



Research Article

Economic and Labour Market Implications of Global Environmental Change on Agriculture and Viticulture in Malta

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Abstract. Agriculture contributes but a limited amount to Europe's gross domestic production, and the overall weakness of the European economy to climatic changes on agriculture is deemed low. Agriculture remains more considerable in the southern and south-eastern European states with regards to employment and economic contribution and these regions are expected to face decreases in yields of 10% or more as a result of the reduction of the growing season and decreased rainfall. In Malta, other than cereal production as a fodder crop, most other crops are supported with a degree of irrigation that may ultimately mitigate adverse climatic conditions. Local producers have indicated that cereals, olives and vines have so far demonstrated varying degrees of susceptibility to climatic factors, although, arguably management factors are also relevant. The development of drier and warmer conditions in the Mediterranean region would also create conditions that are favourable to pests. Analysis of potential output effects triggered by global environmental change indicates that some 6,300 hectares on which wheat, olives and vines are grown, or 55% of Malta's total utilisable agricultural area, could in effect be rendered economically unsustainable when productivity falls by about 23%. Such heavy losses could constitute a potential risk to the sustainability of rural farming systems and livelihoods in Malta.

Keywords: climate change; agriculture; Malta; production

1 Introduction

The latest report of the Intergovernmental Panel on Climate Change confirms that human interference with the climate system is occurring whilst extreme weather and climate events, including droughts and floods, have sig-

nificant impacts on economic sectors, natural resources, ecosystems, livelihoods, and human health. With regards to biodiversity, there is evidence that many terrestrial plant and animal species have already shifted their area of activity, as well as numbers, as a result of past climate change, and they are also doing so now in many regions. It was confirmed that for rural areas, climate change will ultimately affect a number of economic, social, and land-use criteria (IPCC, 2014).

Socio-economic factors are important contributors to both the vulnerability and adaptability of human and natural systems and so assessing climate impacts on both human/cultural and natural systems requires a consideration of all factors influencing these systems, and their complex inter-relationships. Agriculture is considered responsible for an estimated one third of climate change. About 25% of carbon dioxide (CO₂) emissions are produced by agricultural sources, mainly resulting from deforestation, the use of fossil fuel-based fertilizers, and the burning of biomass. Most of the methane in the atmosphere comes from domestic ruminants, forest fires, wetland rice cultivation and waste products, while conventional tillage and fertilizer use account for 70% of nitrous oxides. The Climate Institute reports that the three main causes of the increase in greenhouse gases observed over the past 250 years have been fossil fuels, land use, and agricultural practices (Climate Institute, 2014).

In a 2014 statement, Hans Bruyninckx, Executive Director of the European Environment Agency (EEA), stated that climate change impacts are now visible in Europe and that the expected risks for this region are multiple and self-reinforcing. These include: augmented risk of flooding in coastal areas, further land erosion plus physical and financial losses due to accelerating sea-level rise; further possibilities of inland flooding along many

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river areas due to more heavy rainfall; increased economic, ecological and social impacts resulting from more extreme heat waves, as well as associated health issues and decreasing rural labour productivity. Additionally significant reductions in water availability, particularly in southern Europe, together with losses of crops and ecosystems plus the probability of escalating wildfires are to be expected (EEA, 2014, March 31).

Agriculture accounts for only a small part of the European Union's gross domestic product (GDP), and the overall vulnerability of the European economy to changes affecting agriculture is somewhat low (EEA, 2006). However it is also indicated that agriculture is much more significant in terms of land use, given that farmland and forest land cover approximately 90% of the EU's land surface, rural population and income. Agriculture's contribution is more noteworthy in southern and south-eastern European countries in terms of employment and GDP, and these countries will face decreases from their current yields by 10% or more as a result of the shortening of the growing season, drought and a likely trend for producers to alter practices and crop types resulting from climate change throughout Europe (EEA, 2008). In the context of the Maltese Islands, this scenario would imply the need for additional organic matter to improve water retention, together with the selection of hardier varieties of seed or breeds that exhibit more drought and heat stress tolerance and earlier maturity, such as the replacement of wheat by barley. Another probable good management obligation would be earlier, if not continuous, pest monitoring for disease control to compensate for milder winters with no cold break to destroy pests or, if possible, the provision of disease-resistant varieties.

In Malta's Second UNFCCC National Communication published in 2010, regional climate model simulations showed that, over southern Europe as a whole, the winter wheat yields would not decrease where irrigation is not limited (MRA & UoM, 2010). There would however be negative impacts when water availability for irrigation was limited. The extent of the growing season was likely to decrease, together with increases in the breakdown of organic matter, plant water stress and reduced crop yields. Potatoes, for example, would benefit from elevated CO₂ levels and elevated temperatures; however, an overall reduction in crop yields was expected, particularly in semiarid conditions such as those in Malta. In the longer term, when the absence of water would become a critical factor, the final impact would result in the disappearance of the potato as a staple crop from Southern Europe.

This document also indicated that vines were likely to be impacted as a result of increases in mean temperature and from the dynamics of changing rainfall distribution

and intensity. Impacts of increasing temperatures have already been felt in Spain and France, where vine growers are moving to higher elevations. This could however result in accelerated ripening that could inhibit the production of good quality grapes (MRA & UoM, 2010).

Basing their findings on the conclusion of the IPCC Fourth Report (IPCC, 2007), Parry et al. (2009) advised that global warming was unequivocal and affecting agricultural and forestry management. A number of effects of climate change on agriculture over the next 50 years were predicted. These include: higher levels of atmospheric CO₂; sea level rise; warmer temperatures and increased heat stress; changes in extent and cycles of precipitation; climate variability and storm intensity and variability. Each of these effects is reviewed in turn below.

1.1 Atmospheric carbon dioxide

There is a very high probability that CO₂ will increase from 360 ppm to 450–600 ppm over the next 50 years. In the case of the impact of increased atmospheric CO₂ on crop growth, physiological differences in plants will play on various uptake possibilities. Under conditions of CO₂ enrichment, crops may use less water while producing more carbohydrates, whilst requiring more nitrogen. When plants absorb more carbon, they grow bigger and faster. Depending on the photosynthetic mechanism at work, there are three types of plants: C3 plants, C4 plants and CAM plants. About 95% of the plants on Earth are C3 plants: these deploy a photosynthetic mechanism that takes carbon dioxide directly from the air during carbohydrate production. C4 plants are commonly seen in dry and high temperature areas and the 1% of plant species that have C4 biochemistry are much more efficient at capturing carbon dioxide because these can fix the gas at twice the rates of C3 plants without photorespiration. Increases in levels of carbon dioxide will benefit C3 species such as wheat and rice; however, warmer temperatures and drier conditions will tend to favour C4 species, such as maize, sugar and a large variety of agricultural weeds. Finally, CAM photosynthesis is a carbon fixation pathway that has evolved in some plants as an adaptation to arid conditions. CAM plants are more common than C4 plants and include cacti and a wide variety of other succulent plants; they are usually found in dry desert areas, with the pineapple as one commercialized exponent.

1.2 Sea Level Rise

Inundation of low-lying coastal areas from sea level rise and flooding from major storm events would create significant challenges for agriculture as this will result in loss of land, coastal erosion, flooding of agricultural areas and salinisation of groundwater. Sea level rise will not only pose a threat to agriculture in low-lying

coastal areas, but also promote its elimination, particularly in small islands where there are hardly any inland, non-coastal regions. The intrusion of seawater into Malta's coastal lowlands and aquifers, such as Burmarrad, Pwales and Armier, will create further hazards where drainage of surface water and ground water are impeded. This would oblige the usage of more salt-tolerant crops.

1.3 Warmer Temperatures and Increased Heat Stress

A rise of 1–2 °C in mean temperatures is considered to be a conservative estimate, but it would already contribute to faster, shorter and earlier growing seasons with increased evapo-transpiration and heat stress. Annual average land temperatures over Europe have been projected to continue increasing by more than the global average temperature during the 21st century (Füssel & Jol, 2012). Increases in land temperature in Europe are projected to rise by 1.0–2.5 °C by 2021–2050, and by 2.5–4.0 °C by 2071–2100. The largest temperature increases during the 21st century are projected to occur over eastern and northern Europe in winter and over southern Europe in summer (Füssel & Jol, 2012). The onset of hotter temperatures will also result in a quicker decomposition of organic matter, accelerate soil processes that determine fertility and provide more amenable situations for insect pests to thrive and propagate. This could necessitate additional fertilizer/pesticide applications to sustain current yields. In cases where soil moisture is scarce, both root growth and decomposition of organic matter would be comparatively more limited and would also increase their vulnerability to wind erosion.

Temperature is a crucial input in vine cultivation. If the temperature exceeds 35 °C for a significantly long period, red grapes would become stressed, having very low concentrations of tannins. Malta has a local advantage for producing red wine, unlike white which grows in a wider variety of places. Currently, there are all the right climatic conditions favouring red wine production, except for the lack of water, though this, so far, is controllable with a requirement of 800 m³ (and sometimes even up to 1000 m³) of water per hectare of vines annually. Rain prevails in winter and is, as yet not common in spring. However late rains and higher temperatures would tend to result in a greater frequency of vine diseases. Wide fluctuations in yield are becoming more noticeable; even down by 75%, but also even up to a fourfold drop in quality. A local expert emphasised that the maturity date is crucial, but this is being affected by early and bad breaks of season occurring in mid-February rather than spring. The prevalence of a cold spell after bud break has resulted in up to 50% losses in local Chardonnay production (Aquilina, 2014).

The global spatial pattern of climate change in the coming decades is expected to be largely similar to the pattern of recent changes that indicate a particularly strong warming in high latitudes, increasing precipitation in most tropical and high latitude regions, and decreasing precipitation in most sub-tropical regions. Global warming will lengthen the potential growing seasons in middle and higher latitudes, obliging earlier crop planting, but this again will depend on water availability (Füssel & Jol, 2012). In Malta, about half of the agricultural area is utilised for fodder production. The area under permanent crops with different fruits and vegetables is more limited with the resultant crops reflecting market prices in conjunction with water availability. Constraints in the form of elderly farmers, fragmented small fields, shallow soils, very limited organic matter, together with a high (alkaline) pH in the soil, have limited the introduction of new crops (Attard & Meli, 2008).

1.4 Precipitation

Precipitation changes across Europe show considerable spatial and temporal variability. During past decades, annual precipitation has been generally increasing across most of northern Europe, most notably in winter, but decreasing in parts of southern Europe. Most climate model projections show continued precipitation increases in northern Europe (most notably during winter) and decreases in southern Europe (most notably during summer). The number of days with high precipitation is projected to increase (Füssel & Jol, 2012). Seasonal changes in precipitation of ±10% are thus expected (Parry et al., 2009). Changes in seasonal precipitation will influence the quantity of rainfall, its storage in the soil together with evaporation and run-off. Diminishing rainfall can cause moisture stress in plants during all growth stages. The higher the incidence of evaporation, the more likely there will be soil salinisation with consequent diminishing yields and increased erosion, including drying of springs and aquifers.

Discussions with local producers indicate that variations in wheat production in Malta in recent years have generally been in the range of 10% drops, but even a 50% drop was recorded in one particular case. Similar yield losses were also apparent in olive production. Two years ago, there was an insignificant yield that could have been attributed to a typical off-year, with up to a 90% drop. In 2013, however, the olive crop yield was in the region of 33%: contributory factors include the occurrence of mild winters with limited rainfall as well as a mild summer, that probably also facilitated the presence of the olive moth.

1.5 Climate Extremes

Climate variability and associated extreme meteorological events will witness floods and droughts, causing extreme and possibly unrecoverable physical damage to crops (Füssel & Jol, 2012). Other than possibly exceeding the tolerance of these crops to temperature extremes, heavy rainfall will also result in increased soil erosion in these situations. It would be expected that erosion in agricultural areas would prevail in the regions of natural drainage depressions, where terraced soil is not contained by broken rubble walls, where land is very exposed to the elements and where there is a steep topography.

1.6 Storminess and Variability

The possibilities of increased levels and variability of major storms are considered low, together with the associated risk to damaging events that will affect crops and the timing of farm operations. Yet changes in wind patterns could also contribute to the spread of wind-borne pests and diseases. The presence of higher temperatures could further contribute to the vulnerability to fires following a drought period and thus further the desertification processes.

2 Main crop evaluation: Productivity and Profitability

The Malta National Census of Agriculture and Fisheries of 2010 indicates nine major crop types responsible for the highest land use, for a total national utilisable agricultural area (UAA) of 11,540 hectares in the Maltese islands (NSO, 2012) (see Table 1).

Table 1: Allocation of land area by crop type in Malta (NSO, 2012, Source:).

Crop Type	Land Area (ha.)
Forage/fodder crops	5,552.8
Vegetables	1,730.5
Kitchen Gardens	1,122.9
Potatoes	701.1
Vines	614.1
Fruit & berry	371.5
Olive	140.3
Citrus	111.3
Organic	26.1
Total	11,540.0

For all intents and purposes, forage constitutes a predominance of cereal crops, mostly wheat, harvested as hay for livestock fodder. Moreover, tomatoes, lettuce, watermelon and cauliflowers are the crops with the highest tonnage sold through official markets and these are taken as representative of vegetables and kit-

chen gardens. Peaches constituted the most common of orchard trees, oranges are the most grown citrus and strawberries are the most produced fruit (NSO, 2012).

Except for dry land cereal production, most other crops are supported with a degree of irrigation that may ultimately mitigate adverse climatic conditions. Local producers have indicated that cereals, olives and vines have so far demonstrated varying degrees of susceptibility to climatic factors, although, arguably management factors are also relevant.

Through specific feedback from local farmers, for the calculation of crop output, a 10% decrease in production is assumed as the first financial cost of climate change. Consequently, wheat production, which currently leaves a return of circa €221.52/ha, is reduced to a return of €123.75/ha when a 10% decrease as a result of climate change is assumed: effectively a 44% decrease in returns results. There is a prevailing situation where, with a 23% decrease in production, no revenue would result and the whole operation would be commercially non-viable.

On a similar basis, olive production gives a return of €6,777.28/ha which could decrease to €3,634.48 when a 10% fall for climate change is applied – again, a 46% decrease in returns where, with a 22% decrease in production, no revenue would result. The most immediate issue for the olive affected by climate change is rainfall. Less rainfall means stunted olive oil production.

Climate does not only affect olive trees directly. Changing temperatures also influence insect diversity and frequency for a given area. Rising carbon dioxide levels will exacerbate most insect and pest problems (Trumble & Butler, 2009). Downward trends, where yields are likely to drop by up to 25%, are generally expected due to poor harvests in drought-affected areas (Italian Food.net, 2014). A decrease of this extent will locally result in no profitability. Feedback attained from local oenologists indicates a possible 50% loss pertaining to a false early break as well, but only a 25% return due to higher temperatures. Other than these limitations, in the case of wine production, two further economic scenarios prevail as to whether IGT (Indikazzjoni Ġeografika Tipika) or DOK (Denominazzjoni ta' Orìgini Kontrollata) wine would be produced (MRA, 2015). These are correlated with production volumes per hectare at 18,000:12,500 for IGT:DOK. In effect, IGT allows additional production. Additionally, there is a price range by vintners of €0.65 to €0.80 per kilo, depending on the quality of the grapes and the production regime. Results indicate that IGT production operates with returns of €719.50 for the €0.80/kg price, but with a loss at €0.65/kg or lower. With an assumed 10% climate change deduction, the €0.80/kg return would then also operate at a €677.28 loss. All DOK production entails a loss and IGT would break even with but a 5.9% fall

for the €0.80/kg return. Thus, maintaining the volume of production is crucial for securing economies of scale and, therefore, economic survival.

Forecasts in percentage decreases in production suggest that some 6,300 hectares pertaining to the wheat, olive and vine crop types, as per Table 1, or 55% of Malta's total utilisable agricultural area, could be effectively rendered economically unsustainable should productivity levels fall by about 23%, given that for wheat, olives and vines, the break-even factors for production are 22.7%, 21.5% and 5.9% respectively. This impact could further exacerbate the push factor that discourages farming as a viable occupation. Thus, the onset of drier and warmer conditions in the Mediterranean region could lead to more favourable pest conditions and reduced yields: this has become a potential risk to the very existence of rural farming systems in Malta.

However, it is not only the farmers that will face difficulties. The production of fodder is closely linked to the dairy industry. Instead of purchasing local round bales that cost €30 and that weigh approximately 200 kg or €150/tonne, utilisation of imported hay at 2014 prices of €250/tonne (personal communication with various livestock breeders) will be necessary – effectively a €100/tonne additional expense that could translate into a serious setback to profitability for livestock breeders, milk producers and finally consumers. In Malta, however, inextricably linked with the dairy industry are the other livestock industries via the provision of animal feed. Given that the local situation necessitates the utilisation of specialised smaller ships to provide the basic components for animal feed, any reduction in ordered quantities would necessarily result in higher tonnage costs.

In the case of the local production of fodder, grapes and olives, farmers could seek to cut down on expenses by minimising inputs, particularly fertiliser; but, this again would affect both yield and quality, particularly for wine and oil. The production of DOK wines has suffered a setback since market prices (as also determined by vintners) fell from the €0.93–€1.05 level to the current €0.65–€0.80 range. Attempting to increase production through additional irrigation will affect the brix or sugar content of the crop. Faced with diminishing returns, farmers could be more in favour of vine grubbing or removal after their 10-year commitment for state-aid development expires. Improvements in olive production shall require awareness to climate change issues to help farmers respond with better practices. Ultimately, oil and wine production command a niche in the local market that, if locally unavailable, would again oblige additional imports.

Looking at the value of gross production for the sector as at 2013 as indicated in the Economic Ac-

counts for Agriculture (NSO, 2014), and comparing the milk, forage and wine components of €29,244,000 to the €138,222,000 total value of production, these three areas constitute at least 21% of the value of Malta's agricultural production. Should negative effects of climate change prevail, it may thus be assumed that at least this sector of the industry could be adversely impacted. One suitable response to damage to crops, with associated more difficult timing and management of agricultural operations, could include coordinated collective efforts at raising awareness that in turn promotes creative, practical and profitable responses, possibly including renewable energy, nutrient inputs, and soil management to the farming community. Agricultural adaptation options are grouped according to four main categories that are not mutually exclusive: (1) technological developments; (2) government programmes and insurance; (3) farm production practices; and (4) farm financial management (Smith & Skinner, 2001).

At EU level, through support by the European Agricultural Fund for Rural Development (EAFRD), there is the promotion of resource efficiency that involves extending two forms of support (ENRD, 2015). First, is the encouragement of a shift towards a low carbon and climate resilient economy in the agriculture, food and forestry sectors through better risk management. Second, is the support of market signals that promote climate change mitigation and adaptation through agro-environmental payments, as well as through support for areas facing natural or other constraints. As at 2010, in Malta there were some 12,530 agricultural holdings covering 11,450 hectares of utilised agricultural area (UAA), where 73.5% of these holdings have a UAA of less than 1.0 hectare each with some 18,539 persons actively engaged in agricultural activity. The need thus arises for a combined effort to effectively monitor and tackle productivity, profitability and sustainability, including mitigation of climate change.

3 Conclusion

Better risk management via improved resource efficiency may prove to be the only hope for the conservation of rural farming practices in south and south-eastern European countries faced with what is an already foreseeable battery of climate change impacts. The challenges are exacerbated on small island states like Malta, bereft of large non-coastal regions and with limited spare capacity to soak up and compensate for weaknesses and stresses that may result in other industrial sectors. Rural farming practices in Malta are likely to be considerably challenged by global environmental change.

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