II. ORGANIC FARMING PRACTICES AND CLIMATE CHANGE ADAPTATION

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1. Introduction

The need to adapt to climate change is one of the main challenges facing the future of agriculture. Even if strong and effective mitigation measures were taken, even if greenhouse gas emissions dropped to zero immediately, the climate would continue to change for decades. This is why adaptation is necessary. If global warming can be kept to a moderate level, our need to adapt might primarily reflect gradual changes; but if temperatures rise sharply, adaptation measures will necessarily involve some fundamental transformations in agricultural production. Moreover, as the effects of climate change can vary greatly at local and regional levels, even moderate global warming can trigger fundamental changes in some places.

The main ways in which climate change can affect agriculture are through increased levels of CO_2, changing temperatures, climate variability and the frequency of extreme weather events. It can also cause changes in precipitation and transpiration regimes and shifts in crop growing seasons, and it can alter weed, pest and pathogen pressures. Higher CO_2 concentrations and a moderate rise in temperature will lead to increased crop yields. However, this positive effect would be cancelled out if the temperature increases by more than 1.5°C. This is very likely to happen, given that huge mitigation efforts would be needed to keep temperature increases even below 2°C (*Rogelj et al., 2011*). Increased variability and frequency of extreme weather events such as droughts or heavy rains also have an adverse effect on agricultural production. With changing precipitation and transpiration regimes, the drier zones of the lower latitudes will generally shift to higher latitudes; precipitation will increase near the equator and in the higher latitudes. Total global precipitation will increase and the current monsoon and El Niño regimes will change. All these changes will, however, be subject to strong regional variability. Climate change will have a big impacts on rainfall patterns, water availability and irrigation needs. The changing climate will likewise cause changes in weed, pest and pathogen pressures. These will manifest themselves as a spread from the lower to mid-latitudes, and pest and disease outbreaks will be reinforced by climatic extremes.

All these influences on agriculture will become clearly apparent in the second half of the 21st century, when the effects will become increasingly negative. The adverse consequences of climate change will emerge earlier and have a stronger impact in the lower latitudes, while mid and higher latitudes will experience less pronounced effects which develop more slowly. More detailed information about the various effects of climate change can be found in *Easterling et al., (2007)*, *Meehl et al., (2007)* and *Rosenzweig and Tubiello (2007)*.

2. Adaptation needs

Several key inferences can be made regarding agriculture, based in this understanding of the effects of climate change. As formulated in *Müller et al., (2012, p104)*, for example, "First, impacts vary strongly per region. […] Second, water will be a key issue, in particular due to water scarcity and drought, but also because of extreme precipitation events, waterlogging

Flower strip besides a cabbage field which provides habitat for beneficial organisms, essential for pollination and disease and pest control of crop plants.

and flooding. Third, increased weed, pest and disease pressure will challenge agriculture. Fourth, extreme events will put further stress on agricultural production. Fifth, climate variability and the risk in agricultural production will increase". In the light of these increasing uncertainties, adaptation strategies are needed to reduce the risks involved in agriculture. Likewise, it is necessary to promote plant and animal health in response to the increased stress placed upon them. Finally, potentially drastic changes in the climate may force a transition from intensive crop production to extensive grass-based animal husbandry, and could even make agricultural production essentially impossible in certain regions. As such, in certain contexts it might become necessary to consider some fundamental transformations in livelihoods.

Taking steps to diminish the risks that affect agriculture will essentially reduce the otherwise extensive losses in crop harvests or livestock production which are likely to occur. A first strategy is diversified production, which means that each of several production activities contributes only a smaller part of a farm's revenues. If one area of production fails the financial losses will be limited. Diversification of farm production is a concept practised by rural communities in developing countries and emerging economies, and was also the dominant farming model for centuries in Europe. A second strategy is to reduce the financial risk by minimising input costs. Then if crop losses occur, the extent of the financial loss due to unrecoverable investments is lower. A third strategy is to increase resilience to the effects of climate change in individual areas of production, thus mitigating any adverse effects and corresponding losses. Increasing resilience can be achieved, for example, by improving plant and animal health, because healthy organisms are better able to cope with pest and disease pressure and adverse environmental conditions such as heat waves or water shortages. A fourth possible strategy for avoiding existential financial losses through farming is the use of insurance solutions, such as those already widely used today to protect against losses from hail. However, given the increasing risks, the cost of such insurance schemes may become prohibitive. Insurance solutions such as those based on weather indices (deviations from long-term precipitation and temperature averages as recorded in a nearby reference climate monitoring station) are available in a different institutional setting other than agricultural production and we do not address them in this paper.

3. The potential of organic agriculture

Many of its core characteristics mean organic agriculture is potentially well placed to support the first three adaptation strategies outlined above. Detailed discussions of this can be found in *Müller et al., (2012)*, *El-Hage Scialabba and Müller-Lindenlauf (2010)*, *Niggli (2009)*, *Borron (2006)* and *Milestad and Darnhofer (2003)*. Here we provide a brief overview of their results.

On average, due to crop rotation and organic production practices, rates of biodiversity and crop diversity are higher on organic farms than conventional farms. Set-aside areas and landscape elements such as hedges further increase biodiversity. This diversity in turn improves ecological and economic stability; it reduces pest outbreaks and plant and animal diseases and improves the utilization of nutrients and water (*Smith et al., 2011*).

Organic agriculture uses fewer external inputs, establishes closed nutrient cycles and fosters the optimal use of natural resources, ecosystem services and biological functions, such as predator prey dynamics (*IFOAM EU Group, 2010*). The practice of encouraging such processes with targeted interventions is known as eco-functional intensification (*TP Organics, 2010*). In this way, organic farming responds perfectly to the need for risk-reducing strategies, as it lowers input costs, fosters diversity and invests in healthy organisms. In the long run, this approach increases competitiveness, lowers the risks of incurring debt, and might even protect the livelihoods of small-scale and poorer farmers (*El-Hage Scialabba and Hattam, 2002; Eyhorn, 2007*). An additional financial benefit stems from the price premium for organic products if they are marketed within a certification system.

Furthermore, soil fertility is enhanced as a result of organic agriculture, not only because of the organic fertilizers used, but also the crop rotations involving deep rooting forage legumes which increase and stabilize soil organic matter. This results in significantly enhanced soil organic carbon levels (*Gattinger et al., 2012*) and thus works in synergy with climate change mitigation strategies used in farming, as a form of carbon sequestration. It also contributes to increased water capture and storage capacity (*Reganold et al., 1987*), reduced soil erosion (*Siegrist et al., 1998*) and increased aggregate stability. Moreover, it also stimulates biological activity and raises the diversity of soil life (*Lampkin, 2007; Mäder et al., 2006*). Soils that are rich in organic matter therefore absorb more water during extreme rainfall, reduce surface run-off and erosion, and can sustain a supply of water during dry periods. Consequently, organic agriculture is likely to provide greater resilience in the face of water scarcity and extreme weather events, as well as their consequences such as heavy precipitation, floods and waterlogging (*El-Hage Scialabba and Müller-Lindenlauf, 2010*)

It is important to note that the best practices for farming described above, which produce such a wide range of benefits, are not exclusive to organic agriculture. They are core

elements of organic production, but they can likewise be employed in conventional agriculture. Indeed some of the approaches do feature prominently in more general suggestions for adaptation in agriculture. However, conventional agriculture still generally fails to acknowledge the adaptation value of the systemic view of soil fertility and biodiversity adopted in organic agriculture.

Other adaptation practices such as agro-forestry are not widely used in organic agriculture, but would fit perfectly well in organic production systems. Agro-forestry systems and the use of shade trees can help to mitigate daily temperature peaks and thus improve resilience to heat waves. Such systems also increase the extent of carbon sequestration (*Smith and Olesen, 2010*).

Finally, as a knowledge based system organic agriculture is well placed to use local farmers' knowledge and locally adapted varieties and breeds. It can foster an adaptive and often participative learning approach to the development of crops and practices. These are important sources for greater diversity and adaptation in agriculture.

Soil profile, with a humus rich top horizon under maize. This soil needs regular organic matter replacement through forage legume cropping, green manure and farmyard manure application because of the pronounced carbon losses associated with maize cropping for silage.

4. Challenges

Because of its complexity, organic agriculture is not a panacea. Organic farming is knowledge intensive, and converting to it involves well organised and high quality training, as well as a supply of information and advisory services.

In developing countries the market structure presents a risk for organic farmers. At present, some regions are strongly export oriented. This mainly involves cash crops so the price premium plays an important role in the farm economy. This can result in a dangerous dependence on the export markets and there is a need for diversification to local markets.

Finally, in some regions the effects of climate change might be so devastating that agriculture has to be completely abandoned. It is very difficult to forecast the local effects of climate change beyond a period of two decades. Thus it is important to consider with caution the possibility that an ideal short term adaptation of agricultural production to the changing climate could lead into a *cul-de-sac* if more fundamental changes become necessary later on.

Time must also be taken now to prepare for the long term changes. In the event that early warning indicators point to the emergence of fundamental difficulties for agriculture in a particular region, income alternatives for the affected population should be considered as early as possible.

5. Conclusions

Systemic approaches to soil fertility and biodiversity are one key to the successful adaptation of agriculture. With its core values and characteristics, organic agriculture has already adopted such approaches and therefore represents a promising adaptation strategy. Additional benefits come from the synergies between adaptation and mitigation that can be realised by increasing soil organic matter.

It has been shown that organic agriculture is a promising adaptation strategy. To achieve a broader impact some core practices of organic agriculture, such as the high diversity of crops and practices, and the use of organic fertilizers and legume leys, should also be promoted for use in conventional agriculture without the necessity of full conversion to organic production. If properly applied, planning for climate change adaptation can potentially increase the sustainability of all agriculture by introducing practices such as agro-forestry and the diversification of crop rotations, and by helping to establish healthy soils and diversified production systems, in conventional contexts as well as in organic.