# RESPONSES OF AGRICULTURAL BIOENERGY PRODUCTION IN BRANDENBURG (GERMANY) TO ECOLOGICAL, ECONOMIC AND LEGAL CHANGES: AN APPLICATION OF HOLLING'S ADAPTIVE CYCLE

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# RESPONSES OF AGRICULTURAL BIOENERGY PRODUCTION IN BRANDENBURG TO ECOLOGICAL, ECONOMIC AND LEGAL CHANGES: AN APPLICATION OF HOLLING'S ADAPTIVE CYCLE

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**Abstract**
Agricultural bioenergy production faces dynamics such as yield fluctuations, volatile prices, resource competition, new regulation and policy, innovation and climate change. To what extent is bioenergy production able to adapt to changing environments and to overcome critical events? We investigate in detail how the agricultural bioenergy sector in the German State of Brandenburg adapted to diverse past events. The analysis rests on the adaptive-cycle concept of HOLLING and GUNDERSON (2002a), which has been widely applied in social-ecological systems research. Brandenburg's bioenergy production displays properties of a system in the *exploitation* phase, including a low *potential* and a high *resilience* of the system and a low *connectedness* within the system. There are risks and opportunities for bioenergy production. Sustainable bioenergy production requires a transition from the *exploitation* to the *conservation* phase. But Brandenburg's bioenergy sector has limited adaptive capacity and there are certain barriers for the agricultural bioenergy sector to overcome potentially critical states. Policy needs to be tailored accordingly.

**Keywords**
Adaptive cycle, agricultural bioenergy, potential, resilience, connectedness, critical states

## 1 Introduction

Bioenergy production was expected to contribute to agricultural incomes, employment in rural areas, energy supply and greenhouse gas mitigation (EUROPEAN COMMISSION, 2007). But in the European Union bioenergy outputs are volatile and evidence on wider economic, social and environmental impacts of bioenergy is inconclusive (FERNANDO et al., 2010; FARGIONE et al., 2010). Agricultural bioenergy production does not develop smoothly. It takes place in complex social-ecological settings and a question is, whether bioenergy production is able to adapt to change and what policies are adequate to help it adapt. We analyse how agricultural bioenergy production in the Federal State of Brandenburg adapts to ecological, economic and legal changes within the wider context of bioenergy development in Germany.

## 2 Analytical framework and data

Systemic changes and feedbacks can be described with the adaptive cycle of HOLLING et al. (2002a, 2002b). According to the concept, systems repeatedly move through a cycle of four sequential development phases: *exploitation* (r), *conservation* (K), *release* (Ω) and *reorganization* (α). The phases are characterized with the dimensions *potential*, *connectedness* and *resilience*. *Potential* stands for the capacity of a system to change and the spectrum of future development options possible, such as a farm's capacity to grow a diversity of crops. *Connectedness* describes "(…) the degree to which a system can control its own destiny, as distinct from being caught by the whims of external variability." (HOLLING et al., 2002a). An example would be the degree to which a farm has to rely on external capital. *Resilience* (as

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achieved by adaptive capacity) is a measure of the vulnerability of a system to unexpected or unpredictable disruptions. A farm may for example be resilient to harvest failure.

Bioenergy production in Brandenburg faced a series of events with severe impacts. In previous studies (EHLERS, 2008; KLAUSS et al., 2009; KRAUSE and MELENK, 2008; UCKERT et al., 2009) and our on-going research we identify events of particular importance for change in agricultural bioenergy production in Brandenburg:

1. the introduction of fixed feed-in tariffs for biomass-based electricity in the year 2000 and the amendments to the German Renewable Energy Act (EEG) in 2004 and 2008;
2. the increase of agricultural commodity prices between 2005 and 2008;
3. the abolishment of price interventions for rye under the Common Agricultural Policy (CAP) reforms in 2003;
4. droughts in the years 2003, 2006 and 2007;
5. changes in financial capital supply; and
6. changes in land markets.

Using the adaptive cycle, we analyse how agricultural bioenergy production in the Federal State of Brandenburg adapted to these changes.

## 3 Results and implications

Agricultural bioenergy production in Brandenburg has a low *potential* and limited future development options. Capacity reduction and decommissioning of biodiesel and bioethanol production facilities are signs for low *potential* of the sector. In addition, growth rates of biogas production in Brandenburg are low. Other indications for low *potential* include low capital endowment, negative cash flow and poor liquidity of farm enterprises. A high percentage of land is rented in and capital locked away for land acquisition. Finally, soils have mainly poor fertility and water supply.

Core indications for a low *connectedness* of bioenergy production are strong dependency on external factors such as the electricity feed-in tariffs of the EEG, commodity price effects of the CAP reforms and extreme weather events. In the longer run these change would either decrease or increase the *potential* of the system.

Characteristics above indicate that bioenergy production in Brandenburg may thus be highly vulnerable. But the adaptive reactions to the EEG, the response to abolished grain price interventions, the recovery of production after the drought years 2003, 2006 and 2007, and the recuperation of periods with low commodity prices and high input prices suggest also a high *resilience* of bioenergy production. At least in the medium term *resilience* could increase. Nevertheless, *resilience* remains limited, if bioenergy production shifts to less diverse crop rotations and if climate change increases the vulnerability of energy cropping.

Bioenergy production in Brandenburg can be summarized as being close to the *exploitation* phase of the adaptive cycle (HOLLING AND GUNDERSON, 2002a; HOLLING et al., 2002b), where low *potential* and low *connectedness* are paired with high *resilience*. Sustained bioenergy production requires a transition from the *exploitation* to the *conservation* phase. The characteristics of the subsequent *conservation* phase are a high *potential* of development options, a high *connectedness* and a low *resilience*. Otherwise there is a risk of locking into a *poverty trap*, which is characterized by a low *potential*, low *connectedness* and low *resilience*. When locked into the *poverty trap* a system is not able to generate further wealth. The *poverty trap* may most likely threaten agricultural bioenergy enterprises that rely on marginal soils affected by drought and extreme weather conditions. Consequently, the suitability of energy cropping on marginal land is questionable, because bioenergy production could slip into critical states. Energy cropping on marginal land, as it has been advocated to ease pressure on

land and food supply (VON BRAUN AND PACHAURI, 2006; FAAIJ, 2008), seems to be a problematic option.

The promotion of renewable energy is a high priority of the European Union and its member states. The premiums for electricity from animal manure under the EEG of 2008 are an example for policy that supports the *potential* of a renewable energy system. Subsequent liquidity improvements of enterprises increase the *potential* and *resilience* of agricultural bioenergy production in Brandenburg, because animal manure is widely available. Encouraging also technological and institutional innovations in the renewable energy sector could further raise the *potential* of bioenergy production. For example innovations in the application of residues from bioenergy production and biochars as soil amendment could increase the *potential* and *resilience* of bioenergy production in regions with poor soils. The associated material cycling may also lead to new institutional arrangements among actors in the bioenergy production sector. Its low *connectedness* suggests that agricultural bioenergy production in Brandenburg will continue to depend on external factors such as politically set incentives and international markets. Solutions are conceivable. Developing regionally governed energy markets would increase *connectedness*. But it would also be a long-term endeavour. More sustainable bioenergy policy could be developed with greater comprehension of the link between the state of agricultural bioenergy production and respective needs to adapt.

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