Commentary III: The Potential of Sustainable Agriculture for Climate Change Adaptation

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Abstract

Adaptation in agriculture needs to be based on four pillars:

- Increasing soil fertility: this can be achieved by replacing synthetic fertilizers with organic fertilizers, and monocultures with diverse crop rotations.
- Increasing biodiversity through diverse measures such as crop rotations, use of local varieties, catch crops, hedges and other landscape elements. This applies to field, farm and landscape levels. In addition, the use of sustainable and especially organic crop protection will foster biodiversity of insects, weeds, earthworms and other organisms.
- Providing information and extension services to support sustainable agricultural practices and organic agriculture, agroecology and agroforestry.
- Creating a level playing field for sustainable agriculture at the global level. This involves abolishing distorting subsidies, such as for synthetic fertilizers, and internalization of external costs.

Organic agriculture is an ideal solution as it responds to the first three pillars. In addition, global policies, and trade and competition issues need separate attention.

Adapting agriculture to climate change is unavoidable. For adaptation (on the concept, see box 1) to succeed, it is necessary for farms to take concrete adaptation measures, but also general long-term societal actions are needed. Our comments here focus mainly on adaptation measures for farms.

An aspect often neglected in current discussions on adaptation in agriculture (discussed in detail in Müller, et al., 2012) is that adaptation strategies also need to offer farming families solutions outside agriculture if agricultural production becomes impossible for them. For example, drought resistant varieties and improved efficiency of water use would help adaptation, but in some cases water availability may become too low to continue with agriculture. In such situations, the key question is where agricultural production may be optimally located over the next few decades, where it may be better to abandon it, and which livelihood alternatives will be available.

There are five key impacts and characteristics of climate change in agriculture (e.g. Easterling et al., 2007; Meehl et al., 2007; Rosenzweig and Tubiello, 2007):

- Climate change impacts will vary considerably by region: some regions will be affected positively, and others negatively. However, changes in production conditions will occur everywhere, necessitating adaptation. Regions benefiting from the positive effects of climate change should be able to take full advantage of their changed circumstances.
- Water will become a key issue. In some regions there will be increased water scarcity and drought, while in others extreme precipitation, water logging and flooding will become more frequent.
- Pressure from weeds, pests and diseases will increase.
- Increasing numbers of extreme weather events (e.g. heat waves and heavy precipitation) will pose a further challenge to agricultural production.
- Risks in agricultural production will increase due partly to greater climate variability.

Adaptation in agriculture needs to reduce exposure to these impacts, as well as sensitivity and vulnerability to them. This can be achieved by adopting sustainable agricultural production systems, such as agroecology, agroforestry or organic agriculture (Milestad and

Box 1: The concept of adaptation

We use the three concepts of "exposure", "sensitivity" and "vulnerability" to frame adaptation in agriculture. "Exposure" describes the likelihood that a system will experience certain conditions, such as drought (e.g. Smit and Wandel, 2006). "Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change" (IPCC, 2007b). "Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change" (IPCC, 2007b).

Darnhofer, 2003; Borron, 2006; Niggli, 2009; El-Hage Scialabba and Müller-Lindenlauf, 2010; Müller et al., 2012).

There are many reasons why sustainable agriculture is a system well suited to adaptation. First, traditionally it uses locally adapted varieties and cropping practices, and it can therefore better adjust to local variability of climate change impacts.

Second, it can respond to increased water stress by maintaining and increasing soil organic matter, as this increases the soil's water holding and retention capacity. Using organic fertilizers, such as compost, and adopting diverse crop sequences, in particular with legume leys, are important means of achieving this. These are core practices of sustainable agriculture, and of organic agriculture in particular, with its strong focus on soil fertility, soil quality and plant health. The higher biodiversity in organic agriculture resulting from an optimal combination of crops with different needs also contributes to optimal water and nutrient use.

Third, high biodiversity also helps reduce the occurrence and severity of weeds and pest outbreaks, and plant and animal diseases (Smith et al., 2011; Niggli, 2009). In addition, complex crop rotations contribute to controlling pests more effectively as they break their life cycles. Improved soil fertility and plant health further reduce vulnerability to pressures from increased pests, weeds and diseases (Altieri, Ponti and Nicholls, 2005).

Fourth, improved soil quality and higher content of organic matter in the soil also reduce vulnerability to extreme events such as drought, flooding and water-logging, and erosion (Siegrist et al., 1998; Fliessbach et al., 2007; Niggli, 2009; El-Hage Scialabba and Müller-Lindenlauf, 2010). In addition, mulching and cover crops are common practices in sustainable agriculture, bare fallows are avoided and erosion is correspondingly reduced. Landscape elements such as hedges or agroforestry provide shelter and favourable microclimates, improving moisture management and capacity to adapt to high temperatures.

Fifth, the high biodiversity on sustainably managed farms (e.g. organic) also reduces the risk of total production losses due to climate change, and generally increases the resilience of agroecosystems (Altieri and Nicholls, 2006; Campbell et al., 2009). Through the combination of crop and livestock production as well as a larger number of crops grown, total economic failure can be avoided. Additionally, the economic risks are lower for organic farms, as they use fewer off-farm inputs and correspondingly incur lower upfront costs. Price premiums, for instance resulting from certified organic production, offer further potential for improving producers' economic situations. All these aspects combined provide inexpensive but effective risk management strategies, in particular insurance against crop failure (El-Hage Scialabba and Hattam, 2002; Eyhorn, 2007).

Agroecology, agroforestry and, in particular, organic agriculture thus reduce *vulnerability* through risk reduction based on diversification of livelihood strategies, cropping patterns and lower input costs. The focus on soil fertility, soil health and high biodiversity reduces *sensitivity*. This is of particular relevance for optimal water management and for optimal strategies to cope with pests and diseases. Reducing *exposure* is the most difficult, as this means shifting cropping locations or abandoning agriculture altogether in some circumstances.

How such fundamental changes can be supported, where necessary, needs further research. However, there are some readily available strategies that reduce vulnerability and sensitivity, as briefly described below.

First, soil fertility needs to be built up and soil degradation halted. For this, subsidies for synthetic fertilizers should be abandoned, where possible, without compromising food security. Where this is an issue, carefully designed transformation from synthetic to at least partly organic fertilizers, redesigned crop rotations with legumes and plants with different rooting depths, as well as closed nutrient cycles should be implemented. The simultaneous use of synthetic and organic fertilizers may not be advisable for climate change mitigation due to the resulting higher nitrous oxide emissions. However, particularly in a development context, adaptation in agriculture is key, and mitigation must never compromise on this.

Second, biodiversity needs to be enhanced. Local breeding programmes should be established or revitalized and supported, and farmers should be able to produce their own seeds. Practices such as agroforestry, and well-designed crop rotations need to be supported. Landscape elements also contribute to adaptation as they improve the microclimate. Payments for ecosystem services could be one type of financial incentive mechanism to encourage these practices.

This links to the third point: information and training are crucial for successful implementation of these adaptation strategies. Sustainable agricultural practices and organic agriculture, as a holistic agricultural production system, rely on the presence of a considerable body of knowledge.

Fourth, to be successful, adaptation strategies need to be accompanied by policy and trade measures. Massive trade distortions, such as the current subsidies for conventional production (e.g. cotton in the United States) need to be abolished. Similarly, the market power of agribusiness corporations in the seed markets and in plant protection is a hindrance that needs to be removed.

Finally, all external costs of agricultural production should be reflected in the price. Without this, conventional production will always have an unfair competitive advantage due to distorted production costs that do not include all the environmental and social costs of production. If those external costs were to be included in conventional production, it would prove to be more costly than sustainable agriculture.