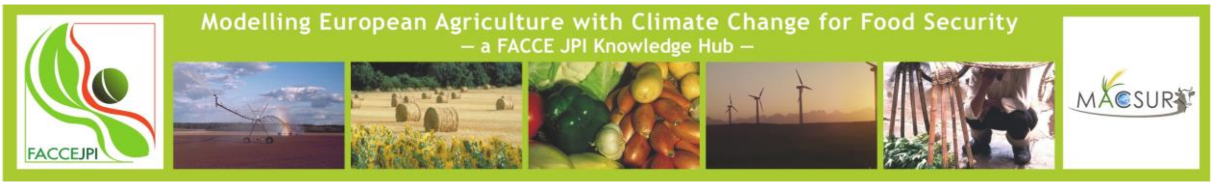

FACCE-MACSUR

Deliverable T3.1: Most relevant aspects of climate change in hot-spot analysis

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Abstract/Executive summary

WP3 develops the tools for assessing the productive and economic impact of climate change and the potential of mitigation and adaptation strategies. This is achieved by focussing, along with CropM and LiveM, on significant crossing issues in specific geographical areas, natural and human resources, and farming systems. Following, the steps for identifying the hot-spots and the basic elements of climate change are shortly described. Next, the main economic and structural characteristics of each hot-spot are described followed by a presentation of the most relevant aspects of climate change, and of their main impacts on farm sector.

Introduction

WP3 aims to implementing tools to be used in hot-spots for answering questions about costs of climate change to the European agricultural sector and its possible resilience; impact of climate change on international trade, both within Europe and with third countries; possible European key strategies for mitigation and adaptation, with their impact for a smart, green and inclusive growth of agriculture in Europe, and food security in the globe. The hot spots were defined in collaboration with researchers from the CropM and LiveM, focusing on geographical areas, natural and human resources, and farming systems where the impacts of climate change are already being perceived, and it is possible to identify potential and promising strategies to mitigation and adaptation. Hot-spots include Mediterranean areas (task 3.1: Gabriele Dono with contributions of Sharon Brody, Ruslana Rachel Palatnik, Uri Mingelgrin), with climate risks to food security related to desertification and water stress; Central and Northern Europe (task 3.2: Heikki Lethonen with contributions of Martin Schönhart), where the impact of climate change is assessed on future patterns of food supply; Sub-Sahara Africa (task 3.5: Luciano Gutierrez with contributions of Stefan Sieber and Peter Zander) where climate-risk assessment concerns global food security issues, and trade patterns between Europe and Africa. Hot-spots are also defined in terms of climate change issues for intensive livestock systems (task 3.3), and for Rural development (task 3.4: Erwin Schmit) as key European response policy. A task for comparative analysis of the hot-spots has also been defined (T 3.6: Davide Viaggi with contributions of Matteo Zavalloni). Following, the main economic and structural characteristics of each hot-spot area are shortly described. Next, the most relevant aspects of climate change affecting each of those areas are defined. Ends a description on how these aspects of climate change affect the farm sector in each hot-spot area.

Methods

Once defined their interest in the various tasks, TradeM partners were asked to identify the hot-spots in the various geographical areas, identifying the relevant farming systems and challenges. The hot spots were defined in collaboration with researchers from the CropM and LiveM, focusing on geographical areas, natural and human resources, and farming systems where the impacts of climate change are already being perceived. This makes easier to identify potential and promising strategies to mitigation and adaptation to be specified, and applied with the Rural Development Policies that are going to be implemented with the next structural measures of agricultural policies in the Consortium countries. The goal of identifying the most promising strategies to mitigation and adaptation has also prompted to ask the partners to focus on the effects of climate change on a local scale and farm. The farms are, in fact, the main stakeholders for the implementation of agricultural policies in the Consortium countries, and their reactions are important for planning adaptation and mitigation policies. In this context, the partners were also asked to define basic aspects of climate change to be simulated, with the sensitive weather components, periods of the year on which focus attention, and time horizon for climate modification. Moreover, TradeM researchers were asked to define, along with CropM and LiveM scientists, systems for assessing productivity responses of crops and animals bred, of farming systems, and of agricultural sectors and to outline the possible impacts of climate change on the agricultural sector in the hot-spots. Likewise, TradeM researchers were asked to address issues of market and institutional conditions and policy. The identification of areas in the hot-spots began after the kick-off meeting of October 2012. It continued by means of a questionnaire prepared by the Task 3.6 before the meeting of Haifa held in early March 2013.

Results

a) Main economic and structural characteristics of each hot-spot area grouping the case studies located in the Mediterranean region, those in Central and Northern Europe, and those in the Sub-Saharian Africa.

Two case studies of the ***Mediterranean region*** are located in Italy and another one in Israel.

The first Italian hot-spot is an area of 54,000 hectares in the Oristano province, located in Central West coast of Sardinia, where attention is dedicated to define the farm typologies that represent its agriculture. Given the wide variety of crops and livestock, and of farm income conditions of this area, it is considered as representing characteristics and climate change related issues of many Italian agricultural systems. Part of the area (36,000 ha) is irrigated by canal and pipeline networks operated by a Water Users Association and provided by a large reservoir that provides water resources for multiple uses (irrigation, civil and industrial uses). The residual 18,000 hectares are not provided by this network and practice rain-fed farming or irrigated with groundwater. 13 farm typologies represent the almost 1,600 farms of the area. 528 of them (33.4% of total) gain less than 30,000 €/year of net income (9.4% of the total area in 2010 values – FADN data and Agriculture Census 2010) growing vegetables and fruits (also in greenhouses) on 4.6 % of land. 804 farms (50.9%) have incomes up to € 50,000 (47.7%): some grow cereals and vegetables crops, others produce citrus fruits and 190 farms rearing sheep in the non-irrigated area. 170 farms have more than € 100,000 net income: part of them breeding dairy cattle based on techniques for livestock management and the supply of feed that are similar to those of the Po valley, the remaining producing cereals both for food and feed markets (Dono et al, 2013b, 2013c).

The second Mediterranean hot spot is the Italian system of milk production of *Grana Padano* and *Parmigiano Reggiano*, probably the most important among the many farming systems in the Po valley. Those systems are also the most important of Italian milk production systems, and of agriculture in terms of income and direct and indirect employment. 2011 Data provided by the Italian Agency for Payment of European subsidies in Agriculture (AGEA), by Farm Accountancy Data Network (FADN), by Italian Agriculture Census 2010, and by Milk Producers Associations indicate that the cattle milk production in these area is 6% of the EU total and 76% of Italy. Grana Padano and Parmigiano Reggiano constitute 73.4% of total POD cheese in Italy. These results are achieved based on dairy farms that are much larger than the Italian average (for instance, in Lombardy 94 dairy cows are in average bred per each dairy cattle farm, against an average of 63 cows reared on Italian dairy cows farms as a whole). Milk production per cow is also above the Italian average, and is close to that of European areas with more specialized and intensive milk production.

Israel is studied as a single hot spot divided into four geographical regions with different climate conditions ranging from Mediterranean, subtropical, semi-arid and arid areas and from plan to mountain areas. The climate has cool rainy winters and warm dry summers, temperatures ranging from 9 to 49°C, precipitation from 30 to 1000 mm/yr (south to north), most between December and February. Frequent drought periods. 440,000 ha of arable land: 182,000 irrigated. 94% of agricultural land is state owned. Two thirds of the land area is classified as semi-arid or arid and suffers from water scarcity. In 2011 71.1% of Israel's arable land was used to grow vegetables and field crops and 6.3% was used for citrus fruits. Wheat accounts for 45.2% of all field crops grown. Co-operative communities account for 80% of agricultural output (CBS, 2013). The three main water sources are the Sea of Galilee, coastal aquifers and mountain aquifers, mainly situated in the North; however 65% of the irrigable land is in the South where the National Water Carrier conveys water. Currently all water sources are owned by the state and an agricultural quota is set subject to the annual water situation. Current irrigation water sources also include marginal water from saline water and treated sewage effluents, rainfall enhancement and desalination (the use of desalinized water has recently increased its relevancy, while saline water and possibly treated effluents is used for salinity tolerant crops such as cotton).

The studies on climate change in ***Central European agriculture*** include analysis on the Austrian and North Germany agricultures.

Austria is studied as a *single hot-spot* even if focussing on differences between Alpine regions, hilly areas and lowland. The agricultural and forest Austrian land is 76% of the total 8.3 mil. hectares, with 41% of forests and 35% of agricultural land. This latter is 47.6% arable land, 50.0% permanent grasslands, 1.6% vineyards and 0.5% orchards. Permanent grassland consists of 60.4% of extensive pastures and meadows, mainly in alpine areas. The agricultural and forestry production value of 8,890 mil. € in 2011 derived for 19.5% from the forestry and 80.5% from the agricultural sector: 45% of this last value comes from livestock and plant production, the remainder coming from agricultural services (agro-tourism). Roughly half of the plant production value originates from vine, fruits and vegetables. Dairy farming account for 15% of total agricultural production, beef production accounts for further 12.6%. Austria is rather dominated by small scale farms with the average agricultural area of 19.5 ha slightly above the EU-average of 14.1 ha in 2010. Land use is highly diverse despite some specialization at regional level: considering the relative weights of arable land and permanent grassland, the latter use of soil accounts for less than 25% of total in hill and flat land, for 25-75% in alpine foreland and for more than 75% in the Alps.

In Germany four rural areas are considered as differing in their sensitivity and adaptability to climate change. The zones are located in the *North German Plain* on a west-east gradient from the Dutch to the Polish borders and are Administrative District Diepholz, Administrative District Uelzen, Region Fläming, Administrative District Oder-Spree. Those areas exhibit different natural assets, land use preferences, economic factors, and society demands, which facilitates studying interactions of the land use systems, regionally different consequences of climate change and increasingly globalized markets. The agricultural land use in each case study region is simulated on the basis of typical farm models based on data from the Germany Agricultural Census 2010 and from FADN data. Land use, herd size, land tenure, income, labour force, and ecological production will be defined. Also, element of the survey will be used as soil treatment, erosion protection measures, landscape elements, irrigation, and means of irrigation. Characterization of soils and climate zones will be done in order to assess yield levels for rain-fed and irrigated agriculture.

The case studies in ***Northern European agriculture*** include hot-spot areas in Finland, in Norway, and in Scotland.

Two regional pilots studies in <u>Finland</u> focus on dairy and meat sectors, which produce most part of value added in northern agriculture. Small farm size is the main determinant of Finnish agriculture and also of the specific regions selected as hot spots (Pyykkönen, 2006). However, after EU integration of Finland specific aids were paid for farm investments which fostered the growth of size on livestock farms. Besides, the number of livestock farms decreased at rate of 6.7% annually, for a total reduction of 50% over last 10 years, even if the overall production volumes in Finland have remained stable due both to farm size growth and livestock production concentration in more competitive regions (Zimmermann & Heckelei, 2012). The two hot spot pilot studies in the Finnish agriculture integrate plant-farm-region-sector level and are Cereals-pigmeat (Varsinais-Suomi, South-West Finland), and Grassland-dairy (Pohjois-Savo region). In both regions cereal, grasslands and set-aside cover more than 90% of the farmland area, even if there is some oilseed and sugar-beet cultivation in Varsinais-Suomi region. Feed crop cultivation, especially grassland fodder, dominate land use in Pohjois-Savo region, while wheat and malting barley cover most of the cereals area in Varsinais-Suomi. In both regions barley, oats and mixed cereals for feed have a strong role in land use and livestock production has a strong role in terms of farm income. Furthermore, 2/3 of the laying hens of the whole country are held in Varsinais-Suomi region. More emphasis is given for grassland-dairy dominated Pohjois-Savo –region (including cheese-making using milk produced using conserved grass silage which require high quality of silage harvest, raw milk, and skills). This is because it is common to other northern European regions, often in less favoured areas, as an important feature in the diversity of European agriculture. Also, grassland-dairy systems, which are also important for rural employment especially at remote sparsely populated areas, produce higher economic value (at least together with beef produced from dairy breed animals) than barley-pigmeat systems. However it was concluded that feed cereals such as barley and oats are also important to be considered in northern European case studies since grasslands are often cultivated in rotation with barley and other feed cereals in northern European areas, because of the need to renew grasslands (due to winter time frost damages, increasing weeds and decreased quality of grtass silage) with new seed utilising benefits of grassland-cereals rotation.

In <u>Norway</u>, a number of municipalities (6) are to be chosen to form a Norwegian case study region. The region is nevertheless a grassland-dairy dominated area and is likely to share similar kind (but not identical) characteristics as Pohjois-Savo region in Finland.

In <u>Scotland</u>, grassland-dairy is an important line of agricultural production in less favoured upland areas. Issues and problems related to climate change adaptation and mitigation are shared with Scottish LiveM researchers as well.

The ***Sub-Saharian Africa*** hot-spots (task 3.5) are represented by two *Tanzanian* areas, and by a Nile Basin zone.

The <u>Tanzanian</u> hot spots are semi-arid Dodoma, and semi-humid Morogoro areas. Within those regions two areas were selected for having similar climates; differing market access; rainfed crop–livestock systems; village sizes with 800-1500 households chosen were MVIWATA (smallholder farmer association) is active. Both regions are population density less than 50 persons per km². Dodoma is characterized with higher level of outmigration towards the agro-ecologically high potential areas. Within the Morogoro region villages in the Kilosa district were selected differing in terms of market access, food availability and security problems, in the Dodoma region the Chamwino district was selected because of its easy accessibility. Not much variation exists in terms of rainfall. The main subsistence crops are maize, rice, cassava, sorghum and banana, while the main cash crops are cotton, coconut, cashew, sisal, sugar cane, and vegetables.

A <u>Nile Basin</u> hot-spot is identified for the flow and use of fresh water resources. To support a participatory planning process for the common water resources in the region, a Nile Basin Agricultural Model (AM) was developed as part of a consultancy for an intergovernmental working group. The AM model is used to project the future demand, supply and trade of agricultural products and to assess the implications for water demands in the Nile Basin. The core of the AM consists of MAGNET, the general equilibrium model hosted at LEI Wageningen UR, (Woltjer et al. 2013) and FAO-AquaCrop (Raes et al. 2012).

b) the most relevant aspects of climate change affecting each hot-spot area.

In the <u>Italian</u> hot-spots of the ***Mediterranean area*** climate change was assessed by analyzing the trend of the meteorological data observed from the middle of the last century to the present, and by comparing the conditions of the present climate and future climate obtained from a regional model simulation. The differences between present and future climatic conditions satisfactorily reflect trends of climate change emerged in the last 30 years (Tomozieu R. et al, 2007; García-Ruiz et al. 2011). The numerical model for climate scenarios downscaling is the Regional Atmospheric Modeling System-RAMS that is forced from a global simulation model, from surface temperatures of the sea coming from the ocean model coupled with the atmosphere. The global climate change is simulated by ECHAM 5.4 developed and used by the Euro-Mediterranean Centre for Climate Change (Tomozieu R. et al, 2013a, 2013b). The greenhouse gas emissions scenario is A1B. Two climate periods were simulated: 2000-2010 present and 2020-2030 near future. The daily data of these two series of years were used to forcing a weather generator in producing 200 years of daily data that permitted a statistically valid analysis on the probability distribution of the events. Preliminary results obtained by RAMS show a slight increase in minimum and maximum daily temperature in *spring*. No significant variations emerged on rains; instead observations highlight a decreasing trend in the recent years. In *fall – winter* a pronounced increase emerges in minimum and maximum temperature along with an increased rainfall variability coupled to a decreasing rainfall; this is aligned with the observed long term trends. In *summer* an increased maximum daily temperature and even more pronounced minimum as climate change footprint; this is also aligned to long term observed trend regarding *hot days* and *heat waves*. Impacts of increasing humidity and temperature on the dairy cattle reflect in a rise of value of TH Index (Dono G. et al, 2013a).

Israel is studied as a single hot spot divided into four geographical regions where climate conditions go from cool rainy winters to warm dry summers, temperatures ranges from 9 to 49^{o}C, precipitation from 30 to 1000 mm/yr (south to north), most between December and February. Also frequent are drought periods. Current climate change models indicate at 2100 an increase in temperature of 3-5^{o}C with greater temperature variability, alongside a 10-30% reduction in current annual average rainfall and a decline in freshwater supplies by 60% from current levels of supply (Brown and Crawford, 2009; Mariotti et al, 2008; Plan Bleu, 2008; Parry et al, 2007; Snir, 2006).

About the ***Central and Northern Europe regions***, climate change impacts on Austrian agriculture are expected to be diverse in magnitude and variability due to the natural and structural differences in production conditions. Alpine areas are expected to be hot-spots of climate change impacts. Even if with different regional climate change scenarios, 1-2°C annual mean temperature increases are expected up to 2050 in *Austria*. Rains are predicted with higher uncertainty. The four Northern Germany regions have been chosen along a geographical transect from northwest to northeast of the country which at the same time crosses two agro-ecological zones being differently affected by climate change impacts on agriculture. One model region in the northwest will most probably profit from the increased mean temperature and through the CO2-fertilizer effect with a slight increase in yields. Going along the transect further east beside general increased continental climate impact, the mean temperature is going to increase due to climate change more during summer. In *Northern Europe* hot-spots of Finland, Norway and Scotland climate change basically means increased temperature and precipitation. However, the winter time precipitation is likely to increase relatively more than then precipitation during the growing season. In addition to a more frequent extreme weather conditions, longer growing period, higher temperature and higher precipitation during growing season is very likely to imply increased pressure and problems due to pests and plant diseases. Such problems have been widely observed in northern Europe already and require more attention to crop protection and crop rotation and other mitigation measures. On the other hand, longer growing season will provide possibilities for higher yields and implied cost savings for skilled farmers who are able to cope with the problems and increased risks. Such benefits are needed due to the fact the production costs are relatively high in northern Europe, especially in least favoured areas where dependence on subsidies is a major limiting factor.

In the Tanzanian hot spots of ***Sub-Saharian Africa** area*, climate change poses a significant risk to current and improved production systems. It also impacts the availability and quality of natural resources. Such direct (climate) and indirect (resource availability) impacts of climate change on food production systems will be assessed with suitable bio-physical process models. Because of the eminent uncertainty in climate change projections and also in the so-called CO_2 fertilization, the analysis of possible climate change impacts will be complemented by a risk assessment and an analysis of new production options. Current and innovative production systems will have to be described and parameterized in the process-based simulation models. This will have to consider the full range of climate change scenarios for Africa and Tanzania.

c) how climate change affects farm sector in hot-spot areas.

In ***Mediterranean regions***, the differences between present and future climatic conditions estimated for hot spots in Italy satisfactorily reflect trends of climate change emerged in the last 30 years. These trends are reflected in the yield and water requirement of crops, as estimated by mean of DSSAT, EPIC and APEX models applied to both observed climate conditions and synthetically estimated for current and future scenarios in collaboration with researchers from the Italian teams of CropM and LiveM. Also the impact of humidity and temperature (THIndex) on milk quality (somatic cells content - SCC) and quantity, calving interval length and heads mortality is considered. As a result Italian *dairy cattle farms* could suffer for an increased uncertainty on yields of reused crop that implies greater forage cropping and purchasing of feeds. Surges of humidity and temperature can reduce quantity of milk, and quality given the increase of SCC. Mortality of heads could also increase, and lengthening of the calving period (Lacetera et al, 2013; Nardone et al, 2010; Vitali et al, 2009). *Sheep milk farms* suffer increased uncertainty on yields of reused crop, hay and grains: decreases of hay production mainly come from non-irrigated grasslands. *Crop farms* suffer more uncertain yields (along with prices) and larger needs of irrigation water as expected given the increase in evapotranspirational demand (Orsini R. et al, 2013). The economic impact of those changes will be significant especially with volumetrically based water pricing in vegetables and dairy farms.

In Israel, increases of temperature are expected to boost total water demand above the increase that is already expected under the current climate conditions. Current demand of 3,140 million m3 (2000-2009) are predicted to climb to 4,756 million m^3 for 2020-2030 and 6,240 million m^3 for 2040-2050. Although economic growth is a significant factor in the demand for water, climatic change will have a significant impact on the sustainability of water supplies (Immerzeel et al, 2011). Agriculture is also affected by several other issues related to climate change. Extreme weather events are more likely to cause stronger storms and more flooding which can cause crop damage. Higher temperatures and changing rainfall patterns are also expected to enhance the migration of weeds and pests to new areas causing further damage to crop availability. Changes in temperature will also alter the length of the growing season, and although this may appear positive in some respects, the negative impact on the land has to also be considered.

In the *Central Europe regions*, the TradeM Austrian group is applying its own bio-physical model EPIC in the integrated modelling framework. Also, the group will integrate in PASMA climate impacts on reducing livestock production. Socio-economic scenario considers the OECD-FAO outlooks for a 2020 time-step and assumes constant prices and production costs for 2040 due to high uncertainties in economic development. Common Agricultural Policy reform is considered with milk quotas abolition, further greening and reductions in agricultural budgets. Impact and adaptation scenarios include one impact scenario, where baseline land use and livestock production is fixed under a changing climate. Autonomous adaptation modelling allows adaptation of livestock numbers, shifts in cultivars and among land uses, soil management and cover crops, and land use intensity. Induced adaptation includes policy measures to alleviate potential impacts from climate change, for instance, a premium for reduced tillage and cover crops. Irrigation is introduced at broader scales.

For hot spots in Germany, with the help of expert knowledge alternative plant production activities will be considered consisting of type of crop, production intensity, technic, machinery, labour, and yields, hence a so called core-adapter-approach. Plant production includes cereal, oilseed, grassland, and fodder crops. Products of this production partly are sold, serve as fodder or are further input for the biogas plant. Cooperating with the project partner of CropM plant production techniques are going to be supplemented. Up to this point livestock production can only be modeled hence the dressed-animal approach for milk cows whereas non-land dependent pig and poultry production maybe included into the research via the black-box approach. Time horizon for adaptation in farm management will be studied at short-term, middle, and long-term by considering operational adaptation (changing intra-farm processes as timing, and localization of production activity or associated task, like switch to drought resistant crop species) and strategic adaptation (changing the intensity of production, extensification).

In Finnish hot-spots of the *Northern Europe regions* both the productivity potential due to longer growing season, and the likely increase in climate and market related risks will be considered. Specific themes deserving special attention are drought (or flood) risks for silage grass production, future developments of such risks and their direct and indirect cost implications for farms; similar analysis in the case of pig farms in the context of high cereals and protein feed prices. Also relevant should be the economic benefits of higher productivity and resulting production re-organisation, including machinery choices and logistic benefits due to higher yields (especially logistic and roughage storage costs in dairy production). Such benefits are less important but probably still significant in the case of cereals-pigmeat production. The GHG mitigation costs include changes in logistic costs of feed and manure, which are conditional on the distance from different field parcels to farm centre, and on the development of feed crop yields. Different adaptations can be taken into account as in the case of manure processing such as mechanical separation of slurry into liquid and solid fractions. More efficient utilization of manure nutrients with related additional costs and cost savings can be analysed from the viewpoint of farm level profitability and reduced need for purchased inorganic fertilizers. Also relevant is increased pressure of pests and plant diseases, the role of new cultivars – the benefits of improved crop protection management versus additional costs. This task is primarily attacked using farm level dynamic crop rotation models whose applications will be modelled on dynamic farm level management, land use and crop rotation analysis in climate and market scenarios of longer than 20 year span. Issues and problems related to climate change adaptation and mitigation are shared with Norway TradeM and Scottish LiveM researchers as well.

In ***Sub-Saharian Africa*** Tanzania and Nile Basin hot-spots the uncertainty in climate change projections and in CO_2 fertilization, requests complementing the analysis of climate change impacts by a risk assessment analysis of new production options.

Discussion

In each of the macro-regions of the study, have been chosen hot-spots that have appreciable differences in agro-climatic and geo-pedological, as well as equipment and farm structures. This ensures a strong representation of the impacts of climate change. In particular, the *Mediterranean* areas include arid climates of the areas facing the deserts of *Israel*, sub-arid climates and typical Mediterranean areas in Sardinia (*Italy*), with differences between the plain areas and hilly areas. In the Po Valley is a classic Mediterranean-continental climate, which is accompanied by the climate of the sub-Apennine foothill areas. In *Central Europe* there are the Alpine regions of Austria and, progressively, hilly and lowland areas. The rural areas of Germany are located on a west-east gradient from the Dutch to the Polish borders. Finally, there are areas of *North Atlantic* and territories nemoral and boreal. There are also strong structural differences in agriculture hot-spot in Sardinia with a variety of crops, livestock, and farm conditions That makes it representative of many Italian agricultural systems. Conversely the other Italian hot-spot focusses on the Grana Padano and Parmigiano Reggiano milk production systems prominent as income in the Po valley's farming systems, and the Italian milk production. In parallel, the internal differences of Israeli agriculture are accounted for with irrigated (with different water sources) and rain-fed land, production of vegetables and field crops, and citrus fruits. Similarly, for *Central and Northern European agricultures*, the *Austrian* sector is defined with small scale farming that dominates production coming from livestock, plant production, and from services as agro-tourism. The *hot-spots* located in *North German* exhibit diverse natural assets, land use, herd sizes, labour force, ecological production and society demands. The same for soil treatment and conditions, climatic zones, irrigation. *Two Finnish hot-spots* focus on dairy and meat sectors, integrating plant-farm-region-sector levels, with small farm size prominent. *Norwegian* hot-spot focusses on grassland-dairy systems, major users of land, and producers of agricultural value and employment. The *Scottish* hot-spot focusses on grassland-dairy, chief in less favoured uplands. The two *Tanzanian* ***Sub-Saharian*** hot-spots have different climate conditions (semi-arid and semi-humid), and market access, rain-fed crop–livestock systems, village sizes.

Climate change is expected to generate in the Italian Mediterranean hot-spots a slight increase in minimum and maximum *spring* daily temperature, and no significant variations for rains. Minimum and maximum temperature increase in *fall – winter* while rainfalls decrease, even if their variability increases. Climate change rises *summer* maximum temperature and even more minimum (*hot days* and *heat waves*), this couples with rises in humidity. In *Israel* climate change is to increase temperature of 3-5^{o}C at 2100 with larger variability, alongside a 10-30% drop in current annual average rainfall and a decline in freshwater supplies by 60%. In ***Central and Northern Europe***, 1-2°C annual mean temperature increases are expected in *Austria* up to 2050; rains are predicted with higher uncertainty. The four *Northern Germany regions* cross two agro-ecological zones that are differently affected by climate change: the western areas experience an increase of mean temperature with larger CO_2 concentration levels; in the eastern areas a continental climate condition prevails with larger increases of mean temperature in *summer*. Climate change increases mean temperature and rainfall in *Finland*, even if rain is likely to increase more in *winter* than during the growing season. More frequent extreme weather conditions are also predicted. No specific variations of weather components are predicted for ***Sub-Saharian Africa*** hot spots.

Climate change should differently affect farm sector in hot-spot areas. EPIC and DSSAT simulations by CropM for ***Mediterranean*** *Italian hot spots* suggest that *dairy cattle and sheep milk farms* could suffer an increased uncertainty on yields of reused crops, grains and hay (drops in non-irrigated grasslands). Estimates on livestock parameters by LiveM indicate rises of temperature and humidity could reduce milk quantity and quality, increase heads mortality and lengthen calving periods. *Crop farms* suffer uncertain yields (along with prices) and larger needs of irrigation water: volumetrically water pricing increases irrigation costs for crop and livestock farms. In *Israel* increase of temperature boost water demand above the increase expected under current climate, drops in annual rainfall reduce freshwater supplies. Higher and more variable temperatures, and rainfall patterns, enhance migration of pests and weeds to new areas. In ***Central and Northern Europe*** *regions* diverse impacts on *Austrian* agriculture are expected with natural and structural differences; climate impacts on reducing livestock production are also integrate in PASMA. The western *hot-spots* of *Northern Germany* could profit with a slight rise in yields from increased mean temperature and CO_2 fertilizer effect. Increases of temperature and rainfall in *Finnish hot-spots*, coupled with more frequent extreme weather conditions boost pests and plant diseases: this is already occurring and requires crop protection and rotation. Besides, longer growing season can increase yields and reduce costs especially in least favoured areas. Higher probability of drought (or flood) rises risks for silage grass production. Also, an increased pressure of pests and plant diseases is expected. In ***Sub-Saharian Africa*** hot-spots the uncertainty in climate change projections and in CO_2 fertilization, requests complementing the analysis of climate change impacts by a risk assessment analysis of new production options.

References

Brown, O and A. Crawford (2009), Rising Tensions: Climate Change and the risk of violent conflict in the Middle East, International Institute for Sustainable Development, Winnipeg, Canada,

www.iisd.org/publications/pub.aspx?pno=1130
CBS (Central Bureau of Statistics) April 2013, http://www1.cbs.gov.il/reader/newhodaot/hodaa_template.html?hodaa=201311097 accessed 20/04/2013

Dono G., Cortignani R., Giraldo L., (2013 a), Probability distribution changes of critical weather events and possible management effects on the agricultural activities in the territory of Oristano, Italian Journal of Agrometeorology. 03/2013;

Dono G., Cortignani R., Giraldo L., Dell'Unto D., (2013 b), Technical and economic characteristics of the farm models that represent the dairy sheep sector in simulations of climate change in the Oristano area, Italian Journal of Agrometeorology. 03/2013;

Dono G, Mazzapicchio G., Di Paolo A., (2013 c), Economic effects of the introduction of a nitrate vulnerable zone in an italian area, Italian Journal of Agrometeorology. 03/2013;

García-Ruiz JM, López-Moreno JI, Vicente-Serrano SM, Lasanta-Martínez T, Beguería S Mediterranean water resources in a global change scenario. Earth Sci Rev 105(3–4), April 2011, Pages 121–139, ISSN 0012–8252

Fischhendler, I. (2008). Institutional conditions for IWRM: the Israeli case. Ground Water, 46(1), 91-102.

Immerzeel, W., Droogers, P., Terink, W., Hoogeveen, J., Hellegers, P. and Bierkens M. (2011), Middle-East and Northern Africa Water Outlook, Future Water Report No. 98, FutureWater, Wageningen, January.

Lacetera N., Segnalini M., Bernabucci U., Ronchi B., Vitali A., Tran A., Guis H., Caminade C., Calvete C., Morse A., Baylis M., Nardone A. 2013. Climate induced effects on livestock population and productivity in the Mediterranean area. In " Regional Assessment of Climate Change in the Mediterranean" , Advances in Global Change Research 51, Eds., Navarra A., Tubiana L., Springer Science+Business Media, Dordrecht (Netherlands), 135-156.

MARD 2009; Agricultural and Rural Developments in Israel, unpublished report submitted as a preliminary survey for the OECD (February)

Mariotti, A., Zeng, N., Yoon, J. H., Artale, V., Navarra, A., Alpert, P., & Li, L. Z. (2008). Mediterranean water cycle changes: transition to drier 21st century conditions in observations and CMIP3 simulations. Environmental Research Letters, 3(4), 044001

MEP (Ministry of Environmental Protection) (2008), The Path Toward Sustainable Development in Israel, Jerusalem, Israel, www.environment.gov.il/?categoryID=159

Ministry of Agriculture & Rural Development (MOAG) http://www.moag.gov.il/agri/files/agriculture/index.html Accessed 18 April 2013

Nardone A., Ronchi B., Lacetera N., Ranieri M.S., Bernabucci U. 2010. Effects of climate changes on animal production and sustainability of livestock systems. Livestock Science, 130, 57-69.

OECD (2009) The Influence of Regulated and Economic Policy in the Water Sector on the Level of Technology Innovation in the Sector and its Contribution to the Environment: The Case of the State of Israel, unpublished consultation paper for the OECD Centre for Tax Policy and Administration project on Taxation Innovation and the Environment, Environment Policy Committee.

OECD (2010), OECD Review of Agricultural Policies, Israel. ISBN 1990-004X http://www.keepeek.com/Digital-Asset-Management/oecd/agriculture-and-food/oecd-review-of-agricultural-policies-israel-2010_9789264079397-en Accessed 18 April 2013

Orsini R., Steglich E., Doro L., Trobbiani P., Toderi M., Perugini M., De Sanctis G., Seddaiu G., Williams J.R., Roggero P.P., Apex model application for the Mediterranean cropping systems simulation, Italian Journal of Agrometeorology. 03/2013

Parry, M., Canziani, O. F., Palutikof, J. P., Van Der Linden, P. J., & Hanson, C. E. (2007). Climate change 2007: impacts, adaptation and vulnerability. Intergovernmental panel on climate change. ISBN 92-9169-121-6

Pyykkönen, P. 2006. Factors affecting farmland prices in Finland, Pellervon taloudellisen tutkimuslaitoksen julkaisuja nro 19

Plan Bleu. (2008). Climate change and energy in the Mediterranean. Sophia Antipolis: Plan Bleu Regional Activity Centre. Valbonne, France, www.planbleu.org/themes/energieUk.html Accessed 18th April 2013

Rosenthal, E., Guttman, J., Sabel, R., & Möller, P. (2009). Limiting hydrochemical factors for sustainability of water resources: The Cisjordanian experience. Chemie der Erde-Geochemistry, 69(3), 191-222.Snir 2006

Ruosteenoja K., Räisänen J., Pentti Pirinen P., Projected changes in thermal seasons and the growing season in Finland, International Journal of Climatology, Volume 31, Issue 10, pages 1473–1487, August 2011

Tomozeiu R., C. Cacciamani, V. Pavan, A. Morgillo, and A. Busuioc, Climate change scenarios for surface temperature in Emilia-Romagna (Italy) obtained using statistical downscaling models, Theor. Appl. Climatol. 90, 25–47 (2007)

Tomozeiu R., G. Agrillo, C. Cacciamani, V. Pavan, 2013a, Statistically downscaled climate change projections of surface temperature over Northern Italy for the periods 2021–2050 and 2070–2099, Nat Hazards 1-26 DOI 10.1007/s11069-013-0552-y

Tomozeiu R., Pasqui M., Quaresima R., Botarelli L., 2013b, Climate projections of temperature and precipitations obtained by statistical downscaling models over Italian regions, Italian Journal of Agrometeorology. 03/2013

Vitali A., Segnalini M., Bertocchi L., Bernabucci U., Nardone A., Lacetera N. 2009. Seasonal pattern of mortality and relationships between mortality and temperature-humidity index in dairy cows. Jurnal of Dairy Science, 92, 3781-3790.

Water Authority 2013, Water Rates Tables http://www.water.gov.il/Hebrew/Rates/DocLib1/prices-1.1.13.pdf Accessed 23rd April 2013.

Zimmermann, A., Heckelei T., 2012, Structural Change of European Dairy Farms - A Cross-regional Analysis, Journal of Agricultural Economics 63(3): 576-603.