al.*, 2005; Todorovic *et al.*, 2012).

As a consequence of air temperature increase and the shortening of the growing season, the average crop water requirements over the whole Mediterranean region are expected to decrease by 4 to 8 per cent (Tanasijevic, 2011, Saadi, 2012). Hence, the average net irrigation requirements (NIR) would decrease or remain stable. This could be explained by an overall reduction of crop evapotranspiration (ET) as well as the spatial and temporal variability of the precipitation change. Therefore, the air temperature increase could have a dominant role on the shortening of the growing season rather than on the increase of crop water requirements (CWR). The impact of precipitation decrease would be limited only to the perennial and winter crops because most of spring-summer agricultural production in the Mediterranean is already characterized by very low rainfall (Tanasijevic, 2011; Saadi, 2012; Todorovic *et al.*, 2012).

However, conditions for rainfed crop systems are likely to be negatively affected by the lack of water availability resulting from CC. Further concerns relate to future agricultural water requirements with respect to water availability under the combined effects of CC, growing population demands, and competition from other economic sectors under future socio-economic development (FAO, 2003; Rosenzweig *et al.*, 2004; Schmidhuber and Tubiello, 2007; Tubiello and Rosenzweig, 2008). in addition, it is important to emphasize the uncertainties related to the combined effects of air temperature and CO_2 concentration increase, future advances of plant breeding and genetics, irrigation and crop production technologies and agronomic management practices. Overall, CC could likely intensify the problems of water scarcity and sustainable agricultural production in the Euro-Mediterranean region

The effects of CC on the coastal areas of the Mediterranean have also to be carefully considered. Coastal erosion caused by natural conditions and human activities and sea level rise, will cause a loss of the productive land and the disappearance of many wetlands. Egypt for instance could pay dire consequences and may lose considerable highly productive lands along its coast compromising food security in the country. In addition, the sea level rise could provoke the intrusion of salty water in the coastal lagoons which provide about one-third of the Egyptian fish production. In fact, the expected increase of air and water temperature would affect the biodiversity of aquatic ecosystems (river and marine) with tremendous consequences on fish production and food security at the regional and global scale (Fig. 9).

The impact of CC on global and regional water resources has been investigated by various authors. The overall results indicated that CC is likely to increase water scarcity around the globe, prevalently in regions that already suffer under present conditions and are exposed to extreme weather events. Warmer, drier conditions will lead to more frequent and prolonged droughts, and the river-basin areas affected by severe water shortage will increase (EEA, 2005; Lehner *et al.*, 2006). However, on the other side, a more frequent and severe flooding could be expected too. As a whole, CC could likely intensify the problems of water scarcity and sustainable agricultural production in the Euro-Mediterranean region (IPCC, 2007) where irrigated agriculture is a major water user accounting for more than 60 per cent of total abstractions.

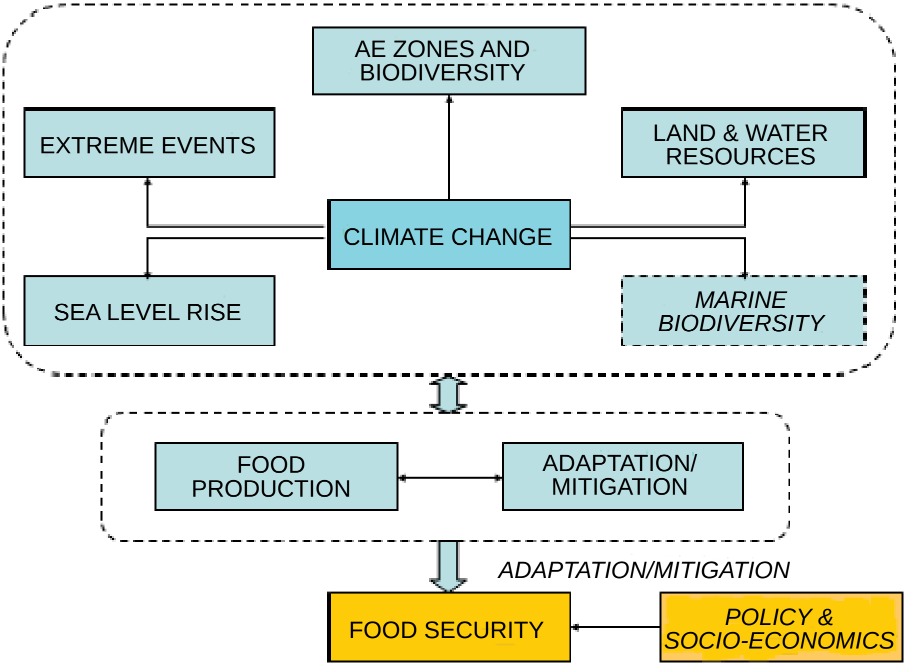


Figure 9. Climate change implications and interlinks with food security

4. Biodiversity and Food Security Nexus

All populations, but in a stronger way the populations of poorer regions in the Mediterranean area, greatly depended on biodiversity richness. For instance, many rural households depend on rainfed farming, local varieties and endemic species as well as fishing and hunting to meet their basic food need. Consequently the loss of biodiversity limit the food options of such populations and undermine the potential for economic growth. For instance, many rural households depend on rainfed farming as well as fishing and hunting to meet their food need. Consequently the loss of biodiversity undermine the potential for economic growth and limit the food options of such populations. The conversion to standardized ecosystems or agro-ecosystem (e.g., monoculture following deforestation) destroys the habitat of diverse species that preceded these areas prior to conversion. At regional level, 149 different threats have been identified by the Mediterranean countries (CEPF 2010), attaining to degradation and fragmentation of habitats, by-catches, overexploitation, pollution and introduction of invasive species (Cuttlelod, 2008).

The first main cause of reduction of biodiversity is the habitat loss or reduction (fragmentation). Factors contributing to habitat loss are: land use competition, overpopulation, deforestation, pollution (air, water, soil) and global warming due to climate change. Many Mediterranean lagoons and deltas are disappearing because of the growth in artificial surfaces that disturb the equilibrium in sediment balance, especially in heavily populated areas with little or no protection from natural sedimentation process. For surface coastal ecosystems, the most serious threat is posed by the construction of facilities and coastal artificialization. Such typology of "urbanization" lead to the loss of ecosystems with a high level of biodiversity (coastal ponds and lagoons, Posidonia beds and surface bio-concretions), a loss which is virtually irreversible on the human scale (Pergent Martini, 2009).

The other main cause of biodiversity reduction and loss is the natural resources overexploitation. In the case of forests or pastures there is currently a huge disparity between the situations prevailing on the two banks of the Mediterranean (De Montgolfier, 2009). To the north, after a period of major overexploitation of natural areas occurred in 18^{th} and 19^{th} Centuries there is a steady regression and the forests are now making a more or less strong comeback in many areas, due to the abandonment of farming and grazing on soils with low productivity. However, biodiversity is at risk in other areas of extreme farm intensification and increasing urbanization. The nature of the pressure in the south of the Mediterranean region is different as there is still very strong over-exploitation of forests and shrubs for firewood.

The over-exploitation of the marine biodiversity currently appears to be one of the major threats to fish, in particular to the migratory ones and to some mollusc, sea urchin and shellfish species (Pergent Martini, 2009). In addition, there are about 200 large oil tankers navigating in the Mediterranean Sea daily posing another threat to marine life in many ways. Climate change appear to encourage the geographic spread of the species introduced through the Suez canal in particular, by providing them with more favourable environmental conditions than in the past, although it is not the only original cause of the introduction of exotic invasive species into the Mediterranean Sea. Little is known about the possible impact of climate change on many marine species, but as a consequence of it many aquatic permanent and ephemeral ecosystem might disappear (Pergent Martini, 2009).

Habitat size and numbers of species are systematically related. A 2007 study (Lankau and Strauss 2007). conducted by the National Science Foundation found that biodiversity and genetic diversity are co-dependent—that diversity among species requires diversity within a species, and vice versa.

Since biodiversity is closely linked to agriculture, even under the most optimistic scenarios, climate change will cause shifts in suitable areas for cultivation of a wide range of crops. Modelling indicates that rain-fed agriculture yields in some regions of Africa could be reduced by up to 50 percent by 2020 (IPCC, 2007). Climate change may increase temperature of between 2–6 degrees Celsius in the MENA and changes in rainfall regimes anticipate both an increase and decrease in precipitation, and an increased frequency of dry spells and floods (IPCC, 2007). These changes will impact both rainfed and irrigated agriculture, making adaptation necessary. Climate change will have an impact on agricultural biodiversity too by increasing the genetic erosion of landraces and threatening wild species including crop wild relatives (Jarvis *et al.* 2008). Severe pest outbreaks may increase with climate change, profoundly affecting agro-ecosystems and global food availability (Tubiello *et al.* 2008). Food production and access to appropriate varieties in many African countries will be severely compromised, exacerbating food security problems and malnutrition (IPCC, 2007).

Relationships of biodiversity and food security could be better described by the fact that agriculture, arguably the most important ecosystem for human health and wellbeing, have been put under severe stress to meet the demands of a growing population. If the world's nutritional demands have to be met, greater attention must be devoted to the limits of ecosystems and the services they provide (Chappell et al, 2011).

5. Energy and Food Security Nexus

In the MENA countries, the availability of reasonably priced energy is a major factor in resolving the interconnected issues of population, food security and environmental sustainability. Many areas in the MENA region are dependent on groundwater for irrigation as well as for water supply. It is thus obvious that increasing need to pump groundwater for those purposes, which relate to the population growth, will bring with it a corresponding increase of the cost of production and will reduce the productivity of the agriculture in the area. Climate change is likely to exacerbate the problem (see sub-priority 3: the climate change nexus), as it will amplify demand for reliable energy supply. This will affect the development of the rural areas in the region and have implications on food security and sustainable livelihoods. As a consequence, it is expected that the energy balance in the area will be affected by the extent to which water management (see sub-priority 2: the water nexus) may be improved to reduce total energy consumption and by the capability in the area to increase supply through renewable energy sources.

The issue of food security linked with energy is very complex; indeed, the problem has been out of for several years as it sits uncomfortably with notions of regional free trade areas and interdependence. However, the combination of sudden global commodity price rises and the continuing inhibitions to free trade in foodstuffs and agricultural products within the Mediterranean region has made it, once again, a subject of acute concern to regional governments. In addition, an examination of the actual trade figures of the Med-10 countries demonstrates that the majority of them are food deficit countries.

Energy efficiency measures, behind-the farm gate and beyond-the farm gate, have been promoted in the MENA countries with varying degrees of success. Historically, energy costs have been a small component of the total operating costs for many food businesses and, for this reason, incentives to reduce energy demands have not been strongly promoted.

Energy is strictly interrelated to water and food security in a number of ways. Food production, especially large-scale agriculture, depends both on energy and water as essential inputs. Water pumping, treatment and redistribution need energy; and energy production needs water. Energy inputs via fertilizers, tillage, harvest, transport, and irrigation and processing have their influence on food prices. Environmental pressures and climatic changes, as well as growing economies and populations, both intensify the existent relations between the three systems. In regions with limited water resources and growing population (such as MENA), those linkages are even tighter and more challenging. In these countries, the population growth and the increasing demand for food is changing (worsening) the rainfall and weather patterns. More of the freshwater available is demanded by energy, industrial and urban systems. Farmers are induced to pump from aquifers faster than they can be replenished (especially in cases where electricity is subsidised) and, as water levels drop, energy for pumping continually increases. In this context, desalination become an option but it is very energy-intensive, can increase CO_2 emissions if fossil fuels are used and is associated with environmental concerns such as brine disposal.

Given these strong connections, each sector (energy, water and food) has the potential to drastically affect the others. Droughts, besides reducing crops and contributing to high food prices, may also impact energy supplies (when water withdrawals are for cooling power plants). Subsidies for food, energy, or water, for example, often have unintended consequences for the other two sectors. The popularity of biofuels as an alternative fuel, for instance, has brought unintended consequences for food and water. Biofuels consume water; additionally, by competing for cropland, they have increased cereal prices on world markets and are not a viable option for the Mediterranean, especially the MENA region.

If food security is to be achieved, strategies, policies, and investments need to consider all the related areas of energy, water and food production, distribution, and use, especially in developing countries. And yet, due to the width of the individual sectors, there is little work focusing on how to support decision-making at the nexus. When it is done, it normally focus on two areas only, and few approaches have comprehensively addressed the broader interdependencies (Bazilian *et al.*, 2011). Thus, the need for understanding the energy-water-food nexus and the impact on it of climate change is obvious and demands for systematic, coordinated planning approach.

The energy-water link in irrigation schemes: results from a case study in Vigia Irrigation District, Alentejo, Portugal

This study analysed the energy efficiency of sprinkler irrigated sunflower, wheat and maize crops during the summer season of 2008. It was applied to selected farms where pressurised water distribution systems are used. Impacts of the crops' energy balance when full and deficit irrigated, as well as relative to upgrading irrigation systems performance were assessed. Centre-pivot and solid set sprinkler systems were used. Energy efficiency (EE) was computed as the ratio between the energy output represented by the crop production and the total energy input; EE hence indicates the amount of energy produced by a crop per unit of consumed energy. Results have shown that maize was the most efficient in producing energy and wheat was the least for all the scenarios considered. Results for maize have shown that adopting a centre pivot system and a full irrigation schedule EE varied between 2.06 and 2.23, while for the solid set sprinkler system EE ranged from 1.89 to 2.18. For wheat, EE averaged 1.32 for centre-pivot and 1.23 for set systems. Results for full irrigation presented higher EE than deficit irrigation because EE greatly depends on the yields achieved. Results have shown also that improving the irrigation system performance leads to increased EE but related impacts are small. Only weak relationships were found when relating EE and water productivity (WP). Results are influenced by the share of irrigation energy input in the total energy input. This share may be greater than 50 per cent for sunflower, is close to 42 per cent for maize, and less than 40 per cent for wheat. The greatest share corresponds to solid set systems when compared to centre pivot systems. Thus centre-pivot irrigation favours attaining higher EE. The low EE values referred above do not favour the use of irrigation for bio-fuel production. Results also indicate that there is a risk when converting surface irrigation to pressurized irrigation which relates to the high share of energy used for irrigation when it is pressurized.

Rodrigues et al., 2010.

However, today as energy costs have increased and more businesses set targets to reduce their carbon footprints, there is renewed interest in improving energy efficiency. In addition, as new energy demand from expanding food sectors in MENA countries are increasing, efforts are being made to minimize their energy intensities. Opportunities to reduce the energy intensity can come from modifying at no or little cost existing farming and food processing practices. These modifications would also require changes in the behaviour of farmers, managers and operators. Introduction of new modern efficient equipment is another option. However, this may require significant capital investment. Producers in MENA countries may be faced with financial constraints to adopt improved energy efficient technologies, such as precision farming, irrigation monitoring, and transport logistics. Options need to consider the balance between efficiency measures, projected energy costs and the need of improving energy access and affordability.

This problem not only affects water-scarce arid countries globally, but also those where intensive agriculture is already practiced, and where water productivity has to be increased and/or diffuse pollution impacts need to be reduced. Despite the strategic interest of this topic, and the technical developments achieved in recent years in reducing water use and energy consumption in water distribution systems, there exists still major opportunities to introduce more effective (and necessary) innovations both in technology and management approaches. In fact, the interest of the water-energy-nexus has led to substantial technical developments to reduce water use and energy consumption in water distribution systems. Responding to the above challenges, it is important to support and boost the necessary innovations, to help overcome the identified barriers, and to develop appropriate conditions for new market opportunities, mainly on: i) Remote control, electro-mechanical components and technologies in water distribution systems, ii) Modelling and development of decision support systems (DSS) in relation to optimum design and management of water distribution systems and pumping stations (Khadra and Lamaddalena, 2010), iii) Pressure and water requirement reduction by means of new on-farm devices and precision irrigation (i.e. on-farm technologies and management, demands forecast, etc.); iv) Electricity tariff policies and energy market negotiation.

We emphasise again that bio-fuels are not an option for the Mediterranean due to its limited land and water resources. On the contrary the region must invest in renewable energy sources (solar and wind) and use its land for producing food and feedstock. Recent data point out that even globally, if the arable land would be used to grow bio-fuels such production would be able to meet by 2050 only 4-6 per cent or the world's energy needs while using 85 per cent of the world's fresh water resources (HLPE, 2013).

IV – Future research needs

Investing in research pays back!

1. Land

To forget how to tender the land is to forget about ourselves.
Mahatma Gandi

To describe better future research needs it is necessary to make a distinction between the concepts of "soil" and "land". Soil is the most upper layer of the Earth's crest (called also Earth's skin) that is more closely related to farming and by pedological agreement ends up to 2 m deep, even though often soils are much deeper. Land on the other side is a delineable area of the Earth's surface, encompassing all attributes of the biosphere immediately above or below this surface, including those near the surface, the climate, *the soil* and the terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the surface sedimentary layers and the associated groundwater reserves, the animal populations, the human settlement pattern and the physical results of past and present human activity such as terracing, water storage or drainage structures, roads and buildings, etc. (FAO 1998). We deal primary in this chapter with land resources.

> "In the United States over the past half century, every dollar invested in public agricultural R&D returned benefits valued at between 20 to 30 dollars. Changes in US corn production illustrate how investments in research and development have paid off in productivity gains. US corn production grew from 67.9 million metric tons in 1900 to 312 million tons in 2011, or 36 per cent of the entire world's output, while over the same period the amount of land under corn production decreased. A sizeable share of the growth derived from use of technological innovations (notably, new hybrid varieties of corn) resulting from investments in research"
>
> *(The Chicago Council on Global Affairs. 2013)*

Despite covering a very limited part of the Earth, soils produce more than 99 percent of global food needs. Fibber, fodder and recently bio-fuels, are other soil by-products. Additional soil-beneficial environmental functions have been recognised by the EU Strategy for Soil Protection (EC COM (2006) 231) such as water filtering, buffering, storing, and cleaning of pollutants, carbon sequestration, source of raw materials, preservation of biodiversity and of archaeological heritage. To this end, implementation of *sustainable land management* (SLM) technologies is hence the best approach for mitigation, remediation and sustained agricultural development. Healthy soils produce healthy food!

However, further studies are needed to show the potential of SLM to increase yields, soil organic content and carbon sequestration capacity, and how best to improve the interaction between the soil-plant-water system and increase land productivity while protecting the environment. Research should also deepen to the practical assessment and application in Mediterranean conditions of technologies such as conservation agriculture, no till or reduced tillage, agro forestry, mulching, cover crops, controlled grazing, integrating crop and livestock production, and well designed terracing to control soil erosion, as well as halophyte cultivation in saline areas. The traditional benefits of crop rotations, nitrogen fixing legumes and trees and the combination of no-till with cover crops needs to be experimented further in a holistic approach (including relative to water) and the *win win* benefits of conservation agriculture in improving soil fertility and increasing crop productivity must be better explored (Bisaro *et al.*, 2013).

Photo credit: F. Turkelboom *Photo credit: R. Bouabid*

Figure 10. Well designed terraces in Syria and Morocco

Additional studies are needed to endorse *productive farming systems* that mostly promote reduced fertiliser use, water conservation, backing of organic farming, conversion of arable land to grassland, cover crops and strips preventing erosion and fires, preserving areas of special biodiversity, maintenance of existing conservation systems, and preserving farmed and rural landscapes. Social aspects and issues in relation to land use and particularly with combating desertification are also priority areas.

2. Water

In order to tackle these challenges, Mediterranean countries will need to promote more efficient measures for managing scarce water and agricultural land in a sustainable manner. Managing supply, increasing water use efficiency and re-allocation of irrigation water, protecting water quality and re-using non-conventional water resources for irrigation are the main key issues for further research (CIHEAM, 2004; FAO, 2012).

In order to tackle these challenges scientific research and policy actions should be focussing on several strategies (Breisinger et al, 2010; CIHEAM, 2004; FAO –ICID, 2011; FAO, 2012; Molden, *et al.*, 2010; Pereira *et al.*, 2009) as below:

- Upgrading rainfed agriculture: rainfed systems dominate world food production and they cover most of the world's cropland area (80 per cent). However the remaining 20 per cent (or the irrigated area) produce 60 per cent of cereals globally. Upgrading rainfed agriculture could generate social, economic, and environmental paybacks, particularly in poverty reduction and economic development. Estimates suggest that about 75 per cent of the increased water requirements needed to attain the 2015 hunger reduction target of the Millennium Development Goal will have to come from water investments in rainfed agriculture, i.e., in water conservation or, in other words, in making better use of the green water. Introducing and/or improving water harvesting techniques may be strategic for rainfed agriculture in the area but other approaches to improve infiltration, soil water storage and decrease evaporation are definitely required (Pereira *et al.*, 2009);
- Increasing production in irrigated areas and consequently improving water use at different scales from crop to irrigation system: in regions that rely heavily on agriculture, irrigation is likely to be even more important in food security strategies; in addition, the increasing competition for water will be an incentive for irrigation to perform better;
- Increasing water resources availability through modernized collection and distribution infrastructures, taking into account economic, social and environmental sustainability criteria, and particularly by improving irrigation water service performances (Lamaddalena and Pereira, 2007; Zaccaria *et al.*, 2010);
- Reducing water losses and wastage, particularly by restoring and modernizing networks in a state of disrepair or having low service performance, and providing for increased performance of irrigation systems, thus for more efficient, sustainable water use;
- Increasing water resources availability through non–conventional water resources such as the re-use and recycling of wastewater and the use of saline water as well as desalinated water. Undoubtedly, water scarcity is a major incentive to finding alternative water supplies. Water conservation is an answer to the problem and certainly wastewater reuse is an important component in water conservation strategies. Wastewater use for irrigation may have the largest field of application because it offers attractive environmental and socio-economic benefits, mainly due to the reduction in effluent disposal in receiving water bodies, nutrient recovery as fertilizers, and improvements in crop production during the dry season; however research is needed to control impacts on soils, on crops and on human health (Coppola *et al.*, 2003; Coppola *et al.*, 2004);
- Supporting diversification in agricultural production in order to re-orient trade flows of food by reducing the production of low-value water-intensive crops. Appropriate economic related research is therefore needed;
- Enhancing water multiple-use systems since the largest gains in water productivity can be achieved by using water for many productive and non -productive purposes such as fisheries, livestock, domestic and environmental;
- Institutions and policies for a new and democratic water governance as essential elements to implement options and strategies for a more sustainable water management.

There is also an urgent need for investment in scientific research and policy changes that will allow water -dependent countries to become more resilient by improving their agricultural productivity, reducing water losses through water conservation measures and water harvesting (Suweis *et al.*, 2013).

3. The Climate Change

As mentioned, CC will affect the agro-ecosystems in heterogeneous ways, with either benefits or drawbacks dominating in different agricultural regions. The shifting of agro-ecological zones will be one of the primary impacts which will interacts with the land and water availability and agricultural productivity under new conditions (CIAGR, 2012). These impacts will lead to the new scenarios and various implications in different areas of the Mediterranean that could have a relevant impact on the overall development of the entire region. In the coastal areas, it should include the sea level rise and loss of agricultural land and biodiversity. The concept of integrated coastal zones management (ICZM) strategy has been formally introduced with the adoption of the UE Recommendation 2002/413/CE by the European Council and Parliament and remain a crucial priority for the Mediterranean.

The relationship between CC, natural resources, agricultural production and food security is very complex and needs a consideration of both bio-physical, social, economic, technical, political and anthropogenic (management) factors and their interactions at different scales and directions (from local to global level and vice versa). Unquestionably, a particular attention should be given to the water-energy-food security nexus which represents one of the kernels of the Green Economy concept and pursues the sustainability development goals[7]. Hence, the eco-efficiency of agricultural water systems and agricultural production could be one of the main topics for further investigations. The efforts should focus on the adaptation measures and the interrelations of innovative technology uptake in agricultural water systems, and their economic and environmental impacts. Research should address the selection of appropriate indicators for assessing system-wide eco-efficiency improvements, the integration of existing tools and assessment methods in a coherent modelling environment, and the analysis and characterisation of existing structures and policies. Then after, the eco-efficiency approach should be extended also to the whole chain of food production, conservation, transport and consumption.

The above mentioned studies should consider a large range of proposed mitigation and adaptation measures to climate change and especially those focusing on conservation and more efficient use of natural resources in agriculture and other sectors (Porter *et al.*, 2010). Particular attention should be reserved for the combined effects of temperature increase, rainfall variability, CO_2 increase and genetic and technological improvements (CGIAR, 2012). Hence, water and carbon balance of modern agro-ecological systems should be among the priorities for research. Equally so, the adaptation to extreme weather events and various abiotic stresses are of primary importance for agricultural production and food security. In fact, for arid and semi-arid Mediterranean lands it is essential to select management practices and exploit varieties able to respond to adverse environmental conditions and to increase yields and water productivity and, in the future, triggering specific combinations of abiotic stresses (e.g., water, heat and salinity) and greater pressure on water resources.

Unquestionably, the translation of research findings into policy making and on-ground implementation in the region are of paramount importance. In fact, the aim should be to promote appropriate and efficient farming systems able to adapt to climate change while reducing pollution and impacts on the environment and getting the benefits of CC (Ewert, 2012). This will be possible through an appropriate institutional setting and further funding of the initiatives that focus on the demonstration units and on-farm implementation activities that include the application of modern monitoring and decision-making technologies (FAO, 2008a). Surely, it could permit the identification and adoption of the locally tailored best management practices that can optimize the use of resources in agricultural production. In addition, it will require on-farm training, field days campaign and increase of awareness on the relevance of the topic for the whole society. The promotion of alternative educational approaches as distance learning courses could be of large interest.

4. The Biodiversity

Although indicators of the state of biodiversity are already able to show declines, there are considerable gaps in their geographic, taxonomic and temporal coverage (CEPF, 2010; Pergent Martini, 2009). Biodiversity loss is a global phenomenon but its impact may be greatest in areas were indicators and data coverage are the least available complete. Particular gaps in knowledge for state indicators include: grassland and wetland extent, habitat condition, primary productivity, genetic diversity of wild species, freshwater and terrestrial trophic integrity, ecosystem functioning and ocean acidification (GEO 5, 2012). Pressure indicators lack data on pollution, exploitation in terrestrial and freshwater ecosystems, wildlife disease incidence and freshwater extraction (GEO 5, 2012).

The principal gaps in response indicators include sustainable management of agriculture and freshwater fisheries and management of invasive alien species, relationship between landscape asset and species (GEO 5, 2012).

Minimizing the adverse impacts of climate change on biodiversity is dependent on the efforts to mitigate climate change itself and on the measures to ensure that the activities and the societal adaptation efforts do not themselves have adverse impacts on biodiversity. Many approaches to adaptation are dependent on the conservation and sustainable use of healthy ecosystems and offer opportunities for synergies in terms of climate change mitigation and maintenance of biodiversity. Further analysis and research are needed on the effective impacts of application of best practices in conserving and restoring biodiversity facing climatic change. This concerns intact forests and wetlands, but also natural and semi-natural grasslands and agricultural ecosystems. For example, some agricultural approaches, such as conservation tillage and agro-forestry, can result in the maintenance and enhancement of terrestrial carbon stocks and also contribute to the conservation and sustainable use of biodiversity (CBD 2009). In this frame studies aimed to prevent the introduction and spread of plant pests and to promote appropriate measures for their control are needed too.

Integration of protected areas into broader landscapes and seascapes through ecological networks, ecological corridors and/or buffer zones to maintain ecological processes and take into account the needs of migratory species are urgent. The research could help to identify priority marine ecosystems and limit use in these areas, through, inter alia, designation of protected areas. Sustainable use of the components of biological diversity foresees investigations to support remedial action where biological diversity has been reduced.

The need for adapted germplasm will require characterization, evaluation, and availability of materials coming from hotspot areas and/or stored in the gene banks all over the world. The amount or identity of plant genetic resources that may be useful to adapt agriculture to climate change cannot be precisely known a priori. Assessments of necessary traits and the conservation and characterization of the broadest range of genetic resources available are needed.

Conservation of genetic resources will become a key issue and in depth analysis are needed to focus on benefits and threats that might arise time by time from the *in situ* and the *ex situ* modalities of conservation to better enable choices (GEO 5, 2012). Some of the more important traits to be found in varieties and genotypes for responding to climate change include: drought tolerance, extreme events tolerance, resistance to very hot and humid conditions, pest and disease resistance, and separation from certain climate sensitive pollinators or symbionts. Most of these traits may be present in traditional cultivars or wild species, but additional studies and further engagement are needed to stop the genetic erosion they are subject too.

Maintaining knowledge of indigenous communities relevant for the conservation and sustainable use of biological diversity, to promote their wider application must be encouraged and the resulting benefits must be widely disseminated. Studies and analysis on collaborative approaches to achieve sustainable use of biological diversity and fair and equitable sharing of benefits arising from the use of genetic resources should remain primary research goals for the future biodiversity conservation in the Mediterranean.

5. Energy

Traditional sources of energy are getting scarcer. As the impact of climate change becomes evident and efforts are made to minimize greenhouse effects, the nature of energy production will fundamentally change. The overall result is definitely increased energy costs. Thus, innovative energy conservation programmes are required.

Renewable energy can be used throughout the food sector either directly to provide energy on-site or indirectly by integrating this energy into the existing conventional energy supply system. Renewable energy sources tend to be widely dispersed throughout rural areas. The availability of a reliable and affordable energy supply can become an essential component for sustainable development.

Reducing the dependence of food systems on fossil fuels by using renewable energy is feasible for farm and aquaculture production. Renewable energy can also be used for transporting raw food feedstock, processing food, distributing finished products and cooking. In MENA countries, renewable energy also presents opportunities to provide much needed basic energy services. Adequate supply of energy in the immediate post-harvest stages is important for reducing food losses. Because of this, significant attention has been given to the possibility of using renewable energy in these countries. For instance, solar energy and biomass have been successfully used for both dry and cold storage.

In locations where good renewable energy sources exist, farmers, fishermen and food processing businesses have also opportunities to generate wind power, solar power, micro-hydro-power. Solar thermal, biomass and geothermal resources generated from decentralized facilities can be used for both heating and cooling.

Animal waste, crop and forest residues, by-products from food processing, food waste from retailers, households and restaurants are examples of biomass originating from different stages of the food supply chain. These biomass resources are flexible energy resources. They can be:

- used on-site if and when needed to provide direct energy inputs;
- processed on-site into energy carriers for sale elsewhere;
- sold off-site for collection and use at community heating or anaerobic digestion CHP plants; and
- sold off-site and collected on a wider scale and in greater volumes to supply larger commercial liquid bio-fuel production plants.

As more knowledge and experience is gained, the costs for renewable energy technologies are likely to continue to decline. In many specific situations, renewable energy is already economically competitive. For example, in remote rural areas without access to the electricity grid, autonomous renewable energy systems are competitive as they allow users to avoid the high expenses involved in connecting to the grid.

V – Policy outcomes

Natural resources management requires the endorsement of an ecosystem-based integrated approach that pays particular attention to both human and environmental components (Conway, 2012). Land, water, biodiversity, climate change and energy are interlinked to each other and the disruption of one of them will definitely impact the others. The Mediterranean region is particularly sensitive to these relationships due to its natural, social, economic and political context.

> *“ **”Mediterranean syndrome”** is characterized by structural deficiencies common to most Mediterranean countries, such as corruption, the lack of comprehensive plans or programmes to combat environmental problems and poor cooperation between the various administrative sectors that hold competence in issues such as desertification*
>
> *(Wilson and Juntti, 2005).*

Therefore, developing and proposing policy outcomes requires first a thorough review of existing Euro-Mediterranean regulatory frameworks and policies and the impacts they have on natural resources at local, national and regional scale. Further on, the role of participatory and scientific context in policy development, guidelines and policies and the wide range of boundary conditions including national and regional dimensions, the institutional framework and its influence in policy development are paramount preconditions to be considered first.

Guidelines and indicators for the establishment of incentives for land-users to enhance sustainable natural resources management and conservation, development of economically sustainable measures that match with environmental quality, establishing the role and responsibilities of rural communities, scientists, researchers, policy and decision-makers in natural resources management and biodiversity conservation requires the adaptation of policies and regulations that follow carefully local conditions and differences between North and South as well as South-South.

One thing is sure however: there is not such as an “*absolute perfect policy”* universally suitable for every place. Last but not least, even the best policies and guidelines would have no impact on the ground if they are not implemented. On the contrary they could have the opposite effect meaning further destruction and degradation. The complex policy, economic and socio-cultural structures that operate at the local, regional and national levels in areas of Mediterranean EU countries and MENA region provide a unique background to explore and analyse how these could hinder, or promote, the implementation of policies aimed at alleviating the threats deriving from natural resources degradation and climate change.

The Mediterranean is one of the most prominent birthplaces of civilization. It is rich in biodiversity, and all kinds of energy sources (non and renewable) and in best management indigenous (and ingenious) practices in land and water management. Still-productive ancient terraces in Italy, Turkey, Syria, Morocco etc, ingenious irrigation systems including the Sahara oasis, and sustainable land use patterns spread throughout the region could easily prove this. However, the region is faced also with a number of degradation processes that are seriously threatening its future and its people especially food security. They include water and wind erosion, salinisation, overgrazing, deforestation, forest fires, vegetation cover destruction, desertification and drought, climate change, water scarcity, soil impoverishment, floods, groundwater degradation and contamination, etc. These processes often are accelerated by human mismanagement that has brought in many cases to irreversible damages. In this case, the impacts of these degradation processes become heavier with the weakness or lack of societal commitment and/or governmental responses.

Many crucial policy and governance questions remain still open and some of them are listed below as a framework for discussion and debate:

- Haven't we witnessed cases of wrong policies?
- Is the wrong or weak implementation of adequate legislation and appropriate policies a common practice in the Mediterranean?
- Is it enough only to document a problem, orient research towards problem solving and then do little to apply it?
- Did the existing links between the research bodies, governmental institutions (policy and decision makers), civil stakeholders and end users reveals to be effective?
- What about the impacts of partnerships between the governmental bodies, private sector and NGOs in reversing resource base degradation and to which extent?
- Who is responsible for natural resources degradation and who must pay for it?
- How can we promote the bottom up approach to strengthen the democratic and creative basis of legislation and policies related to combating natural resources degradation without undermining the coherence and implementation of relevant laws and decisions?
- What is the role of the farmers and other local stakeholders in the elaboration of guidelines to support policy making?

Natural resources management policies and institutional frameworks related to biodiversity conservation, land and water management, climate change adaptation and mitigation and increased energy efficiency have a strong impact on the economical development and environmental quality of every country. They require the development and adoption of legislation and regulatory aspects as well as the elaboration policies and guidelines addressing country specific conditions.

In particular the Mediterranean countries need to pay special attention to the below mentioned issues:

- ***Coordination gaps*** and lacks in decision making at national, regional or local level;
- International donors and development agencies including the EU, should consider themselves as ***stakeholders*** and fully responsible for the foreign aid invested in the MENA region and not as outsiders or simply financing entities;
- ***Disparities in legislation framework*** between the Mediterranean EU nations and those in the MENA are evident; not withstanding this, results on the ground show that both regions face similar problems in natural resources management;
- ***Competing forms of land use*** and issues like food security, food safety, trade and market strongly influence the status and quality of natural resources and the overall social and political stability especially of the MENA countries;
- ***Agricultural productivity and environmental quality*** are very much linked to each other; legislation should consider them both in an ecosystem-based context;
- ***Interference*** between different aspects of legislation makes difficult to establish the roles and responsibilities of governmental structures at all levels therefore legislation needs to be renewed and updated continuously;
- ***Decentralisation*** of power and local involvement in decision making ***policies*** through a bottom-up approach could increase chances of success in sustainable natural resources management, public awareness and active participation. However experience shows that societies that switch from ***centrally-controlled*** forms of governance to more democratic systems tend to accelerate degradation of the natural resources as the rule of law implementation is weakened due to the diminishing role of governmental institutions and the mistrust on them by the local people; knowing this, it is required to use public participation to prevent such negative issues;

- ***Policy and politics*** are two different things; being a politician does not necessarily mean being a good policy-maker. Following this, the support of the scientific community in policy development is essential and should be strengthened;
- ***Corruption*** could have devastating repercussions on natural resources. It should be combated with the same strength as the naturally occurring degradation processes;
- ***Good governance*** should be based on sound institutions, prudent policies, transparent processes, open access to information, and equitable public and democratic participation in decision making.

Further attention should be paid at ways in which the multi-functionality of agriculture can be enhanced and some of its negative outputs, especially in the context of climate change, can be minimized. But, considering future developments and most importantly population increase in the MENA, the agricultural sector will continue to play a dominant role both in the rural areas of Europe and most importantly in North Africa and the Middle East. This would require that the agriculture development policies and natural resources management advance harmonically and not at the expense of each other.

VI – Final remarks

Meeting the region's food needs will be one of the most important challenges and a package of solutions including sustainable land management, efficient use of water, conservation agriculture, high yielding cultivars best suited to climate change, and better use of fertilizers is needed rather than promotion of a single strategy. Still the region will continue to rely on food imports to meet its basic nutritious needs. Biodiversity conservation and mitigation/adaptation actions to climate change will remain important priorities for a region that is particularly vulnerable to these threats. Unfortunately, natural environmental endowments do not offer easy solutions to these problems. The critical conditions for land and water management and stewardship call for a complete reassessment of roles and potentials of agriculture and overall natural resources management strategies. These might include retrenchment of agriculture into the most favoured areas, supported by comprehensive, enabling policies, good governance and programmes and set aside areas that are at environmental risks. Furthermore, closer links with ecotourism and re-renewable energy production (solar and wind) should be explored but not at the expense of fertile soils that must be conserved for food production.

Despite the technical developments achieved in recent years in reducing water use and energy consumption in water distribution systems, there are still many opportunities to introduce more effective (and necessary) innovations both in technology and management approaches to reduce energy consumption in water distribution systems.

Finally research results must find the way towards implementation. Addressing sustainability concerns in natural resources management requires the adaptation of an ecosystem based management approach that considers both natural conditions and socio-economic factors. This approach should be ecologically sound, economically viable, socially just, culturally appropriate, humane and based on a scientific holistic approach. Consequently, sustainable natural resources use and management in the region is not a choice but a prerequisite to secure prosperity and improve the livelihoods of its people by establishing societal responsibilities and priorities in this crucial process.

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Additional materials

EcoMENA

Powering Sustainable Development in MENA

EcoMENA's primary mission is to create mass awareness on renewable energy, sustainability, waste management, environment protection and resource conservation in the Middle East and North Africa (MENA) region.

http://www.ecomena.org/

Video presentations

"Introducing two degrees up" prepared by the CGIAR, 2012

http://www.youtube.com/watch?v=oaEY3hhjLDs&list=PL5924FD982CBEA3FD

"Climate-smart agriculture: helping the world produce more food". World Bank Institute, Washington, DC.

http://lnkd.in/9JcyfC

Notes

[1] A person is considered food insecure, or hungry if food availability or access to food fails below FAO's recommended average calorie intake level of approximately 2,100 calorie per day, depending on the region. As of 2012, none of the MENA countries is below that level.

[2] MENA region in this study include: Syria, Lebanon, Jordan, Israel, Palestinian Authority, Egypt, Libya, Tunisia, Algeria, and Morocco.

[3] Drylands include arid, semi-arid and dry sub-humid zones based on values of aridity index. Aridity index is calculated as the ratio between mean annual precipitation (PPT) to mean annual potential evapotranspiration (PET). Drylands of concern to the UNCCD include those lands with an aridity index between 0,05 to 0,65 (excluding polar and sub-polar regions).

[4] www.wassermed.eu

[5] www.ramsar.org

[6] http://www.rtcc.org/rethinking-water-and-energy-links-in-middle-east/

[7] http://www.water-energy-food.org/