Biochar: A regional Supply Chain Approach in View of Climate Change Mitigation

Book outline and short descriptions of registered contributions, Reference for authors

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Purpose of this document

The main purpose of the current document is to inform authors about the context of their chapters. This should allow each author to reduce the risk of redundant presentations (specifically within sections) and to allow other involved authors to understand the background of other chapters. It should also help to ensure coherence throughout the entire book. The given information is based on communications with the authors over the last few months, the information provided at the author registration, as well as their submissions to the FOREBIOM Workshop. The titles are to be understood as working titles, changes are still possible. It should act as a rough guideline for the respective chapters, but the chapters may not be limited by this abstract.

Some of the short abstracts below come with comments of the Editor (in red). Please review them and let me know your opinion or suggestions for abstract modifications.

Preparation of the manuscript (this will be updated in further versions of this document)

The publisher contacted me again to emphasize the importance of the quality of figures and tables. If possible, use tables generated by your word processor, without unnecessary formatting. Please refer to http://authornet.cambridge.org/information/productionguide/stm/submitting_in_word.asp for details.

Figures

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References

References should be formatted according to the Harvard (author-date) format: http://authornet.cambridge.org/information/productionguide/stm/notes_on_text_references.asp#harvard. We suggest literature management software (e.g. EndNote) that has pre-installed presets of the Harvard reference style.

The book in a nutshell

Our aim is to present a regional supply chain approach for biochar production and application, in view of climate change mitigation and adaptation strategies. Therefore, we have included experts from major climate regions (temperate, mediterranean and tropical). The book will establish direct links between theoretical chapters and actual case studies. It consists of 4 main sections:

Section 1 provides a general overview and introduction of biochar systems. It identifies the current status of biochar research, open questions as well as chances and limitations for climate change mitigation/adaptation strategies. In addition to that, a separate chapter will present a biochar life cycle assessment that identifies the carbon footprint of a biochar system.

In section 2, we present potential sources for biomass as large amounts will be needed in order to effectively influence carbon budgets. Authors from Austria, Turkey and Malaysia present their view on potential sources in terms of quality and quantity, as well as limitations, with respect to current biomass markets and its projected future development. The impact of land management (for biomass cultivation) and land use change on carbon budgets will be presented as well in order to get a holistic view on a potential biochar system.

Section 3 represents pyrolysis, the process of converting biomass into biochar. Pyrolysis will be discussed with emphasis on settings (temperature, type, duration etc.) and their influence on the resulting properties, in view

of soil amendment and stable carbon fractions. Sustainability assessments, different production scales and the characterization of by-products, such as syngas or acidic fractions will be included here.

The final section 4 aims at addressing the complex interactions between biochar and soil. Carbon stability is an important measure in climate change mitigation, but likewise adaptation can build on significant improvements of certain soil parameters (e.g. water holding capacity). Among others, we will address the role of nitrogen and present biochar mycorrhiza relations and present a practical case study from vegetable production on biochar amended soils in Thailand.

Section 1: Introduction and Overview

Section 1 consists of an introduction and a summary of the key topics of concern in a biochar system in view of climate change mitigation and additional benefits. Here we also include a supply chain assessment (from feedstock to the final product) as well as a life cycle assessment of biochar from the end-user point of view. An example for a currently working biochar system is given from the Botanical Gardens Berlin (Germany), where waste biomass is recycled as biochar into a growth medium.

Chapter 1 (Viktor Bruckman et al.): Biochar for climate change mitigation: the FOREBIOM experience

This chapter aims at a summary of the book chapters and presents results of the FOREBIOM project. It will present the status of biochar research and application in different regions of the world and explain the major country specific challenges and research needs and potential solutions. Aspects of sustainable biomass supply and competition with other markets, economic considerations, and on pyrolysis and on biochar and soil interactions will be presented. Results of the workshops 1-3 will be presented and linked to actual data from our field experiments that will be briefly presented. The entire chapter represents a review on the current state of the art knowledge on biochar for climate change mitigation and the role of the FOREBIOM project in this nexus.

Chapter 2 (Nate Anderson et al.): A supply chain approach of a biochar system

This chapter will set the stage for sustainability, pyrolysis conversion, applications, case studies and soil interactions in the framework of industrial supply chain engineering and management. It will briefly examine each component of the supply chain as it applies to biochar used as a soil amendment, and then cover several key topics that are central to the understanding and management of effective and efficient biochar supply chains. It will also lay the foundation for a clear understanding of the LCA of biochar products and applications in the forthcoming sections.

Chapter 3 (Rick Bergman et al.): Life-cycle analysis of biochar

A holistic view that covers the entire supply chain will be presented here, with a focus on the biomass conversion step. The LCA tries to assess the environmental impact associated with all steps of the biochar system, from feedstock production to soil amendment. Editor: It would be interesting to sketch here the possibilities to influence the impacts – from a geoengineering point of view. This will be essential if we want biochar amendment to be an efficient GHG mitigation strategy. As discussed earlier, you may present a holistic

view (review) that comes with certain case studies (on biomass conversion I assume).

Chapter 4 (Saran Sohi et al.): Drivers and sustainable strategies for biochar deployment in Europe's plantation forestry

Plantation forests are seen as a potential source of biomass for energy and industrial feedstock materials. In contrast to traditional forestry, forest plantations may deliver large amounts of biomass in relatively short rotations. Highly mechanized systems require a high degree of accessibility as it is the case in agricultural systems. In order to avoid conflicts between agriculture and biomass production (competition for land), plantation forests are usually set up on marginal lands, where biochar may provide essential benefits for a sustainable production (e.g. soil nutrient retention, reduction of GHG emissions, water holding capacity). Editor: It would be interesting to propose a closed cycle of biochar production from plantation forests that is recycled back in such plantations, while syngas and other byproducts are further used.

V2 Chapter 5 (Robert Wagner et al.): Biochar as an integrated and decentralized environmental management tool in the Botanic Garden Berlin – Dahlem

A fully functional material cycle was established in the Botanic Garden Berlin-Dahlem with a number of economic and ecological benefits. Lignified materials (pruning and stem wood) from maintenance operations is being pyrolized and used as a supplement for composting and growth medium. The production of high quality biochar compost reduces the purchase of external compost and peat. In addition biochar could be used as a storage medium for nutrients contained in human urine from park visitors. The amount of fertilizer which has to be purchased could also be reduced. This example shows very well the potential of a functioning biochar system as a tool for mitigation of climate change including all steps of a biochar life cycle, from sustainable biomass to the utilization of biochar as a compost, substrate and soil amendment and therefore concludes the first section with a generic point of view.

Section 2: Sustainable biomass for pyrolysis

This section deals with potential biomass resources (with focus on forestry), its availability, economical as well as ecological constraints, and competition with existing markets (bioenergy sector).

Chapter 6 (Michael Englisch et al.): Sustainable Biomass for Pyrolysis

The focus here will be sustainable forest biomass potentials in Austria, in context of the ecosystem production capacity, competing markets for biomass and accessibility. The work is based on the national forest inventory as it is conducted by the author's institution. Issues such as soil degradation as a consequence of excess nutrient extractions and biodiversity will be considered. The development of appropriate harvesting restrictions based on site classifications will be described.

Chapter 7 (Eduard Hochbichler et al.): Sustainable biomass potentials from coppice forests for pyrolysis: chances and limitations

Coppice forests are of very distinct significance for biomass production as this type of forest played an important role for producing fuelwood in the past and gains increasing attention as a potential source for biomass again. Usually situated on marginal land, there is hardly any competition with agriculture. It is recently re-discovered as a

potential source for forest biomass produced in an agriculture-like system (naturally short rotations) which is adapted to drought and requires little maintenance costs. In addition, coppice forests are considered a hotspot for biodiversity and the potentials for biomass production are not well known. Extraction of compartments with a relatively small diameter implies a relative higher extraction of base cations and therefore soil degradation (eventually after a few rotations) may become a problem. This chapter is of high significance because such systems exist worldwide, especially in suburban regions (e.g. Vienna, Tokyo (Satoyama), as well as dry areas (e.g. Spain, Italy). Certainly there would be a high demand of biomass from such forest ecosystems if biomass pyrolysis becomes more popular.

Chapter 8 (Mun Tang et al.): Towards Environmental & Economic Sustainability via Biomass Industry: The Malaysian Case Study

This contribution will focus on the Malaysian Case Study, but reflects the situation in a number of other Southeast-Asian countries. There are relatively little sustainable biomass resources from forests in these countries, but cultivation of forest-like crops (e.g. oil palm, rubber trees) is omnipresent. This implies large potentials for biomass which can be pyrolized. However, there are concerns regarding the sustainability (currently, biomass from oil palm plantations is left on site to restore soil organic matter and recycle nutrients) as well as missing of legal frameworks and regulations. The authors will present the biomass industry point of view, but this will be based on scientific research conducted at FRIM (Forest Research Institute, Malaysia). Editor: The proposed title narrows the focus to Malaysia only. A Malaysian case study is fine, but you should bring this into context of the Asia-Pacific region (focus Southeast Asia). Keep in mind that the overall aim of this book will be climate change mitigation by using biochar. Therefore, try to identify potential resources that have the potential to serve as a feedstock for biochar production and it would be a benefit if you have information if biochar can be used in plantations (palm, rubber tree or pineapple, for instance).

Chapter 9 (Betül Uygur et al.): Carbon sequestration potentials of forest biomass in Turkey

Here we present the carbon sequestration potentials of Turkish forests. This implies a closer look at the carbon stocks and harvesting potentials. This chapter will be comparable to the one from Dr. Michael Englisch as the author is in a team that is responsible for the Turkish forest inventory and carbon reporting. The chapter tries to assess natural C sequestration by forest ecosystems versus sequestration potentials of biochar. Or in other words: Does it make sense to convert biomass into char for the purpose of C sequestration or will we lose more soil C as a consequence of intensive forest management? Editor: Please include the latter mentioned comparison of carbon sequestration of forests versus more intensive forest biomass utilization (for pyrolysis e.g.) and associated soil C loss etc… Would be great if you can conclude if it makes sense to increase forest biomass extractions for the sake of C sequestration/GHG mitigation or not.

Section 3: Biomass pyrolysis

Here we present chapters dealing with pyrolysis, mainly describing different methods and feedstocks and their respective impact on the final product (biochar) and its properties in view of soil amendment. An assessment of potential energy yields in comparison with

conventional thermal biomass utilization (combustion) will be included.

Chapter 10 (Frederik Ronsse et al.): Biochar production

This chapter is devoted to the discussion of pyrolysis methods and the associated impacts on the resulting products (biochar, biogas and biooil), in specific on the biochar properties. Editor: Please provide a good overview on current pyrolysis methods and their impact on biochar properties, specifically carbon stability and soil functions. I would appreciate if you can include an economic assessment (costs and benefits of associated byproducts (e.g. heat) that would allow feasible large scale pyrolysis, for instance). Perhaps you can define minimum criteria for biochar production if the ultimate aim is to sequester carbon and present tradeoffs that are perhaps necessary to make the process feasible.

Chapter 11 (Byungho Song et al.): Pyrolysis application of biomass char

The aim here is to present the energetic potential of biochar production, i.e. from an engineering point of view. The question on gas yield potentials and the associated kinetics of gasification is part of this chapter. This is of crucial interest for engineers in order to plan pyrolysis reactors that are feasible from an economic point of view. Bio-gas may be used for heating purposes (both drying incoming biomass as well as room- and process heat) or for producing electricity (via ORC process). Editor: I suggest you include “the energetic potential” or “tradeoff between energy and biochar production” in your title, to reflect the potentials for energy bases on syngas production during the pyrolysis process. You may also discuss the necessary scales at which energy production is feasible (at current state of the art).

Chapter 12 (Basak Uzun et al.): Pyrolysis: A sustainable way from Waste to Energy

The chapter aims at a sustainability assessment of pyrolysis, with a focus on waste materials (green waste) based on the products resulting from the pyrolysis process. This will be assessed in terms of the energy yields, process efficiency and capability to produce tailored biochar with a specific environmental function (e.g. carbon sequestration, water retention, reduction of GHG emissions, liming effect as a consequence of a pH-change, etc.). Editor: The authors should try in addition to include a country-specific assessment on the potentials of biochar production from waste in Turkey.

Chapter 13 (Maliwan Haruthaithanasan et al.): The role of biochar production for sustainable development in Thailand, Laos and Cambodia

The chapter deals with biochar production and the traditional methods used in the SE-Asian region. Discussed will be the benefits (small scale, inexpensive, useful by-products, e.g. “wood vinegar”) versus the risks (pollution, limited influence on the final product) of such production methods. As the main aim is the production for high grade barbecue charcoal for domestic consumption and international export, it will assess the amounts of residues (fine material) which is currently stored and treated as waste material or sometimes pelletized. Editor: The focus should be on biochar production (This is why I have added the term in the title). It would be a benefit if you can elaborate on social implications (e.g. stable rural jobs), but maybe also mention health issues (dust/smoke).

Section 4: Biochar-Soil Interactions

The final section 4 aims at addressing the complex interactions between soil and

biochar: how does biochar affect soil microbiology and consequently mineralization? Further issues are long-term stability, biochar-nitrogen interactions, water retention, and reduction of GHG emissions. The focus of this section should be clearly laid on GHG mitigation and adaptation strategies that can be achieved by using biochar as a soil amendment.

Chapter 14 (Gerhard Soja et al.): Biochar applications to agricultural soils in temperate climate – more than carbon sequestration?

Biochar as a boon for soil fertility in the tropics still has to show that it is able to provide the same benefits to soils in temperate regions. Here we present an Austrian study with the objective to analyze the extent of benefits that biochar application offers to agricultural soils in Europe beyond its role as a carbon sequestration strategy. Based on hypothesis testing, several potential benefits of biochar were examined in a series of lab analyses, greenhouse and field experiments. Three hypotheses could be confirmed: biochar can protect groundwater by reducing the nitrate migration in seepage water; biochar can mitigate atmospheric greenhouse gas accumulation by reducing soil N2O emissions; biochar can improve soil physical properties by increasing water storage capacity. One hypothesis was only partly confirmed: biochar supports the thriving of soil microorganisms only in specific soil and climate settings. Two hypotheses were refuted: biochar does not generally provide nutrients to plants except when produced from specific feedstocks or by combining it with mineral or organic fertilizers; the cost effectiveness of biochar application is not given under current production costs if the existing benefits of biochar are not transferable to financial value.

Chapter 15 (Deborah Page-Dumroese et al.): Opportunities and Uses of Biochar on Forest Sites in North America

This chapter draws conclusions from several biochar experiments conducted in North America. The feasibility of using in-woods fast pyrolysis to turn excess forest biomass into bio-oil, syn-gas, and biochar will be determined. The resulting biochar may be subsequently applied in order to positively influence soil properties (nutrient leaching, water holding capacity). Especially latter can contribute to increased resilience of a number of forest stands in North America. The chapter also elaborates on methods of applying biochar on forest sites (including biochar pellets).

Chapter 16 (Ibrahim Ortas et al.): Role of mycorrhiza and biochar on plant growth and soil quality

Certainly, biochar amendment has both positive and negative impacts on mycorrhizal communities and it is necessary to understand the mechanisms behind this in order to create the maximum benefit of biochar amendment to the soil in terms of biomass productivity. Some mycorrhiza communities have been found to be very sensitive against changes in soil chemistry (e.g. pH) and since biochar amendment has the potential to change chemistry significantly. It may create an environment which is unsuitable for these specific species. On the other hand, biochar may be used to restore optimum conditions for mycorrhiza (remediation approaches). The chapter will discuss interactions at the biochar-mycorrhiza-plant nexus.

Chapter 17 (Rebecca Hood-Nowotny et al.): Use of stable isotopes in understanding the impact of biochar on the nitrogen cycle

This chapter assesses the impact of biochar amendment on nitrogen cycles using stable isotopes. Stable isotopes will play an important role in discovering the true

mechanisms behind the yield increases observed in biochar amended systems. Editor: Can you elaborate a bit more on GHG emissions reduction (extend the current discussion) and C sequestration by using biochar, in specific, the role of nitrogen in this process.

Chapter 18 (Thavivongse Sriburi et al.): Practical experience of biochar amendment in Thailand

The cultivation of white radish was improved (total yields) as a consequence of biochar amendment. He will explain the experimental setup and compare laboratory pot experiments with in-situ results and experience. A focus on his chapter lies in the assessment of the carbon cycle, specifically the carbon sequestration potential of their proposed cultivation method. This might be of specific interest for promoting eco-branding. The chapter demonstrates a practical example of biochar amendment in the soil and concludes section 4. Editor: Please try to include data on carbon balance (soil carbon stocks) if you have such.