Organic Cotton for Employment, Growth and Environment?

1. Project summary

We will assess the potential of organic cotton production to improve the livelihoods of millions of poor households in Sub-Saharan Africa (SSA). These households depend on production, trading, or processing of cotton but are at risk of losing their main source of livelihood, since most current cotton production systems are in many respects not sustainable. Particularly in East Africa, cotton value chains experience low and even declining international competitiveness due to low margins and farmers' limited access to credit and yield-increasing agrochemicals, while in West Africa the massive use of pesticides and agrochemicals results in severe environmental and health problems. Organic cotton production can solve both problems, as it strictly limits the use of agrochemicals and could increase incomes through access to premium prices. However, no in-depth and comparative evaluation of organic and conventional cotton farming has been conducted in SSA. We will develop and apply an interdisciplinary framework for assessing the various aspects of sustainability of different existing and innovative ways of cotton production in SSA, e.g. pesticide residues, soil fertility, greenhouse gas emissions, and economic and social conditions along the value chains. This research will generate new knowledge that will foster green growth, poverty reduction, and job creation by increasing the sustainability of the livelihood of millions of poor households in SSA.

2. Objectives

The overall aim of our project is to increase knowledge about the sustainability of cotton production in SSA, where we will particularly focus on organic cotton production. Existing studies on organic cotton production in SSA have focused on specific aspects (e.g. profitability) rather than provide an overall picture (e.g. OBEPAB 2002, Matthess et al. 2005, Mgeni 2012). In order to fill this gap, we will develop an innovative framework for evaluating and comparing the sustainability of agricultural value chains and we will apply this framework to conduct an overall and in-depth analysis of the sustainability of conventional, organic, and other innovative cotton production methods in SSA. Using this interdisciplinary framework, we will evaluate how the different production methods and value chains affect the environmental, economic, and social aspects of sustainability. The combination of the individual results will provide much deeper insights into the various advantages and disadvantages of the different types of cotton production and value chains than the current literature. In order to ensure that all relevant aspects of sustainability will be appropriately addressed in our analysis, the project will aim for close collaboration of researchers across different countries and with different academic backgrounds. This will also strengthen the international scientific network and the research capacity in the partner countries. Finally, by generating new knowledge, scientific networks, and research capacity, the project will contribute to a greener economy, inclusive growth, and employment by increasing the sustainability of cotton production and improving the livelihoods of millions of poor households in SSA.

3. Project's methodology

This project will develop an innovative framework for evaluating and comparing the sustainability of agricultural value chains. Based on expert knowledge of project participants and external experts, we will define around ten different standardized cotton farming methods. These methods will include typical conventional farming methods, typical organic farming methods, and innovative cotton farming methods such as legume-based cotton farming. In order to enable a profound comparison of cotton

production between the two analyzed countries, the majority of the selected production methods will be applicable both in Benin and in Tanzania.

We will use experimental plots to assess and compare all selected cotton farming methods. From these experimental plots, we will observe agronomic and environmental data, e.g. input use, output production, nutrient leakages, soil degradation, greenhouse gas emissions, and pesticide residues in the soil, the lint, and the seed. Furthermore, incubation studies will be conducted to better understand the mechanisms related to residue decomposition, which would inform innovations aimed at minimizing negative environmental impacts and increasing yields.

We will supplement this experimental analysis by a "real-world" analysis of cotton producing farm households, because the reality at farms often deviates from the situation at experimental plots. We will use farm household surveys to obtain information about the selected conventional and organic cotton farming methods currently practiced. The surveys will be conducted in areas where cotton is an important source of income and where some of the selected cotton farming methods can be observed (e.g. organic production, conventional production with little agrochemicals, or conventional production with extensive use of agrochemicals). The surveys will collect general information about the surveyed farm households and their farming practices but they will focus on plot-level data from cotton production. We will collect the same information as from the experimental plots such as input use (e.g. land area, labor, machinery, seed, organic and chemical fertilizers, pesticides), output production, crop rotation, and other relevant aspects. The information that is available from farmers through the surveys will be supplemented by measurements that will be carried out at the surveyed plots, particularly environmental impacts (see above). This analysis will also be used as a baseline that describes the current state of cotton production.

In contrast to experimental plots, the farm-level analysis can only investigate the effects of currently practiced cotton farming methods. However, the differences between observations at experimental plots and the farmers' fields for currently practiced cotton farming methods can be used to assess how the innovative cotton farming methods that are only analyzed at the experimental plots would likely perform at farm level. Results obtained from the farmers' fields, experimental plots, and incubation experiments will be used to validate APSIM (Keating et al. 2003), a process-based model that will be used to predict long-term effects of the different cotton production systems. Hence, the combination of experimental plots with observations at farm level will allow us to comprehensively analyze conventional, organic, and other innovative cotton farming methods. The farm-level analysis will also allow us to analyze socio-economic aspects of sustainability. We will use matching methods (e.g. propensity score matching) to assess how the existing cotton farming methods (e.g. organic production, conventional production with little agrochemicals, or conventional production with extensive use of agrochemicals) affect the agronomic outcome, the environmental impacts, and the farm households' economic and social well-being. As farm households that use different cotton farming methods usually differ in more respects than just the cotton farming method, it is necessary to use econometric matching methods in this analysis in order to obtain the causal effects of the cotton farming methods. These econometric analyses will not only be based on the survey data that we will obtain in our project (see above), but also on already existing survey data (e.g. Floquet & Mongbo 2009, Floquet 2010, Syprobio 2014).

As the econometric analysis with survey data can only assess the effects of the existing farming methods, we will use a simple stochastic simulation model to analyze the effects

of the innovative farming methods on the agronomic outcome, the environmental impact, and the farm household's economic situation. This simulation study allows us to scrutinize the farm households' income risk as well as on dynamic effects, which cannot be thoroughly analyzed with the econometric analysis described above. We will simulate a set of "typical" farm households that will be derived from our farm household surveys. The cotton production will be simulated with the APSIM model, which will be calibrated with data obtained from the farm surveys and the experimental plots (see above). As we want to focus on the effects of the cotton farming method, the simulation model can take all production decisions as exogenous, which keeps the simulation simple and makes the interpretation of the simulation results easily comprehensible.

Our analysis will include the entire cotton value chains (VCs), because a well-functioning VC is essential for economically and socially sustainable cotton production. Furthermore, the other segments of the cotton VCs play an important role for employment generation and poverty reduction in Benin, Tanzania, and many other SSA countries. Our analysis of the different cotton VCs will include mapping the input-output structure in the chains and the geographical extension of the VCs, examination of the key stakeholders and the governance systems that coordinate activities in the chains as well as the regulatory and institutional mechanisms that operate along the chains. Furthermore, social capital within VCs, and the ability of stakeholders at specific segments to interact with each other and organize for better access to production factors, markets and voices will be investigated by network analysis (network density/diversity, bonding/bridging linkages). A subsample of cotton trading companies engaged in exporting lint and a subsample of ginneries will be selected for interviews. Assessment of trading companies and ginneries' performance criteria will include the value added of entering into distinct organic vs conventional VCs, profitability, efficiency and employment creation. Further, interviews will be conducted with representatives of key national and local players.

The overall competitiveness and economic sustainability of the selected ways of cotton production under different policy and world market scenarios will be analyzed by the Policy Analysis Matrix (PAM, Monke & Pearson 1989). Information on the use of inputs and the production of cotton and associated crops will be obtained from our farm household surveys, measurements at farmers' fields, and the experimental plots. Standard approaches will be used to obtain private and social prices (see, e.g. Pearson et al. 2004). We will use the "Extended PAM" (Kray 2002) in order to account for possible market imperfections in the VCs. We will develop two methodological improvements of the PAM. First, we will allow for substitution between inputs by generalizing the Leontief production function in the PAM to a (nested) Constant-Elasticity-of-Substitution (CES) production function. This means, for instance, that we use cost minimizing input quantities rather than fixed quantities for evaluating the production costs at different scenarios (e.g. private prices, social prices). Second, we will extend the deterministic PAM to a stochastic PAM that accounts for variations in the production of cotton, farm household characteristics, and external factors between farms as well as between time periods. We will do this by stochastic simulation studies that provide the distribution of each outcome parameter (e.g. domestic resource costs, i.e. an important indicator of competitiveness) rather than the outcome parameters based on an (artificial) average farm. This is a very important advantage in the analysis of agricultural production and agricultural VCs, because agricultural production is usually characterized by large variations in productivity so that outcome parameters based on an average farm (as obtained by a traditional PAM) are of very limited relevance, whereas the distributions of

the outcome parameters (e.g. competitiveness) are very informative for assessing a sectors competitiveness.
With the above-described analyses, we will obtain several indicators that measure the environmental, economic, and social aspects of sustainability for each of the analyzed cotton farming methods in each of the two analyzed countries. The major differences in the use of agrochemicals and the productivity between East Africa and West Africa will facilitate our investigation of effects of the different ways of cotton production on the environment, the farm households' economic and social well-being, and the performance of the entire cotton VCs. We will use three alternative approaches to conduct the overall assessment of the environmental, economic, and social aspects of the different ways of cotton production: (a) a qualitative multi-criteria assessment, e.g. visualized with "spider web diagrams" to illustrate the strengths and weaknesses of each cotton farming method; (b) adjusting the "social prices" in the PAM for positive or negative environmental and social effects; and (c) the Environmental PAM (Pearson et al. 2004) that also takes into account environmental and social effects. A comparison of the results of the three approaches will indicate the robustness of our overall analysis.

4. Expected outputs and outcomes

The project will create new knowledge about the environmental, economic, and social sustainability of different ways of cotton production in SSA. In order to achieve this, the project will develop two methodological innovations for assessing the economic sustainability of VCs as well as a general framework for an integrated assessment of the different aspects of sustainability that can be used as a template for subsequent research projects. The information that will be generated within the research project will be beneficial for many actors in the cotton VCs. For instance, farmers will be aware of the existence of more sustainable (environmentally friendly and profitable) ways of cotton production; policy makers will be able to design better agricultural and environmental policies and regulations; and state agencies and NGOs will be able to design better instruments that reduce negative environmental impacts and at the same time increase employment, income generation, secure livelihoods, well-being and growth along organic and conventional cotton VCs. The research capacity in Benin and Tanzania will be strengthened by intensifying international research collaboration and jointly educating 4 PhDs in these countries. Capacities will also be strengthened by collaborating with and involving farmers, value chain actors, extension agents, and other stakeholders.

5. Relevance

Cotton plays a significant role in the economy of many countries in SSA. For example, in Benin, cotton accounts for 40% of foreign exchange earnings, employs 45% of rural households and provides income to more than one third of the population (PSRSA 2011). In Tanzania, cotton provides employment to 500,000 rural households, is a source of livelihood for 40% of the population, and is one of the most important sources of foreign exchange earnings. However, most current cotton production systems are not sustainable and this could become a significant obstacle to the future development of these countries. Particularly in West Africa, the massive use of pesticides and other agrochemicals results in severe environmental and health problems. Pesticides frequently contaminate natural resources and accumulate in biota, including food and humans (Pazou et al. 2006a). Furthermore, poisoning by agrochemicals has direct socio-economic effects. For instance, in Benin 147 persons were poisoned and 10 died by cotton pesticides in 1999/2000 (OBEPAB 2002). This is worsened by the fact that, besides the officially approved pesticides, prohibited pesticides, such as lindane and dieldrin, are

illegally used in cotton production (Pazou et al. 2006b). In contrast to West Africa, cotton production in East Africa experienced only small productivity gains, because most farmers still have limited access to credit and agrochemicals (Tschirley et al. 2010). This resulted in declining competitiveness and profitability of cotton production in Eastern Africa. Although Tanzania has recently introduced a 'passbook' system (Poulton 2009) to provide some minimal level of yield-increasing inputs to farmers, the utilization levels appear to be low, since smallholder farmers still lack cash or access to credit during the growing season (Tschirley et al. 2010). These problems in East and West Africa have led various institutions to promote organic cotton. Organic cotton production could be an attractive alternative that solves both problems, because it strictly limits the use of agrochemicals and it could increase the income of poor farmers through higher sales prices. Organic cotton has a high potential for value addition, which in turn contributes to employment and socio-economic well-being of farmers (Hussein 2009). Indeed, several studies indicate that organic cotton production reduces health problems (e.g. Gazanfer 2007), maintains soil fertility and food security and can even increase yields (Vaiyapuri et al. 2008, Ferrigno et al. 2005). Hence, the adoption of organic cotton contributes to a green economy and reconciles the economic, environmental and social aspects of cotton production. Moreover, improving productivity and output in agriculture through environmentally friendly production practices is seen as a key element to reach the Millennium Development Goals (Meyer 2009).

Therefore, organic cotton farming is clearly targeted in Benin's Agriculture Sector Development Plan (PSRSA 2011) as well as in Tanzania's Agriculture Sector Development Strategy and its "Kilimo Kwanza" (Agricultural First) resolution (TNBC 2009). The strategic reference document for agricultural development in Benin (PSRSA 2011) suggests not only to update the studies on the marketing of cotton fibre in Benin but also to make a thorough study of cotton VCs including organic cotton. This should guide the actors in the VCs in relevant technical and economic choices, notably to value niches markets including organic cotton and fair trade. Given the importance of cotton in the economies of many SSA countries, several of them have implemented policies to improve cotton performance. In Tanzania, both the Agricultural Sector Development Strategy (ASDS 2001) and the "Kilimo Kwanza" resolution promote cotton production in general. The former identified cotton as a crop with a high potential of net foreign exchange earnings and it promoted commercial agriculture in non-traditional export crops, for which organic cotton production is playing an increasingly important role. Indeed, recent studies show an increase in both the area cultivated and the number of farmers involved in organic cotton production in Tanzania (Mgeni 2012). The "Kilimo Kwanza" resolution viewed cotton as one of the potential crops in transforming agriculture with minimal financial requirement; a growing domestic and/or external market demand; and employment creation. Both ASDS and "Kilimo Kwanza" aim at modernization and commercialization of agriculture sector, which will be highly productive and profitable as well as utilizes natural resources in an overall sustainable manner.

The rationales of selecting Benin and Tanzania are numerous. Tanzania represents East African countries and has been selected because it is one of the largest East African cotton producers with 460,000 ha used for cotton production compared to 29,000 ha in Kenya and 100,000 ha in Uganda in 2011 (ICAC 2011). In spite of Tanzania's great cotton production potential, it ranks lowest in productivity among East African countries, with a stagnant productivity average of 171 kg/ha compared to 256 kg/ha in Kenya and 333 kg/ha in Uganda for the years 2010/11 and 2011/12 (ICAC 2011). Mwangulumba & Kalidushi (2012) also noted an alarming negative correlation between area under cotton

cultivation and cotton yield in Tanzania due to low use of inputs and poor agronomic practices. In addition, a poor performance of the market for organic cotton is one of the drawbacks to organic cotton production in Tanzania. Although the poor market performance has been identified over a decade ago (Baffes 2002), detailed research to integrate production and marketing of organic cotton has not been conducted in Tanzania. Thus, Tanzania was also selected to address market limitations from production to the world market through a value chain analysis to enhance the competitiveness without degrading the environment. Another reason to select Tanzania is the fact that Tanzania is currently undergoing a transformation of its agricultural sector by opening it to private investors (URT 2006). Research in the cotton value chain will contribute to make the transformation of the agricultural sector beneficial for small-scale farmers and actors along the value chain. Furthermore, conventional cotton production around Lake Victoria, where about 99% of cotton production in Tanzania is located (TCB 2010), has already substantially polluted this lake, although the use of agrochemicals is still low in this region. However, the use of agrochemicals is expected to strongly increase in the future, which could spoil the main source of fresh water not only in East African countries but also in Sudan and Egypt. Adoption of organic cotton production methods and thoughtful pest and nutrient management could significantly reduce the pollution of this lake.

Benin has been selected, because it represents a typical West African cotton producing country, where the income and employment of the rural areas are highly dependent on cotton (Gazanfer 2007). Benin's organic cotton sector is currently undergoing a progressive transformation from an experimental, small-scale and donor-dependent initiative towards a market-oriented, large-scale and self-financing transnational commodity network (Glin et al. 2012). This is one of the reasons justifying the inclusion of organic cotton in the national recovery plan in the agricultural sector (PSRSA 2011). The Government of Benin has one of the highest interests in organic cotton in Western Africa. Through the SONAPRA, it officially organized the commercialization of organic cotton in Benin during the 2012-2013 campaign. Furthermore, this country represents the first country in the FCFA zone to have deeply reformed its cotton sector in the 1990s, through a liberalization and privatization process (Gergely 2009). Finally, contamination with pesticides is a very relevant problem in Benin (OBEPAB 2002, Pazou et al. 2006a, 2006b).

6. Project plan

Preparation phase (July-December 2014):

- planning the inception workshop
- selecting the two currently unidentified PhD students
- applications for enrolling all four PhD students

Initial phase (January-May 2015):

- inception workshop with all project participants in Benin
- setting up a project website
- workshops with stakeholders in Benin and Tanzania
- planning details of the project (e.g. selecting sites for farm surveys and experimental plots, selecting relevant cotton farming methods)
- arranging practical issues (e.g. selecting technical staff and enumerators, study stays in Denmark)

Main project phase (June 2015-September 2018):

- regularly meetings of members of the different work packages and the steering committee (in person and via video-conferencing)

- each PhD students has two 6-months study stays in Denmark
- conducting analyses at the experimental plots
- conducting farm household surveys and measurements at farmers' fields
- analyzing pesticide residues
- qualitative and quantitative analyses of the different value chains
- statistical analysis of the agronomic and environmental data
- calibrating the APSIM model and using it for analyzing long-term effects
- econometric analysis of the impacts of the different cotton farming methods
- developing new features of the PAM and using it for analyzing competitiveness
- analyses with the stochastic simulation model
- overall analysis of the sustainability
- writing scientific papers and submitting them to peer-reviewed journals
- disseminating results through workshops, brochures, …

Final phase (October-December 2018):

- all 4 PhD students submit and if possible also defend their PhD thesis
- concluding workshops with stake holders in Benin and Tanzania
- concluding workshop with all project participants in Tanzania

Post-project phase (January-July 2019):

- remaining PhD students defend their thesis
- revising papers according to reviews from peer-reviewed journals

7. Participants, organization and management

The main applicant, Arne Henningsen, will be the main coordinator of the project. He has a broad experience in research projects, among them interdisciplinary projects and projects in developing countries (e.g. Benin, Tanzania, Ghana, Ethiopia) and he has acted as a project coordinator, work package leader, and PhD (co-)supervisor. Furthermore, his BSc/MSc education not only included courses in social sciences but also in the fields of natural sciences and agronomy. Hence, he has a basic knowledge of all academic fields that are included in the project and this will facilitate his work as the main coordinator of this project. Finally, he has already successfully co-operated with some of the project partners in Denmark, Benin, and Tanzania in other research projects, which will alleviate possible problems of international and interdisciplinary cooperation.

The partners in Denmark, Benin, and Tanzania have been selected according to the academic fields that are required to assess the overall aim of the project. They are all renowned experts in their academic fields in their countries and most of them already have experience with international research co-operations. We almost achieved gender equality among the participating researchers (50% females in DK, 20% females in BJ, 50% females in TZ).

The project will be managed by a steering committee and is organized in 5 work packages (WP). The steering committee consists of the project coordinator (A. Henningsen, DK), E. Sodjinou (BJ), and N. Amuri (TZ) and will coordinate the project activities. It will frequently communicate via e-mail and video conferencing and physically meet at least once each year. All participants will meet at an inception workshop in Benin and at a concluding workshop in Tanzania. The specific tasks within each WP will be coordinated by the WP leaders. Most WPs are lead by a team of a one researcher from Denmark and one researcher from the South. Core members of each WP will meet at least once per year. Between these physical meetings, modern communication technologies (e.g. e-mail, video conferencing and desktop sharing services such as skype.com, file synchronisation services such as dropbox.com, version control systems) will facilitate the communication within and between the WPs.

- WP1–Project management: This WP will coordinate the data collection and ensure coherence and compatibility of the research of the other work packages. Leader: steering committee. Other members: all.
- WP2–Agronomy and environment: The main tasks of this WP are the measurements of environmental impacts and agronomic indicators at farmers' plots, the plot experiments, and the validation and application of the APSIM model. Leaders: J.E. Olesen (DK), N. Amuri (TZ). Other members: I.S. Fomsgaard, I. Öztürk (DK), R.G. Kakaï, A.M. Igue, 1 PhD student (BJ), T. Bwana (TZ).
- WP3–Farm households, value chain, and institutions: The main tasks of this WP are the socio-economic analyses and the value chain analyses. Leaders: E. Sodjinou (BJ), A. Henningsen (DK). Other members: M.N. Larsen, L. Hajderllari (DK), A. Floquet, R.L. Mongbo, 1 PhD student (BJ), J. Hella, D. Mgeni (TZ).
- WP4–Overall Assessment: This WP conducts the overall assessment of the sustainability based on the results from WP2 and WP3. It will synthesize the individual results to a holistic overview and derive overall conclusions. Leader: A. Henningsen (DK). Other members: all.
- WP5–Dissemination: This work package will facilitate the communication with stakeholders and particularly disseminate the findings to stakeholders and beneficiaries of this project. Leaders: E. Sodjinou (BJ), J. Hella (TZ), other members: all.

MSc students are not included as (official) partners in this research project. However, we will be very open for mutually beneficial collaborations with MSc students. For instance, participants of this project could supervise MSc students (in the South) who participate in the experiments, data collection, or data analysis for our project and write their MSc thesis about this research.

8. Project's international dimension

The project will be implemented in three countries Benin (West Africa), Tanzania (East Africa) and Denmark (Europe) denoting diverse social, cultural and economic dimension This diversity will provide an opportunity for utilizing comparative advantages of each country and partners in terms knowledge, experience, and infrastructure capacity. The collaboration within the project will strengthen the participants' international scientific networks. Furthermore, the participants will use their existing international networks to facilitate other project members' access to these networks. Participation in international PhD courses and presentations at international scientific conferences will integrate the four PhD students in the international academic community.

9. New knowledge

Most recent studies on cotton sectors in SSA focus on the organisation and performance of the conventional cotton production in East and West Africa in the wake of structural adjustment and market liberalisation (e.g. Tshirley et al. 2010, Goreux & Macrae 2002). These studies stress the wide diversity of institutional arrangements in conventional cotton sectors and the implications in terms of, e.g., 'system performance', input credit, extension services, and productivity. Despite the growing importance of organic agriculture, often supported by international development agencies and local and international NGOs, there are very few academic studies on the performance of the organic or other 'niche market' cotton production systems. For example, Glin et al. (2012) explore the emergence of and dynamics in the organic cotton value chain in Benin and pay attention to the institutional and social aspects in governing the value chain. Their work shows that non-economic agents – e.g. civil-society-based transnational

network organizations and trust building mechanisms – are critical in governing the organic value chain and in ensuring smallholders' continued participation in the organic cotton production system in Benin.

The distinctiveness of the organic value chain *vs* the conventional one is stressed among others by Mbiha & Ashimogo (2010) and Glin et al. (2012) and seems to be influenced by the forms of governance and (different) actors engaged in the VCs and the institutional arrangements. Although some stakeholders participate in both organic and conventional cotton products, the organic cotton networks were developed outside the conventional cotton institutional framework in Benin and promoted by the civil society and social movements (Glin et al. 2012). Further, fewer actors tend to be engaged in organic cotton produce, while smallholders are linked to ginneries/buyers in various forms of contract farming or outgrower schemes (Mbiha & Ashimogo 2010; Bassett 2012). On the other hand, however, Fairtrade cotton seems to be intertwined with the conventional cotton chain as revealed by Bassett's (2012) work on Fairtrade cotton in Burkina Faso and Mali. Bassett (2012) argues that Fairtrade cotton fails to provide an alternative to conventional cotton as it works within the same 'premises' as the conventional one.

Several studies have examined the benign effects of organic farming on farm outcomes such as farm revenues and household well-being, and the extent to which organic certification promote sustainable farm practices (e.g. Kleemann & Abdulai 2009). A study by Bolwig et al. (2009) documents that smallholders engaged in certified organic export production of organic coffee, cocoa and pineapple in Uganda had a significantly higher net income than those engaged in conventional production. The results, however, also showed enormous differences in profitability between organic farmers of different crops, with organic pineapple farmers earning three and five times more than cocoa and coffee farmers respectively (see also Gibbon et al. 2010, Raynolds 2004). A general conclusion from the literature in this area seems to be the positive impacts of organic production on farm revenues and household income based on various econometric approaches (Kleemann & Abdulai 2012). However, with regard to organic cotton production and other non-conventional VCs such as Fairtrade cotton production, we are not aware of any empirical studies on the impact of organic cotton farming on farm outcomes and the extent to which organic cotton cultivation promote sustainable farm practices.

Most of the existing studies on agricultural VCs explore issues of governance and upgrading at a national or global scale (e.g. Ponte & Ewert 2009) and have little to say about the direct impact on smallholders of their incorporation in VCs and the ways institutions interact with VCs that 'touch-down' in specific places (notable exceptions are Dolan & Humphrey 2004, Fold & Gough 2008, Neilson & Pritchard 2009). Efforts to incorporate broader development issues in the analytical endeavours – such as the interaction between VCs and the environment – have only recently started within the VC perspective. For example Bolwig et al. (2010) and Riisgaard et al. (2010) provide a practical guide to identify ways to improve the position of smallholders by e.g. international organisations and donor agencies, i.e. upgrading through action points (Riisgaard et al. 2010). Very few also study in a systematic and comparative way the impacts that VCs have on smallholders' decisions concerning their farming and cropping systems. Hence, the interdisciplinary approach in our project to assess the interaction between organic and conventional VC dynamics and environmental, economic and social conditions of farm households is a truly innovative approach to analyse the sustainability of cotton production in SSA and its determinants.

Further, there are little or no studies on the environmental outcomes of different cotton production systems (e.g. pesticide residues, greenhouse gas emissions). This project will

provide the first comprehensive study of the sustainability of different cotton production methods in SSA. In contrast to previous studies of conventional and organic cotton production in SSA, our analysis will include the entire VCs and integrate environmental, economic, and social aspects. Furthermore, our analysis will take into account pesticide residues, which are currently generally ignored in sustainability analyses as well as in the analysis of cotton production. The project will also generate knowledge on innovative improvements of existing conventional and organic cotton farming methods. Furthermore, we will develop methods to combine the "environmental PAM" with the "extended PAM" as well as to combine data from experimental plots and the real world in the PAM. The "extended PAM" will be combined with a qualitative analysis so that the causes of the price gaps in the values chain can be identified. We will also extend the deterministic PAM to a stochastic PAM in order to account for variations in cotton production (between farms and between time periods). Finally, the project will propose and evaluate different approaches for an overall interdisciplinary sustainability analysis, which can serve as a template for many subsequent studies of sustainability.

10. Publication and dissemination strategy

The results that will be obtained in this research project will be presented at national and international scientific conferences and published in renowned national and international peer-reviewed journals, jointly by project participants in Denmark and in the South. We expect that at least 10 high-level international journal papers will originate from the project (at least 4 from each of WP2 and WP3 and at least 2 from WP4). Regular workshops with relevant stakeholders (e.g. farmers' organisations or cooperatives, extension agents, officials, politicians, certification agencies, traders, processors, NGOs) will be arranged in the two partner countries in order to exchange information, to ensure the practical relevance of our project, and to disseminate our results to the broader public. The research results (e.g. environmental impacts of different cotton production methods, agronomic practices that improve the environmental and economic sustainability of cotton production, efficient marketing strategies) will be be disseminated to stakeholders and actors of the cotton value chain (e.g. farmers) through professional associations and extension agents as well as through brochures, technical-economic manuals, fliers, and posters. Policy briefs will be prepared to enhance fast communication of research findings to policy makers.

11. Strategy for phasing out of the project

It is expected that the project will not abruptly end with the end of the project period. For instance, several jointly written manuscripts will still be under review at the end of the project period and some of them will need some revision by the authors before they are accepted for publication. Furthermore, this project (as basically all research projects) will not only answer our current research questions but also raise new research questions. These research questions can result in new research projects that are jointly conducted by some of the current project partners. The partner institutions in the South plan to recruit some the PhD students who are educated in this project, when the project ends, because they intend to increase the number of well-qualified researchers with experience in international research co-operation. The knowledge and expertise that the participating researchers will acquire within this project will allow them to give research-based recommendations to politicians and stake holders also after the end of the project.

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