



Leapfrogging Agriculture as Usual: The Potential Contribution and Sustainability Benefits of Organic Farming to Carbon Sequestration In Portugal

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Abstract – Climate change entails major challenges and a window of opportunity of about 20-30 years for fruitful societal intervention. As such, significant contributions for carbon sequestration that are available during this period must all be harnessed at the earliest. This analysis attempts to explore the climate change benefits of a full scale conversion to organic farming using Portugal as a model. The additional carbon capture entailed in organic practices is estimated from published data and a theoretical carbon emission reduction potential is calculated. The carbon benefits translate into a carbon market value which does not provide the necessary economic enticement for the transition to happen. However, when the corresponding additional ecosystem services from organic farming are taken into account, the resulting value could turn into the necessary motivation. A suggestion is made of a possible solution to finance such massive payment system based on radical fund reallocation in the European Union's Common Agricultural Policy.

Keywords – Carbon Markets, Climate Change, Organic Agriculture Transition, Portugal, Soil Carbon Sequestration, Sustainability.

I. INTRODUCTION

Society is currently experiencing both the dwindling of the global resource base and the finiteness of the planet's life supporting services, climate change being an example in point. The latter has attracted a considerable amount of research (see for example Jaffe and Kerr 2015; McKibbin and Wilcoxon 2002; Nordhaus 2007), which consistently shows the risk of crossing critical environmental thresholds, leading to irreversible natural damage (Solomon et al. 2009).

How to react to impending climate change has been the subject of numerous analyses (e.g. Berrang-Ford et al. 2015; Nordhaus 2007; Rogelj et al. 2013; Stern 2006), and the role of agriculture has also been examined (Fernandez and Blanco 2015; Snyder et al. 2009). However, a literature search has not evidenced any studies looking into the potential of a massive reorientation of farming policy based on ecosystem services provided and accompanying carbon sequestration potential. Portugal, being the European Union member state with the highest percentage of emission increase allowance (European Environment Agency 2011), is positioned as an obvious target for such a first rough proof of concept analysis.

In this article a preliminary attempt is made at evaluating the extent to which a large scale transition to a

more sustainable farming approach in Portugal would significantly contribute toward meeting the challenge of reducing climate significant emissions and how such a system could theoretically be paid for. The study is structured as follows. The initial section reviews climate change objectives and obligations at the European Union and national levels. Afterwards the double role of farming in increasing and offsetting emissions is evaluated based on published literature. Finally, two major and complementary alternatives to financing an appropriate agricultural conversion are evaluated. As a simplification throughout the text reference is made simply to "CO₂", although "CO₂ equivalent" is what is intended where appropriate.

II. CLIMATE AND SUSTAINABILITY

A. The Climate Change Challenge

Among atmospheric scientists there is agreement that cumulative anthropogenic emissions are increasing the atmospheric greenhouse gas (GHG) concentration as terrestrial and oceanic sinks are insufficient to reabsorb the additional fossil fuel derived carbon at a sufficient rate (Falkowski et al. 2000). Emissions essentially originate from fossil fuel combustion (over 75%) and land use change (the remaining balance) (Snyder et al. 2009). This has not always been this way, however, as until about 40 years ago all of agriculture combined had resulted in higher CO₂ equivalent emissions than fossil fuel use (Desjardins et al. 2005).

This reality entails a high urgency challenge as, according to Hansen et al. (2006), an average temperature increase above 1°C (from 2000 levels, which translates into roughly 1,7°C from pre-industrial time) already carries a "dangerous" evolution in climate patterns. One of the reasons is that climate systems involve non linear response curves with thresholds which, when crossed, lead to new and essentially irreversible steady states that directly threaten humanity's survival (Rockström et al. 2009).

As such, the consensual scientific estimate is that atmospheric carbon must be reduced down to below 350 ppmv (parts per million) from its current 403 ppmv value in order to minimize the harshest implications from human interference with atmospheric homeostasis (Hansen et al. 2008; Mauna Loa Observatory 2015). Background levels – estimated at 280 ppm for the pre-industrial period – are

29% lower. This means a severe reduction in net emissions that must happen on a time scale of, at most, 20-30 years, except this is not the future where business as usual is headed (Hansen et al. 2008; Smith 2004).

In fact, according to the latest installment in the United Nations Intergovernmental Panel on Climate Change reports' series (Intergovernmental Panel on Climate Change 2013), the increase in warmer days (both on the hot and on the cold ends) is "virtually certain" and will continue well beyond the end of this century. This could translate, before the year 2100 is reached, into almost 4 billion additional people at risk of hunger, malaria, water shortage and coastal flooding alone (Parry et al. 2001).

Impact is unlikely to be homogeneous, meaning some regions will be particularly hard hit. Africa, for instance, suffers from about 90% of all malaria cases (Patz et al. 2005). And since most tropical agriculture is already operating under extreme conditions, even small temperature shifts could trigger, both for Africa and Latin America, a 30% productivity downturn and a corresponding increase in food insecurity (Intergovernmental Panel on Climate Change 2000). Even temperate regions face serious threats, such as those stemming from sea level rise: one million people could be affected by flooding annually in the United Kingdom by 2080, unless swift measures are taken whereby impact could be drastically reduced (Met Office 2011). In Portugal, in particular, decreased rainfall is to be expected under the business as usual scenario (Storch et al. 1993), which may compound the already devastating consequences of annual forest fires during summertime (Pereira et al. 2005).

B. The Kyoto Objectives for the EU and Portugal

The Kyoto Protocol, which was adopted in 1997 and came into force in 2005, now has 192 convention parties. It created binding GHG emissions targets for signatory countries during the 2008-2012 period. At the European Union (EU) level (with 15 member states at the time) this translated into an 8% reduction target commitment relative to the 1990 reference year (European Environment Agency 2011). Within this collective goal, however, Portugal was allowed a 27% emission increase limit – the largest of all EU member states.

The 2012 Doha climate talks agreed on an extension of the Kyoto Protocol to 2020, with the EU-27 unilaterally committing to a minimum GHG emission reduction of 20% and keeping open the option of reaching 30% if other major countries agree to follow suit (European Environment Agency 2011; Lesser 2013). During this period Portugal has been allowed a 30% increase over 1990 levels, that is, about 1% over 2005 emissions (Agência Portuguesa do Ambiente 2012). This target will probably be overachieved because of the 2008 financial crisis, among other reasons (Agência Portuguesa do Ambiente 2012).

III. AGRICULTURE AS FRIEND AND FOE

A. Agriculture's Double Role

Agriculture represents one of the main contributors to climate change, as pointed out by Snyder et al. (2009). In 2009 agriculture accounted for 10.3% of the total GHG emissions in the EU, that number reaching 10.5% as regards Portugal (Instituto Nacional de Estatística 2012). It is interesting to note, however, that the overall emissions associated with cradle to grave food production reach an estimate of 32% if fuel use, fertiliser production and agriculturally induced land use change emissions are accounted for (Bellarby et al. 2008).

On the other hand, there is potential for agriculture to act as a carbon sink, the exact worth of which varies greatly depending on the management practices involved (Smith et al. 2001). This can be translated into economic value, as recognised in the Kyoto Protocol which states, under article 3.4, that carbon sinks in agriculture may be included when calculating overall country performance.

There are many ways in which agriculture's emissions can be decreased. Mitigation may come from managerial changes in crop and grazing land (such as improved residue strategies, agronomic routines and reduced tillage), a concerted effort toward degraded and eroded soil restoration, changing fallow period patterns and, of course, from better livestock management (Smith et al. 2007). The know how for this is available and no time need be wasted, although technical research and development could significantly accelerate change (Smith et al. 2007).

In the EU in particular, a high potential has been estimated relative to current agricultural practices. In Smith (2004) the realistic soil carbon sequestration potential of organic farming in the EU is calculated at 3.9 Mt C y⁻¹, the largest amount for all cropland practices analysed, albeit with a significant degree of uncertainty involved. Some other practices available, such as zero tillage farming, also present benefits over conventional farming.

B. A Comparison Between Organic and Conventional Farming

According to the definition put forward by the International Federation of Organic Agriculture Movements (IFOAM), organic agriculture is a socially, environmentally and financially balanced approach to food production (International Foundation for Organic Agriculture 2005). This holistic view is based, still according to IFOAM, on four main principles – fairness, care, health and ecology – and results in increased sustainability of the food supply (Seyfang 2006). The differential performance of organic and conventional farming systems has been extensively studied under many different conditions and experimental designs, sometimes with somewhat contradictory results.

Soil organic matter (SOM – of which 58% is pure carbon (Lal 2004)) is not evenly distributed: in a meta-analysis, Mondelaers et al. (2009) demonstrated (with a 95% confidence interval) that SOM concentration in organic farming is significantly higher – averaging 12% – over what can be found in conventional farming (even though not all studies find significant variation between these two

forms of agriculture and more research is needed to clarify).

A detailed revision of comparative studies has calculated organically farmed soil consistently presents even higher carbon contents: 20% when Europe, the US and Australasia are combined; 28% if focusing on Northern Europe alone; and 33% when only UK studies are included (Gundula 2009).

This large divergence between farming practices can be explained by differences in levels of composted animal waste use, leguminous cover crops and crop residue recycling, all of which tend to be higher in organic agriculture (Hansen et al. 2001).

C. The Carbon Benefits of Adopting Organic Farming

An important feature of the soil carbon increase associated with organic farming is that the rate of sequestration is highest during the first 20 years (where about half the increase happens) and then tapers off until at about 100 years, when the system has reached its new equilibrium (for the new farming regime) and the net carbon accumulation slows down to zero (Bhogal et al. 2009). This in fact means that the conversion to organic farming brings with it important and immediate benefits, something which has a direct bearing on climate policy. Longer term benefits, however, will have to come from elsewhere.

In practice carbon sequestration through the conversion to an organic farming approach provides a much needed good return mitigation option which should be explored while longer term measures are still being put into place and hence take more until results can be measured (Smith 2004). There is one limitation to be noted, however. If at any point there is reversal in land management, previous SOM acquisition through organic farming may be rapidly lost (Smith et al. 1996). As such, any adoption must be envisaged as a long term intergenerational commitment.

D. Carbon Sequestration in the Organic Transition

A report by the European research project PICCMAT calculates that a switch to organic agriculture begets an additional 400 kg per ha per year of SOM (Freluh-Larsen et al. 2008).

One of the longest running and most studied setups, the Rodale farming systems trial, presents an even better outlook. Data collected with a 20 year interval show an annual soil carbon increase of 981 kg per ha per year in organic production with animal manure inputs, as compared to only 293 kg per ha per year in the conventional system (Pimentel et al. 2005). This translates into an additional 688 kg of soil carbon per ha per year benefit obtained through organic farming practices.

How this number could be translated into the Portuguese situation cannot be anticipated exactly, but given the skeletal nature of most Portuguese soils (Cardoso 1965) and hence high potential for carbon acquisition, it can be posited that reality may disclose even higher values.

E. The Portuguese Reality and Potential Prospects

Portuguese agriculture (including forestry and fisheries) is responsible for about 10% of the national carbon emissions (Alves et al. 2011). The total agricultural area

currently in use is $3.7 * 10^6$ ha, with an additional 128 000 ha available, but not in production (Instituto Nacional de Estatística 2011). Overall, only about 121 000 ha are under organic management (Ministério da Agricultura 2004). Theoretically, if all in use conventional agricultural area were to be brought under organic production, $3.55 * 10^6$ ha would be making the transition.

That a country could plan on turning farming 100% organic may be seen as farfetched but has in fact already happened in 2012, when Bhutan announced such a plan at the Rio+20 Conference on Sustainable Development (Barclay 2012). Also, an equivalent albeit more dispersed move has actually already happened within the European Union. In fact, the total area converted to organic farming in the EU-15 between 1985 and 1999 amounts to an overall number ($3.2 * 10^6$ ha) not dissimilar to the noted Portuguese dimension (Padel 2001).

Using the Rodale measured benefit of 688 kg C per ha per year, this newly converted organic production area in Portugal would potentially sink in 48 million tonnes of additional soil carbon over the course of 20 years (at a yearly rate of 2.44 million tonnes of additional soil carbon). Considering that the Portuguese agriculture emits 7.8 million tonnes of carbon per year (Instituto Nacional de Estatística 2009), the transition could offset slightly over 30% of all Portuguese agriculture's estimated emissions during a minimum of 20 years. This is a clear improvement over the government's projected emissions increase. But how can the odds be stacked in favour of such a large scale conversion?

IV. TWO PATHS, ONE WAY TO A DOUBLE WIN

A. Carbon Credit Policies

The EU agreed a carbon market can efficiently and economically reduce GHG emissions within the block (Art. 1, Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the community and amending Council Directive 96/61/EC), a decision implemented through the EU Emission Trading Scheme (ETS). The ETS works on the 'cap and trade' principle (European Commission 2012a), whereby economic agents can define their own most effective approach to emissions reductions.

Currently about 45% of all EU emissions are covered through this approach, encompassing the largest industries, power plants and some flight routes (European Commission 2012a). Some emitters not included in the ETS include transportation, domestic use, the third sector and agriculture, although they may come to be included in the future (Ellerman 2008). The ETS, the world's largest, has resulted in a solid carbon administration infrastructure and a uniform carbon price across all 31 participating countries. It has also put a number on the price tag of fossil fuel burning, which effectively defines the market value of carbon sequestration (Ellerman 2008).

B. Carbon Price Evolution

The average carbon price has risen from €17 in 2006, to €20–25 in 2007, to €27 (US\$42) in 2008 (Maraseni 2009).

It took a plunge to an average price of €14 in 2009 (Kossoi and Ambrosi 2010), with little variation in 2010 and 2011 (14.56 € in 2010 dropping slightly to 13.93 € in 2011 (Kossoi and Guignon 2012)). In 2012, however, carbon prices dropped again to about €6.5 per ton of carbon at the end of the year (E. Santos, Portuguese Environment Agency – Personal communication, 10 January 2013).

The latter trend is expected to reduce the attractiveness of investment in low carbon technologies and in more efficient and best management practices (Verdonk and Vollebergh 2012), prompting the European Commission to put forward a number of carbon market stimulation measures which include extending the ETS to additional sectors, among others (European Commission 2012b).

That current prices are undervalued has also been defended by Creti et al. (2011), who consider the carbon market is bound to increase prices in order to regain equilibrium. French investment bank analyst Coghe estimates that, whatever measures the European Commission does implement, prices will increase to €9.3 in 2013 all the way to €14 in 2020 (Ferdinand 2013). Permits, however, are still trading at much lower values due to current overabundance.

C. An ETS Based Incentive for Carbon Sequestration in Farming?

When the current (September 2013) value of €5.30 per ton of captured carbon is considered (Reuters 2013b), and taking the above mentioned 981 kg per ha per year overall carbon sequestration ability of organic production, the estimated market value for this societal service is €5.2 per ha per year (or €18.5 Million when the full Portuguese to be converted agricultural area is considered).

By itself, a market incentive this low is not likely to induce a large scale transition to organic farming in Portugal. In fact, it has been estimated that a payment of €500 for a total of five years would not act as enough of a motivator to tilt farmer behaviour in such a direction (O'Riordan and Cobb 2001). Hence, a complementary approach is necessary if this useful change is to happen at all.

D. The Market Value of Organic Farming's Other Services

An organic approach to farming has been found to offer improved sustainability over conventional production, with increased biodiversity and ability to naturally control pests and lower energy consumption, higher soil quality, nutrient surplus and overall lower environmental impact (Dulja et al. 2013; Maeder et al. 2002; Reganold et al. 2001; Sandhu et al. 2010) and, by definition, much reduced pesticide use with corresponding benefits regarding water quality (European Commission 2004), an advantage compounded by organic's lower nitrate to water leaching rates (Hansen et al. 2001). Increased financial advantages have also been detected with organic farming methods (Pacini 2003), as well as an ability to feed the whole world on the same area currently in use (Badgley et al. 2007).

All of the above make organic farming more compatible with and supportive of natural ecosystems and their functioning. This in turn benefits biodiversity as well as

the whole of society, since ecosystems provide services that also fulfil human needs directly and indirectly, such as decomposing organic matter and purifying drinking water (Costanza et al. 1997; Millennium Ecosystem Assessment 2005).

When organic farming is compared to the conventional reference as regards the non-market value of ecosystem services (excluding carbon sequestration), the estimated difference is €310 per hectare per year in favour of the organic method even when lower, most conservative estimates, are used (Sandhu et al. 2008). Being of societal benefit, it can be argued that such services justify payment.

Economic views regarding the theory and practice of commodification of ecosystem services are complex and still evolving among controversy (Redford and Adams 2009; Soma 2006; Kosoy and Corbera 2010). Still, payment for ecosystem services is a relatively common practice, from the agri-environment measures of the European Union's Common Agricultural Policy to the pollination services that have been in place for a number of years (Dobbs and Pretty 2008; Gómez-Baggethun et al. 2010).

E. A Solution for Soil Carbon Sequestration

According to Daugbjerg et al. (2011), Danish policies introducing direct organic farmer payments (starting at €412 per ha the first year and decreasing slowly from there) were successful in promoting a large conversion to organic agriculture. These subsidies were seen as a fundamental tool for creating the intended flux.

Considering farmer dynamics in the two countries to be comparable, an assumption that remains to be tested, that sum of money should be enough to spur the necessary conversion interest in Portugal as well. Peer pressure and additional complementary measures, such as technical support and supervision, would have to be put in place as well.

However, it should be noted that Denmark has a 61% higher purchasing power when compared to Portugal (World Bank 2013), which effectively means that the "motivational weight" of a €412 Danish payment is equivalent to a €161 payment in Portugal. Hence, if direct farmer payments of the €310 per ha calculated above were to be introduced in Portugal for those taking up organic farming it is reasonable to assume they would create an even larger scale of inducement than the Danish. When the €5.2 per ha ETS carbon payment is included the total in fact increases to €315.9 which, corresponds to almost double the threshold that won many Danish farmers over. The €310 per ha ecological services subsidy translates into a yearly €1,100 Million for a national 100% organic conversion considering the 3.55×10^6 ha mentioned above for agricultural land in use in Portugal.

This funding could theoretically be covered to 100% through the €1,364 Million in annual subsidies (2012 data for combined first and second pillar values) that Portugal receives under the current European Union Common Agricultural Policy (A. Catalão, EU Agriculture and Rural Development Commissioner Dacian Cioloș' Cabinet Member – Personal communication, 11 September 2013).

It is unlikely that agriculture's stakeholders would be readily willing to give up all other funding opportunities within these two main pillars but, if a multiyear implementation period were to be introduced, reactions might not be as pronounced.

Agricultural policies are typically very complex, and the European approach is no exception. For several years many stakeholders have been negotiating a new version of the EU's Common Agricultural Policy, that will be entering into force on the first of January 2014 and which includes somewhat shy greening measures with the intention of strengthening beyond what is farming's current practice through conditional direct payments (European Commission 2013). Therefore, the thesis presented in this study could give Europe's stand new depth and breadth – which may look ambitious (but not unnecessarily so) for the moment.

One visible limiting factor in the overall analysis is the very low market value accorded each ton of sequestered carbon. Any emissions trading scheme such as the European ETS should make sure CO₂ emission permits are kept progressively scarcer, i.e. pollution becomes increasingly expensive, in order to function properly (O'Shea 2002). If carbon prices were to reach levels of 40 to 50 euros per ton of CO₂, as has been called for by some analysts (Reuters 2013a), a national transition to a more sustainable farming approach could be made that much more swiftly.

V. CONCLUSION

The evaluation of agriculture's contribution to climate change in Portugal points to the conclusion that carbon markets do not provide enough of a financial incentive to effectively promote large scale carbon sequestration. However, a profound shift in the way European farm subsidies are allocated could fund all additional ecosystem services as provided by organic farming, thus triggering a massive carbon sequestration program for the next 20 to 30 year horizon where, climatologists warn, lies the danger of irreversible climatic destabilization. Such a program would inevitably involve a steep learning curve, but could represent a win-win situation as regards overall land use and national sustainability.

However, this approach will not solve the global atmospheric CO₂ surplus challenge and it definitely carries a time limit, meaning it may only help buy valuable time until other, more permanent energy strategies and adaptation measures are developed and put in place. But, even if organic farming's total contributions to global emissions abatement needs remain small, it is an approach society cannot afford to pass given the urgency of the climate situation and need for immediate measures.

This study aimed at a preliminary proof of concept and left out endless considerations, namely a vast range of socio-political consensus building and implementation constraints, not to mention political will and the ability of governments to take in climate change's overall challenge. A detailed and rigorous analysis should be undertaken given the immediacy of the threat for society's survival prospects.

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