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Abstract

Organic agriculture, as an adaptation strategy to climate change and variability, is a concrete and promising option for rural communities and has additional potential as a mitigation strategy. This article is a short review of this topic. Adaptation and mitigation based on organic agriculture can build on well-established practice because organic agriculture is a sustainable livelihood strategy with decades of use in several climate zones and under a wide range of specific local conditions. The financial requirements of organic agriculture as an adaptation or mitigation strategy are low. Further research is needed on yields in organic agriculture and its mitigation and sequestration potential. Other critical points are information provision and institutional structures such as market access.

Key Words: adaptation, climate change, climate variability, mitigation, organic agriculture, rural development, sustainable livelihoods, vulnerability

JEL Classification: O13, Q18, Q54, Q56

Contents

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Introduction

The Fourth Assessment Report of the IPCC (Inter-governmental Panel on Climate Change), Working Group II (hereafter AR4-WGII), states that "a wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits, and costs, but these are not fully understood" (IPCC 2007a, 19). Other important statements of the AR4-WGII include that "vulnerability to climate change can be exacerbated by the presence of other stresses," that "future vulnerability depends not only on climate change but also on development pathways," and that "sustainable development can reduce vulnerability to climate change, and climate change could impede nations' abilities to achieve sustainable development pathways" (IPCC 2007a, 19–20). In general, climate change and variability are a considerable threat to agricultural communities, particularly in lower latitudes. This threat includes the likely increase of extreme weather conditions, increased water stress and drought, and desertification, as well as adverse health effects (extreme heat and increased spread of diarrhoeal and infectious diseases, such as malaria). Adverse effects are likely to multiply if adaptation fails. This may then overstretch many societies' adaptive capacities, which may lead to destabilization and security risks, including loss of livelihoods, malnutrition, forced migration, and conflicts (IPCC 2007a; WBGU 2008; Lobell et al. 2008). The Bali Action Plan from the UN Climate Change conference in Bali in 2007 (UNFCCC 2007) clearly emphasizes the importance of enhanced action on adaptation.

The following pages outline how organic agriculture (OA), used as an adaptation strategy, has the potential to address the combined threats of climate change and variability and other stresses. These pages should be read as a short, compact review of the potential of OA as an adaptation strategy and also a mitigation strategy, based on published literature (including reports and web-references), thus providing ample reference for further details. It combines

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different strands of literature from both the “organic community” and the “climate community.” It also aims at fostering discussion on OA as an adaptation and mitigation strategy beyond the “organic community.”

Adaptation entered the agenda more prominently only recently, while mitigation has been a topic for long time. This is also reflected in the fact that there is more research available on OA as a mitigation than as an adaptation strategy (e.g., Niggli et al. 2008, and references therein; IFOAM 2006, 2007, 2008; AgroEco 2006; and also Kotschi and Müller-Sämann 2004). OA as a mitigation strategy faces many technical complexities (carbon sequestration and greenhouse gas emissions avoidance measurement and accounting, assessment of differences in crop rotations and practices, etc.), while the biggest challenges for OA as an adaptation strategy are more of a socio-cultural matter. Potential synergies between adaptation and mitigation strategies in agriculture do, however, exist (Rosenzweig and Tubiello 2007; IPCC 2007a).

In this paper, the main challenges posed by climate change and variability that can be addressed by OA as an adaptation and mitigation strategy are outlined after a short introduction to organic agriculture. Some institutional and financial requirements are discussed, as well as some key critical points of OA as an adaptation and mitigation strategy. The focus is OA as an adaptation strategy because it still receives less attention in the literature. OA as a mitigation strategy is covered only cursorily, but references for further reading are given.

1. Organic Agriculture

As codified in the *Codex Alimentarius* from the FAO/WHO:

> Organic agriculture is a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system. An organic production system is designed to a) enhance biological diversity within the whole system; b) increase soil biological activity; c) maintain long-term soil fertility; d) recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources; e) rely on renewable resources in locally organized agricultural systems; f) promote the healthy use of soil, water, and air, as well as minimize all forms of pollution thereto that may result from agricultural practices;… (*Codex Alimentarius* 1999, 2)

OA is not only a specific agricultural production system, it is also a systemic and encompassing approach to sustainable livelihoods in general, where due account is given to relevant factors of influence for sustainable development and vulnerability, be this on physical, economic, or socio-cultural levels (cf., e.g., Eyhorn 2007). OA has a long tradition as a farming system and it has been adapted for many climate zones and local conditions; as a result, much and detailed situation-specific information on OA is available. Furthermore, OA has a recognized potential as a development strategy for rural communities. (See, e.g., El-Hage Scialabba and Hattam 2002; and Eyhorn 2007; for information on OA in various contexts, see, e.g., DARCOF 2000; Eyhorn et al. 2003; Halberg et al. 2006; and the database, "Organic eprints," at http://www.orgprints.org/.)

For completeness, I mention that there are several approaches of "sustainable agriculture" besides OA (cf., e.g., Eyhorn et al. 2003). These capture important aspects (such as improved pest or water management, crop rotations, etc.). The advantage of OA is that it comprises a bundle of mutually adapted and optimized practices and is thus a whole operational farming system with a proven record of good performance. In addition, the certification available for products of OA allows realization of higher prices.

2. Challenges Addressed

Organic agriculture avoids nutrient exploitation and increases soil organic matter content. In consequence, soils under OA capture and store more water than soils under conventional cultivation (see, e.g., the discussion and references in Niggli et al. 2008). Production in OA systems is thus less prone to extreme weather conditions, such as drought, flooding, and water logging. OA accordingly addresses key consequences of climate change, namely increased occurrence of extreme weather events, increased water stress and drought, and problems related to soil quality (IPCC 2007a).

Furthermore, OA reduces the vulnerability of the farmers to climate change and variability. First, OA comprises highly diverse farming systems and thus increases the diversity of income sources and the flexibility to cope with adverse effects of climate change and variability, such as changed rainfall patterns. This leads to higher economic and ecological stability through optimized ecological balance and risk-spreading. Second, OA is a low-risk farming strategy with reduced input costs and, therefore, lower risks with partial or total crop failure due to extreme weather events or changed conditions in the wake of climate change and variability (see, e.g., El-Hage Scialabba and Hattam 2002; Eyhorn 2007). As such, it is a viable alternative for poor farmers. In addition, higher prices can be realized for the products via organic certification. Higher farm incomes are thus possible due to lower input costs and higher sale prices. The coping capacity of the farms is increased and the risk of indebtedness is lowered. Risk management, risk-reduction strategies, and economic diversification to build resilience are also prominent aspects of adaptation, as mentioned in the Bali Action Plan (UNFCCC 2007).

Crops and crop varieties used in OA are usually well adapted to the local environment. Local effects of climate variability cannot be foreseen in detail because, on the local level, climate change models are not very accurate or even available. Adaptation thus may utilize measures that build on self-adaptive capacity, such as local crop-breeding. The systemic character (on farm breeding, etc.) of OA is especially adequate to provide such. Notwithstanding this potential, more research is needed on how OA systems perform under increased disease and pest pressures, which are important effects of climate change on agriculture (IPCC 2007a), and on how local crop varieties adapt to climate change and variability. OA also seems to perform better than conventional agriculture under water constraints (Badgley et al. 2007; Hepperly et al. 2006).

By its nature, organic agriculture is an adaptation strategy that can be targeted at improving the livelihoods of rural populations and those parts of societies that are especially vulnerable to the adverse effects of climate change and variability—for example, the rural population in sub-Saharan Africa; and improvements via reduced financial risk, reduced indebtedness, and increased diversity (Eyhorn 2007). By its systemic character, OA is an integrative approach to adaptation, with potential also to work toward the United Nations Millennium Development Goals, in particular Goal 1 (“eradicate extreme poverty”) and Goal 7 (“ensure environmental sustainability”).[1] The pivotal role agriculture plays in achievement of these goals and the challenges climate change poses to this task are widely acknowledged. (See, e.g., DFID 2005) OA addresses many of the key challenges identified for adaptation to climate change and variability and it fulfils many of the criteria, which are seen as important general

[1] UN Millennium Development Goals, http://www.un.org/millenniumgoals/environ.shtml.

prerequisites for such strategies as described, for example, in FAO (2008), UNDP (2007), GTZ (2007), Slater et al. (2007), and Prowse and Braunholtz-Speight (2007).[2]

OA as a mitigation strategy addresses both emissions avoidance and carbon sequestration. The first is achieved through:

- lower N_2O emissions (due to lower nitrogen input)—it is usually assumed that 1–2 percent of the nitrogen applied to farming systems is emitted as N_2O, irrespective of the form of the nitrogen input. The default value currently used by the IPCC is 1.25 percent, but newer research finds considerably lower values, such as for semi-arid areas [e.g., Barton et al. 2008];
- less CO_2 emissions through erosion (due to better soil structure and more plant cover)—there usually is less erosion in organic farming systems than in conventional ones. The effect of erosion on CO_2 emissions is still controversial, however (cf. IPCC 2007b; Lal et al. 2004; Van Oost et al. 2004; Renwick et al. 2004); and
- lower CO_2 emissions from farming system inputs (pesticides and fertilizers produced using fossil fuel).

The effects of animal husbandry on mitigation in OA also need to be assessed. Animal manure is often of particular importance to organic farms, but livestock is also an important source of greenhouse gases (IPCC 2007b, ch. 8; Niggli et al. 2008).

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[2] The “OA community” is aware of the potential of OA for climate change adaptation (see, e.g., IFOAM 2007, 2008; FAO 2007b; AgroEco 2006; Borron 2006), but this discussion is not linked to the discussion on adaptation in the “climate community” and its content is hardly known beyond the “organic community.” OA is linked to other proposals for adaptation, as it is, for example, an “adaptive social protection” strategy, as recently promoted by the Institute of Development Studies (IDS 2007); or a “community-based adaptation” strategy, as promoted by the International Intstitute for Environment and Development (IIED 2007). It is also an answer to the third crucial question addressed in the special issue of *Climate Policy* on how to integrate adaptation and mitigation in a development context: “What methodological approaches exist that would help to achieve both mitigation and adaptation responses to climate change embedded in the context of local sustainable development?” (*Climate Policy* 7, no. 4 [2007]). It also scores well regarding the several key points identified for this challenge in the editorial to this special issue (Bizikova, Robinson, and Cohen 2007). In particular, OA has the best premises to utilize local and indigenous farmer knowledge and adaptive learning, which are seen as important sources for adaptation in farming communities (Tengö and Belfrage 2004; Salinger et al. 2005; Stigter et al. 2005; Nyong et al. 2007; Niggli et al. 2008). OA also has all the aspects of optimal strategies as identified in Rosenzweig and Tubiello (2007), and it is a strategy that could address the challenges and goals for agriculture in the context of development and climate change as identified in the recent framework document of the World Bank (2008). For a recent overview on a wealth of concrete adaptation projects (not in OA), see, e.g., McGray et al. (2007), and also Eldis (2008) and UNFCCC (2008).

Soil carbon sequestration is enhanced through agricultural management practices (such as increased application of organic manures, use of intercrops and green manures, higher shares of perennial grasslands and trees or hedges, etc.), which promote greater soil organic matter (and thus soil organic carbon) content and improve soil structure (see, e.g., Niggli et al. 2008; IFOAM 2006, 2007, 2008; AgroEco 2006; and also Kotschi and Müller-Sämann 2004). Increasing soil organic carbon in agricultural systems has also been pointed out as an important mitigation option by IPCC (2007b). Very rough estimates for the global mitigation potential of OA amount to 3.5–4.8 Gt CO_2 from carbon sequestration (around 55–80 percent of total global greenhouse gas emissions from agriculture) and a reduction of N_2O by two-thirds (Niggli et al. 2008). For sound estimates, however, more information on the mitigation potential of OA—duly differentiated according to climatic zones, local climatic conditions, soil characteristics, variations in crops and cultivation practices, etc.—is still needed. (Some differentiated numbers are reported in Niggli et al. [2008] and references therein.) More research is also needed on how OA performs regarding emissions per unit product (cf. footnote 3).

3. Institutional and Financial Aspects

The importance of adequate institutional frameworks and financial management for adaptation has frequently been pointed out (e.g., Kandlikar and Risbey 2000; Smit and Skinner 2002; Burton and Lim 2005). Regarding the institutional framework, OA can, in principle, build on the existing general agricultural institutions present in any country and internationally. However, a main hindrance is the fact that OA is not yet broadly recognized for its potential as a development strategy and even less as an adaptation or mitigation strategy. In particular, its capability to produce yields high enough to replace conventional agriculture to a significant amount is often questioned. In developing countries, yields are not necessarily lower, as recent research points out.[3] In OA, prospects for long-term sustained productivity are a given and are different from many intensive conventional farming systems, where, after some decades, decreasing yields are observed (see, e.g., Matson et al. 1997; DFID 2004). Specialized institutions for OA—such as IFOAM (International Federation of Organic Agriculture Movements) or topical sections in larger organizations, such as the FAO (Food and Agriculture Organization of the United Nations)—have the crucial task of spreading the knowledge about OA. The fastest dissemination of OA as an adaptation and mitigation strategy could be reached if it became part of national agricultural policies and the international agricultural policy discourse. Detailed information on some national OA policies is contained in Rundgren (2008), for example.

OA as an adaptation and mitigation strategy does not hinge on large additional financing for the OA farming system itself. (Additional costs come from extension services, the general provision of information, and, if certified, certification costs.) However, it is crucial to have access to international markets and to develop local markets for the products. In the transition phase to OA, additional financing for the farms may be necessary: training and extension services need to be provided and lower yields for the 2–3 years of the transition period may necessitate some additional support. It is sensible, then, to emphasize knowledge transfer and infrastructure building (including access to markets, etc.), rather than direct monetary transfers only, although such may be necessary in certain cases. The economic viability of organic farming is also likely to increase with increasing energy prices (which makes conventional farming more expensive, due to the energy costs for production of fertilizers and pesticides) and

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[3] On yields, see, for example, Drinkwater et al. (1998); Maeder et al. (2002); Parrott and Marsden (2002), which contains a review of some case studies; and most recently Badgley et al. (2007), who estimated the average yield ration (organic: non-organic) for a global dataset of 293 examples. They found that "for most food categories, the average yield ratio was slightly <1.0 for studies in the developed world and >1.0 for studies in the developing world" (Badgley et al. [2007], 86). Eyhorn et al. (2007) contains details on yields of organic cotton in Madhya Pradesh, India. It has also to be emphasized that OA is a multi-output farming system, for which yields in single outputs may not be an adequate indicator without consideration of the other outputs. For the advantageous environmental and yield performance of many "sustainable farming systems" (not only certified organic), see Pretty et al. 2006. On the advantageous performance of OA under water stress, see Badgley et al. (2007) and Hepperly et al. (2006). Of particular importance for its mitigation potential is the performance of OA regarding emissions intensities (i.e., emissions per unit product). Combining the numbers on sequestration and emission reductions and yields (cf. above), results are mixed and crucially depend on the specific situation (soil characteristics, climate zone, crop variety, etc.). Some crops and production practices (e.g., potatoes or greenhouse production, respectively) seem indeed problematic regarding emission intensity in OA if compared to conventional production (cf. Niggli et al. 2007, and references therein).

with decreasing levels of subsidies for conventional agriculture. Several options to meet the financial requirements exist in principle. Examples are governmental support and research programs for agriculture, microfinance strategies, biodiversity conservation initiatives (e.g., Carroll et al. 2007), and, for OA as a mitigation strategy, the programmatic or sectoral Clean Development Mechanism. (On these, see, e.g., Hinostroza et al. 2007; Sutter 2007; or Baron and Ellis 2006.)

4. Concluding Remarks

Although promising, OA clearly is no panacea and several critical issues remain to be resolved.

To begin with, there is a need for more research. OA is often criticized for lower yields in comparison to conventional agriculture. Recent research invalidates this prejudice, especially in the context of extensive farming systems, which characterize much of agricultural production in developing countries (cf. footnote 3). Further research on this is, however, still needed. Furthermore, the self-adaptive capacity of on-farm breeding to climate change and variability needs to be investigated in detail. For OA, as a mitigation strategy and for its eligibility under the Clean Development Mechanism, detailed greenhouse-gas accounting measurements have to be provided. More research on emissions per unit product in OA is also necessary.

In the current situation, access to and increased development of (local) markets for the products, local processing possibilities, and export infrastructure are of particular importance for OA. For this, the role of international institutions and trade policies (World Trade Organization, Food and Agriculture Organization, United Nations Development Program, United Nations Environmental Program, etc.) has to be discussed. The institutional environment for OA as an adaptation and mitigation strategy also has to be identified, in particular, on a global level. Knowledge transfer has to be institutionalized. There is a wealth of knowledge available on OA, especially in the north (e.g., in various EU countries). Clearly, this knowledge is tied to specific climatic circumstances and cannot be transferred to other regions without due caution and modification.

To be successful, wider recognition of the potential of OA is needed among bodies that currently mainly promote conventional agriculture. An important step could be that (national) agricultural policy begins to prominently support organic agriculture as an adaptation and mitigation strategy.

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