The Economics of Cotton Production in Mali and the Challenges of Land Degradation

Case study in Koutiala and Bougouni

An Economics of Land Degradation study on Cotton Production in Mali carried out in the framework of the "Reversing Land Degradation in Africa by Scaling up Evergreen Agriculture" project

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Economics of Land Degradation Initiative (ELD)

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Acronyms and abbreviations

BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry of Economic Co-operation and Development)
CMDT	Compagnie malienne pour le développement du textile (Malian textile development company
COI	Cost-of-illness (methodological approach)
COS	Carbone organique du sol (Soil organic carbon)
DAP	Diammonium Phosphate
ELD	Economics of Land Degradation
EU	European Union
FCFA	African Financial Community Franc
FENABE	Fédération Nationale des Agriculteurs Biologiques et Équitables (National federation of organic and fair trade farmers)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German international development co-operation agency)
IER/ECOFIL	Institut de l'Économie Rurale, programme Économie des Filières (Rural economics institute, supply chain economics programme)
IPR-IFRA	Institut Polytechnique Rural de Formation et de Recherches Appliquées (Rural polytechnic training and applied research institute)
MOBIOM	Mouvement Biologique Malienne (Malian organic movement)
NGO	Non-Governmental Organization
NPK	Nitrogen (N), phosphorus (P) and potassium (K)
SDG	Sustainable Development Goal
SLM	Sustainable Land Management
SOC	Soil organic carbon stock
UNCCD	United Nations Convention to Combat Desertification
ZPA	Zone de production agricole (Agricultural production zone)

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About the ELD Initiative and the “Reversing Land Degradation in Africa by Scaling up Evergreen Agriculture” project

Soil degradation, desertification and drought are global phenomena representing a growing threat to the future of our environment. They cause loss of the services provided by terrestrial ecosystems, which are essential for people and economic development. Food production, water availability, energy security and other services provided by intact ecosystems are jeopardized by the continual loss of land and soils.

Desertification already affects around 45% of the African continent (ELD Initiative 2017), so the need to take action is inescapable. Inaction in the face of this threat could have significant consequences for economies and long-term development prospects.

The “Economics of Land Degradation” (ELD) Initiative was launched in 2011 by the European Union, the German Federal Ministry of Economic Cooperation and Development (BMZ) and the United Nations Convention to Combat Desertification (UNCCD). The ELD Initiative provides scientific support to policymakers at both the national and international level. The initiative draws on a vast network of scientific experts and partner institutions and seeks to bring about a worldwide transformation in the understanding of the economic value of productive land. The goal is to promote more sustainable land management and familiarize stakeholders with the socio-economic arguments.

The ELD Initiative offers a comprehensive economic assessment, using tried and tested evaluation tools and methods in order to help stakeholders assess the profitability of land. These evaluations will be taken into account in the decision-making process. The ELD Initiative is coordinated by a Secretariat hosted by the BoDeN sectoral project of the German International Development Co-operation Agency (GIZ) at the offices of the GIZ in Bonn, Germany.

Land degradation is explicitly included in goal 15 of the United Nations Sustainable Development Goals (SDGs) adopted in 2015. Goal 15 aims to “Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss”.

Targets 15.3 and 15.9 respectively strive to achieve a land degradation-neutral world and integrate ecosystem and biodiversity values into national and local planning. At international level, the UNCCD has been appointed as lead agency to monitor these targets. By developing economic arguments, the ELD Initiative complements the work of the Convention’s scientific and technical committee.

Land degradation is a complex, pernicious issue, which affects flora and fauna as well as many areas of human life. As a result, it cannot simply be resorbed through the adoption of technical or technological measures. Combating degradation effectively demands inclusive measures designed to reduce poverty (SDG 1), improve food security (SDG 2), ensure clean water and sanitation (SDG 6), economic growth (SDG 8), responsible consumption and production (SDG 12), climate change adaptation (SDG 13) and peace and justice (SDG 16).

Launched in 2017, the “Reversing Land Degradation in Africa by Scaling up Evergreen Agriculture” project aims to boost livelihoods, food security and climate change resilience by restoring terrestrial ecosystem services. The beneficiary countries of this project are Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal and Somalia. It is implemented jointly by the ELD Initiative and the International Centre for Research in Agroforestry (ICRAF), with funding from the EU and co-funding from BMZ.

The role of the ELD Initiative in this project is to raise public awareness of the threats and opportunities in the various land-use options, by supporting the setting up and sharing of cost -benefit analyses in each target country. In parallel, it also builds the capacity of national institutions and experts to assess the economic effects of investments targeting land management, with regard to the costs of land degradation.

This report has been written within the framework of such a national process. It seeks to provide policy-makers and administrators with scientific information on the economic consequences of land degradation and the alternative ways of achieving rural economic growth.

Executive summary

Cotton production supports four million people in Mali, around one quarter of its population. In early 2019, the cotton farmers confederation set an ambitious objective of raising production to one million tonnes for the 2019/2020 season (France24 2019). With an output of 700,000 for 2019/2020 (Reuters 2020), this target was not met, but it is illustrative of the continued interest in boosting national production, with cotton predominating the agricultural sector. The role of the state in supporting the cotton industry is considerable, particularly through the Malian textile development company (CMDT) which buys cotton from farmers and inputs to farmers at subsidized prices.

From an economic perspective, there is an opportunity cost associated with any government support, since one franc CFA spent on cotton means one less franc CFA for other activities. To improve the profitability of the farming sector and growth prospects for the Malian economy, it is vital for public funds to be allocated where they provide the highest return, particularly in the context of increasing climate variability and pressing land degradation.

Consequently, in analysing the contribution of cotton production to the Malian economy, it is important to take account not only of gross production and gross value, but also the farmers' expenditure on inputs. This study sets out to do exactly that and compare the economics of conventional and organic cotton production in Koutiala and Bougouni cercles [second-level administrative units]. For that purpose, three detailed household surveys were conducted with cotton producers in Bougouni and Koutiala. Cotton production for exports started in Koutiala in the 1950's, whereas Bougouni is a more recent production zone, subject to continued expansion of surfaces dedicated to cotton. The analysis produced the following interesting findings:

- Conventional cotton producers in Koutiala1 have an average yield of 950 kg/ha, compared to 1050 kg/ha for cotton producers in Bougouni. Cotton producers in Koutiala are also highly dependent on significant quantities of organic fertilizers (household waste, compost and manure transported by cart) to maintain their yields. On average, they use 36 wheelbarrows, whereas Bougouni producers use only seven. As a result, Koutiala producers have higher production costs. The average profit per hectare is FCFA 97,850/ha, compared to FCFA 147,430/ha in Bougouni.

- When accounting for health impacts from pesticide use and government spending on subsidies, the societal profit is FCFA 74,340/ha in Koutiala and FCFA 119,015/ha in Bougouni (Table S.1). These results provide evidence to support the initial hypothesis, which suggests the soils are more degraded in Koutiala than in Bougouni. Measurements of soil organic carbon stocks on cropland confirm this finding.

1 Type B, who have between two and nine head of cattle and one animal traction unit, accounting for the majority of farmers.

Table S.1: Summary balance sheet for conventional and organic producers (type B) in Koutiala and Bougouni

Results for the 2018/2019 growing season	Koutiala	Bougouni	Bougouni
	Conventional producer	**Conventional producer**	**Organic producer**
Yield (kg/ha)	950	1 050	445
Price (FCFA/kg)	255	255	300
Revenue (FCFA/ha)	242 250	267 750	133 500
Input costs (FCFA/ha)	105 688	81 606	52 844
Private profit (FCFA/ha)	97 850	147 430	80 650
Cost of illness (FCFA/ha)	1 100	4 570	0
Cost of subsidies (FCFA/ha)	22 407	23 848	0
Societal profit (FCFA/ha)	74 340	119 015	80 650

- There are also signs of food insecurity amongst cotton producers in Koutiala, with one in five households not being able to meet their daily food needs, and one in two considering that their diet was poorly balanced in the year prior to the interview.

- Such results are a warming against business-as-usual practices in cotton production. Bougouni should not follow the same trajectory as Koutiala, because Bougouni risks being in the same situation as Koutiala just a decade from now. There are signs that this could happen, as the majority of farmers in Bougouni engage in extensification rather than sustainable land management, burning harvest residues and using few organic inputs, as was the case in Koutiala in the recent past.

In parallel with these trends, there is growing interest in organic cotton at the international level. In Mali, however, operators in the organic sector feel they are unjustly treated. Premiums are either not paid or paid very late. The sector cannot get credit at a favourable rate and there seems to be no transparency in price setting. Organizations of organic producers are advocating a review of the monopoly on cotton marketing and calling for legislation on organic farming to promote its development. A system needs to be put in place, not only to encourage organic cotton production but also to allow conventional cotton to be produced sustainably.

- The present study also shows that average cotton yields for organic cotton producers of type B2 are 450 kg/ha, less than half the yields of conventional cotton producers. Nevertheless, organic farmers also spend considerably less on inputs, about half that of conventional cotton producers. As a result, and despite low yields, they manage to earn a profit of FCFA 80,600/ha, which is slightly higher than that of an average conventional cotton producer in Koutiala.

In terms of productivity, organic cotton producers' yields vary from 200 kg/ha to 1500 kg/ha, highlighting the potential for organic cotton producers to improve yields with other farming practices.

Furthermore, statistical analysis of the household survey results shows that a typical organic cotton farmer can increase yields by 200 to 720 kg/ha. Firstly, by introducing agroforestry practices and, secondly, by ensuring that cotton residues are grazed exclusively by their own animals (rather than another owner's animals), thereby adding an additional 400 kg/ha to their yields. These practices are in line with the principle of agro-ecological farming, which calls for a closed production loops within a single farm and minimized use of external inputs.

Increased cattle wealth also leads to higher yields. For each additional cow, organic farmers can expect an increase in yield of 30 kg/ha. The practice of combining crop farming and livestock systems, is gradually becoming more widespread amongst conven-

2 Producers with between two and nine head of cattle and an animal traction unit.

tional cotton producers. Conventional cotton farmers, thought to a lesser extent than the organic, also adopt agroforestry practices and apply manure, household waste and compost to the fields, with the aim of improving their yields.

The application of additional sack of inorganic NPK fertilizer increases yields by an average of 64 kg/ha, equivalent to additional revenue of FCFA 16,760/ha. This value corresponds roughly to the international market price for fertilizers, indicating that for every franc CFA invested in fertilizers, society enjoy one franc CFA in return. This is hardly efficient and suggest that public resources could be invested better in other programmes or sectors.

It is possible that the poor return on investment is due to the application of standardized fertilizer doses (200 kg; identical to the norm in most West African countries), that does not account for differences in soil condition. Observations from recent research demonstrate that differences in soil fertility need to be taken into account when applying inorganic fertilizer (Igué, Gaiser & Stahr 2004). In particular, relatively small quantities of urea and NPK should be applied when the soil is not degraded, and vice versa. The standardized recommendation is therefore is neither economically, nor ecologically sustainable (Honfoga & Parrales 2018).

The costliness of external farm inputs also calls for the promotion of production methods and crops, that can enhance soil fertility over the long term. For example, aside from agroforestry, the analysis in this study shows that the use of crop legumes in rotations with cotton can help increase yields. However, a much larger range of SLM methods (direct sowing under plant cover, minimum tillage, crop associations, permeable rock dams, etc.) can be used in cotton production systems (see e.g. GIZ Benin 2019).

In order to promote further uptake of SLM practices in Mali, it is essential that such measures figure amongst the technical standards and specifications of permanent supervisory bodies (CMDT, FENABE, MOBIOM etc.). This would enable these methods to be introduced effectively into traditional farming practices and fit into the overall action and extension strategies that are devised for each locality.

There is also a need to establish a more level playing field amongst conventional and organic cotton producers, and amongst different farming practices (conventional versus SLM) that farmers may wish to adopt. The transition towards SLM practices requires initial labour and capital investments (e.g. in tree nurseries, small scale water reservoirs, composting facilities, soil preservation and restoration structures). It is therefore important to facilitate access to patient financing at low interest rates.

Today, Mali produces food and cash crops by relying primarily on the principles of the green revolution along with farming systems that make intensive use of external inputs and resources, which have a high environmental cost. The present serves to provide insights into the economic case for adopting SLM and evergreen agricultural practices, and avoiding further land degradation.

Recommendations

Recommendations for public decision-makers

Conventional cotton production has a high cost to the Malian government treasury, as subsidies for inputs are amongst the highest in West Africa. Untargeted subsidies may also encourage cultivation of soils less suitable for agriculture. This is problematic in the long term, given the difficulty in restoring the production capacity of tropical soils (Morris et al. 2007).

Whilst government subsidies have continued to rise, yields have stagnated. At present, producers in Koutiala need to use an average of 200 kg of non-organic compounds and 30 wheelbarrows of organic fertilizers (compost, manure and household waste) per hectare to maintain yields of 950 kg/ha! There are consequently many producers looking to settle in other cèrcles (such as Bougouni) where there is still some fertile land, to compensate for the low profits.

At national level, production is maintained through the expansion of cultivated areas– to the detriment of pastures and forests. This threatens Mali's ability to achieve the SDGs, particularly land degradation neutrality (SDG 15.3). In this context and considering the findings of this study, sustainable intensification should be favoured over continued land expansion for cotton cultivation. To this end, it is important to:

- Support investment in sustainable land management (SLM), especially with regard to agroforestry and the use of leguminous crops and composting. Such measures allow farmers to realize the productive potential of their land, without adversely impacting government spending and their trade balance (on imported chemical inputs).
- Stimulate access to low-interest and longer-term credit to allow farmers to invest in SLM practices;
- Guarantee a level playing field amongst organic and conventional cotton producers in terms of access to subsidized inputs, credit, equipment and machinery.
- Encourage the development of a legal and institutional framework for organic cotton farming, to allow the sector to achieve its potential.
- Review the way the conventional cotton subsidies are allocated, so that farmers can choose to invest in the system they favour according to their preferences and capacity. This is all the more important in view of increasing climate variability, which demands flexibility and innovation on the part of farmers in their production systems;
- Put in place a system which encourages sustainable production of (organic and conventional) cotton and food crops, particularly through investment in re-greening and SLM measures – techniques enabling farmers to increase their yields without damaging the balance of trade (through imports of inputs) or the public purse (through subsidies).
- Establish an overall action and extension strategy that includes SLM practices as part of the technical packages and standards of supervisory bodies (CMDT, FENABE, MOBIOM, etc.) to ensure the sustainability of investments in SLM.
- Finally, the true potential for evergreen farmer and SLM has not yet been fully exploited in Mali. To up-scale such practices, there are lessons to be learned from the experience of farmers in Mali and that of neighbouring countries, such as Benin, which have achieved significant productivity gains.

Recommendations for farmers and providers of extension services

In Koutiala, the heartland of cotton production, conventional cotton producers are faced with land degradation, stagnating yields and rising input costs. As a result, the average cotton farmer enjoys a per hectare profit of only FCFA 97,500. At the same time, the average conventional cotton producer in Bougouni (a recent cotton-growing zone) enjoy profits of around FCFA 150,000 per hectare.

Abdoulya Diarra, a senior technician with the CMDT, stresses the importance of implementing land restoration measures in Koutiala, and preventive land degradation measures in Bougouni, so as to avoid that Bougouni or other cotton expansion zones follow the same trajectory as Koutiala (Abdoulya Diarra, personal communication, August 2019[3]).

To this end, it is advisable to adopt local solutions and SLM measures, such as using residues (rather than burning them), manure, organic household waste and compost; agroforestry; growing leguminous crops in rotation with cotton; and allowing animals to browse on crop residues. In this way:

- Organic farmers can increase yields from 200 kg/ha to 700 kg/ha by using agroforestry in their cotton fields (minimum 20 trees/ha) and ensuring that their own livestock are grazing on crop residues. In addition, six wheelbarrows of household waste can increase yields by 100 kg/ha;
- Conventional cotton producers in Koutiala who practise agroforestry by using leguminous crops in rotation can achieve additional yields of 250 kg/ha. Furthermore, ten extra trees (such as shea, locust bean or *Acacia Albida*) per hectare generate additional revenue of around FCFA 27,000/ha. Most forest products can be harvested in the dry season, allowing farmers to balance their annual income while improving the food and nutritional security of their households.
- Furthermore, recent studies (Igué, Gaiser & Stahr 2004; Honfoga & Parrales 2018) demonstrate that inorganic fertilizer use needs to be adapted to the condition of soils, to prevent them from degrading and make cotton production more profitable. For example, the application of low to moderate inorganic fertilizer doses is recommended in the situations where soils are relatively fertile (like Bougouni) and higher doses are needed on more degraded soils.

It is also recommended, however, that farmers and their supporting organizations, dare to go beyond these measures and adopt additional practices, such as, but not limited to:

- Direct sowing of herbaceous legumes under vegetation cover;
- Maximum re-use of cotton residues;
- Use of cultivators and light machinery, as well as ploughing perpendicular to the contour lines with tie-ridging;
- Denser agroforestry (minimum 25 trees/ha);
- Treatment of plants with aqueous extracts of bio-pesticide plants (*Hyptis*, neem, *Gliricidia*) and living fences of *Gliricidia*, etc. (GIZ 2019).

These measures are also known for their ability to mitigate the uncertainties around climate variability. Soils with a healthy tree cover are richer in organic matter, carbon and nitrogen; retain more moisture and are therefore more resistant to drought and flooding.

In conclusion, under the current conditions, with changing climates, unsustainable levels of expenditure on conventional farming inputs and low profit margins, it is necessary to promote re-greening through SLM measures to encourage resilient and economically rewarding farming for both producers and society.

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Introduction

Farming is the motor of the Malian economy. Almost 80% of the labour force is employed in agricultural production, which accounts for more than 35% of the country's GDP, including 15% for cotton production alone (FAO 2017). Since the end of the 1950s, production of cotton and food crops has increased significantly in the Malian cotton zone, particularly in Koutiala cercle, located in South-East Mali on the border with Guinea, Ivory Coast and Burkina Faso.

Mali's main exports (figures for 2017) are gold (FCFA 847 billion), prepared cotton (FCFA 80 billion) and raw cotton (FCFA 72 billion). Raw and prepared cotton accounts for 11% of the value of the country's exports, second only to gold (OEC 2020).

With an output of 700,000 tonnes of raw cotton in the 2017/2018 season, Mali became the leading African cotton producer, before Burkina Faso (BBC 2018). Cotton is produced by more than 190,000 farmers on an area of around 700,000 ha (Maiga 2019). Cotton is mainly grown by family farms in combination with herding and food crop production. The growing and marketing of cotton is seen as a tool for modernization and poverty reduction and is therefore a major concern for the Malian government.

Cotton is Mali's second largest export crop (Ministère de l'Environnement et de l'Assainissement 2017), providing an income for 40% of the Malian rural population (Camara 2015). According to Benjaminsen (2001), 20 - 45% of the nation's cropland is devoted to cotton and more than 70% of national production takes place in Sikasso region.

Agricultural development transforms the landscape. The most visible environmental impact is the extension of cultivated areas to the detriment of pasture and forested areas (Benjaminsen 2001). Deforestation and inadequate farming practices lead to a loss of organic matter through erosion and excessive mineralization (especially salinization), with the ongoing search for new, more fertile forest land as a corollary.

According to the information gathered at the workshop to launch the Evergreening Africa project in Mali, Koutiala cercle is the largest cotton production basin in Mali and one of the main areas affected by land degradation. Serious wind and water erosion of the soils is seen due to the inadequate vegetation cover, pressure from herding and inappropriate cropping techniques, such as ploughing parallel to the contour lines or heavy use of animal-drawn and motorized equipment. Heavy use of chemical fertilizers and pesticides has also contributed to salinization of land in the cercle (Kone & Camara 2019). Camara (2015) stressed that "despite the use of chemical and organic fertilizers, the cultivated soils are becoming impoverished and threatening the profitability of several farms. Failure to observe the habitual fallow period is one of the irreversible causes of soil impoverishment".

There are therefore serious fears that soil degradation in Koutiala will lead to emigration of cotton producers to other cercles (including Bougouni), which would be at risk of experiencing the same land degradation process (Kone 2019). The CMDT is aware of the need to take preventive action in the Bougouni area and curative action in Koutiala (Abdoulya Diarra, personal communication, August 2019).

Migration induced by land degradation is exacerbated by strong demographic growth. With a growth rate of 3.6% per year, the population doubles around every 20 years. Agricultural (cropping and herding) migration from conflict zones in the north to more fertile and secure areas in the south is increasingly common in Mali. Migrants from neighbouring countries add to these internal population movements.

With climate change, drought is no longer a transient threat but a recurrent reality. Experts from the Intergovernmental Panel on Climate Change (IPCC) predict that Mali's climate is going to get hotter, drier and more variable. Average temperatures could rise by 4.5°C by 2025. Most climate models anticipate that droughts will be more extreme in the Sahel. Generally speaking, the rainy season will be shorter and more variable. These changes in the climate are liable to threaten the food security of

Malian farmers, by shortening the growing season by 20-25% in semi-arid and arid African zones by2050 (Coulibaly & Wormworth 2007).

To maintain the land's production capacity against this backdrop of heavy demographic growth, climate change and decreasing productivity, there is a need to invest sustainably in land and restore its fertility. This echoes current practice in Benin. According to Mélanie Djedje (e-mail correspondence, January 2019), head of the Soil Protection and Rehabilitation to Improve Food Security in Benin project (GIZ)[4], the Minister of Agriculture declared for the first time at the launch of the 2018/2019 season that "agricultural nomadism has to stop because there is no more land. Ecological intensification is the only option."

To date, investment in land intensification has primarily consisted of increased use of chemical fertilizers, pesticides and organic manure (Benjaminsen 2001). As regards SLM, some 600 villages have been involved in combating water erosion: stone bunds have been built there by the Soil Protection and Restoration Division project, which began in 1986 with funding from the Dutch Development Co-operation and was set up with support from the CMDT. The project was effective at the time, but "stone bunds are no longer sufficient today in view of the faster pace of land degradation. A new revolution is needed" (Abdoulya Diarra, personal communication, August 2019).

In view of this, the French Development Agency signed a new agreement in September 2019 to support the cotton sector in Mali. The EUR 18.5 million AgrECO project has the twofold objective of supporting the agro-ecological transition of production systems in the cotton production area and sustainably improving producers' income (French Embassy in Bamako 2019).

This study was begun against the background described above and set the following objectives:

- Describe the economic position of conventional cotton producers in Bougouni and Koutiala, while identifying any signs of greater degradation of the soils used to grow cotton in Koutiala (in comparison with Bougouni, where agro-ecological systems are more diversified). To do this, an analysis of the economics of cotton producers in Bougouni and Koutiala was carried out, with the aid of three household surveys and an assessment of land cover and soil organic carbon stocks;
- Understand the real contribution of cotton to the Malian economy by analysing the costs of subsidizing inputs into cotton production, which represent a significant burden for the Malian State;
- Highlight the impacts on the health of conventional cotton producers of using these subsidized inputs. With the consequences of pesticide use for farmers' health on the one hand and increasing demand for organic cotton at the international level on the other, many farmers are tending to implement organic cotton production technology. The supermarket chain Carrefour, for example, has committed to purchase 3000 tonnes of Malian organic cotton to help structure and boost the organic cotton sector (Sahel Intelligence 2019);
- Understand the economics of organic cotton producers in Mali and suggest measures aimed at making the institutional environment more conducive to improving organic farmers' productivity and conditions;
- Recommend steps to be taken by conventional and organic farmers to intensify their cotton production sustainably; these recommendations will be based on the results of the economic analyses in Bougouni and Koutiala and a study in Benin.

This study has been conducted by a consortium of national and international researchers and consultants; including the University of Geneva and Altus Impact, who are supervising and supporting research in the country. Two institutions in Mali helped with the study:

- The Rural Economics Institute/Supply Chain Economics programme (*Institut d'Économie Rurale, programme Économie des Filières* (IER/ECOFIL): one researcher; in association with the National Directorate of Agriculture and National Directorate of Animal Production and Industry;

- The Rural Polytechnic Training and Applied Research Institute (Institut Polytechnique Rural de Formation et de Recherches Appliquées - IPR-IFRA): three researchers.

4 For more information, please contact Ms Djedje at the following e-mail address: melanie.djedje@giz.de .

In addition, teachers and researchers from the following institutions took part in the study:

- The Territorial Development Institute of the University of Social Sciences and Management (Institut de Dévelopement Territorial, Université de Sciences Sociales et de Gestion), Bamako;
- The Higher Training and Applied Research Institute (Institut Supérieur de Formation et de Recherche Appliquée);
- The University Teaching Institute (Institut de Pédagogie Universitaire);
- The National Directorate of Water and Forests.

The economic studies were conducted by means of three surveys of producers in Bougouni and Koutiala, as well as interviews with experts, particularly from IER/ECOFIL and CMDT, and the leaders of MOBIOM and FENABE.

02

Organization of the cotton sector in Mali: conventional and organic cotton

2.1 Organization of the conventional cotton sector and key issues

Since Mali's independence in 1960, successive governments have focused on developing production, based on a vertically integrated model with significant involvement of the public authorities, managed by the Malian textile development Company (CMDT).

The CMDT was set up in 1974 to oversee the sector (replacing the CFDT/Compagnie Française du Textile). The Malian State owned 60% and 40% by French interests (Dagris company, now Géo-coton); the CMDT was responsible for purchasing the harvest, ginning and then marketing the cotton fibre and seed. Involved at all stages of the value chain (seed production, phyto-sanitary protection, sale of inputs, credit and equipment, research), the CMDT also has the task of formulating rural development policies in its area of operation.

The sector has made uneven progress. Cotton marketing is characterized by extreme world price volatility, due to variations in the dollar price, stocks, exchange rate and subsidies from industrialized countries. In the mid-1990s, devaluation of the CFA franc and the doubling of world prices enabled the sector to make a financial surplus for four years, with a considerable expansion of production areas. Subsequently, falling prices led to an unprecedented crisis in 2000–2001, together with a producers' strike, bringing production down to 250,000 tonnes the same year. The CMDT then alternated between surplus and deficit periods, depending on world prices (Camara 2015).

The large majority 95% of the national output is exported and the sector provides 22% of the country's export earnings (Camara 2015). The main destinations are China, India and Bangladesh (Maiga 2019). The lack of a processing industry, which obliges Mali to export the raw material, deprives the country of a large part of the added value it could gain from the sector (processing cotton generates much more significant income than selling it raw). The Malian government's ambition is to set up a local processing industry so that at least 10 - 25% of the cotton produced can be processed in Mali (Maiga 2019). For the moment, however, attempts to establish processing plants have failed.

In Mali, as in other West and Central African countries, the economic position of family farms producing cotton has long been seen as more satisfactory than that of producers of food crops alone, because producing a cash crop supplements income from other farming activities (Günther, Marouani & Raffinot 2007). The findings of large-scale poverty surveys however, such as the Malian poverty assessment survey (Enquête Malienne d'Evaluation de la Pauvreté - EMEP) carried out in 2001, reveal a different reality. That survey classes Sikasso, the leading cotton production region, amongst the poorest in the country, hence the term "Sikasso paradox" used to illustrate a situation where, despite expectations, the cotton production zone has relatively high levels of poverty (Mesplé-Somps et al. 2008). This is all the more paradoxical in that cotton farmers are considerably better equipped than others with production factors (agricultural equipment, livestock, etc.).

2.2 The development of a fair trade organic cotton sector

It was against a background of price instability and serious crisis in the conventional cotton production system that organic cotton began to be grown in 2002 in Mali. In 2004, it received "fair trade" certification. This alternative proved very popular, particularly amongst women (Droy 2011).

The Malian Organic Movement (MOBIOM) was set up in 2002 by nine co-operatives with support from the Swiss non-governmental organization (NGO) Helvetas to promote the development of organic farming in Mali. In 2011, MOBIOM encompassed 84 fair trade organic cotton co-operatives, some 10,000 farmer producers (Table 1) and more than 4000 ha in the Sikasso (Bougouni, Garalo, Kolondièba, Yanfolila), Kayes (Kita), Koulikoro (Fana, Dioïla) and Ségou (Bla, San) regions (Mouvement Biologique Malien 2011).

Organic cotton is ginned in Mali and processed outside the country. The producer price, set in advance, is very attractive compared with that of conventional cotton: it includes a guaranteed minimum price (calculated on the basis of production costs) and two premiums (the organic premium and the fair trade premium) for taking part in fair trade. In principle, each organic cotton producer receives the guaranteed price directly (FCFA 300/kg, as against FCFA 255/kg for conventional cotton producers). Nevertheless, over the last few years, according to MOBIOM and FENABE and based on the results of our surveys, cotton producers receive this premium very late, if at all. Previously, the fair trade premium went into a fund intended for investments of collective interest (schools, wells, storage hangars); in this way, the fair trade organic sector helped to fund community development projects in the operational areas of MOBIOM, with 72 social projects carried out in 2011 (Mouvement Biologique Malien 2011).

Leaving aside the attractive (in principle) price of cotton, the main benefit of organic cotton production for producers is a more environmentally friendly system less harmful to health and arable land; its potential is estimated at several thousand tonnes per year. Organic cotton production is, however, currently marginal, accounting for 200 tonnes of the total annual output of 700,000 to 800,000 tonnes (Ambassade de France à Bamako 2019).

Development of the sector is held back due to the following constraints, noted by both MOBIOM and responses to the household survey, carried out in connection with this study:

- Non-payment of the premium;
- Low yields;
- Lack of availability of good quality organic fertilizer;
- Poorly equipped producers and lack of access to credit to finance them;
- Absence of an organic seed scheme;
- The eligibility criteria for State subsidies, which do not favour organic cotton producers (for example, only conventional cotton producers can access tractors);
- Lack of autonomy of the organic cotton value chain (in terms of marketing and production).

According to the French Embassy in Bamako (2019), the organic sector should complement the traditional cotton sector and generate thousands of additional jobs for cotton growers, as well as increased income (Ambassade de France à Bamako 2019). To realize this potential, according to our discussions with representatives of MOBIOM and FENABE, it is necessary to establish a legal and institutional framework in Mali favourable to organic farming and ensure that organic cotton producers are operating on a level playing field with conventional producers.

Box 1: History of organic cotton in Mali

1998–2001	Experimental phase
2002–2005	First production phase
2006–2008	Second production phase
2008–2011	Third production phase with transfer of skills from Helvetas to MOBIOM

In the remaining section of the study, we present an assessment of the economics of organic and conventional cotton production, together with an analysis of the determinants of land use productivity. On this basis, we draw lessons on how organic and conventional producers can increase yields and combat land degradation.

03

Study sites and data from the ELD survey

Bougouni and Koutiala are part of Sikasso region. Bougouni cercle covers an area of 20,028 km² (RGHP 2009). It is bordered to the north by the Dioila and Kati cercles, to the south by Ivory Coast, to the west by Yanfolila cercle and to the east by the Yanfolila and Kolondiéba cercles (Figure 1). Koutiala cercle covers an area of 12,000 km² (RGHP 2009). It has 263 villages spread across 36 rural municipalities. Sikasso region features considerable pedological diversity, especially red and brown soils, with the characteristics of hydromorphic leached ferruginous tropical soils, and grey soils (Diallo & Diallo 2019; Kone & Camara 2019).

Bougouni and Koutiala have a dry tropical (or Sudano-Sahelian) type climate with rainfall in excess of 1100 mm/an. The year is split into two seasons: a dry season from November to April and a rainy season from May to October. The highest temperatures are recorded towards the end of the dry season (April/May). Temperature varies between 25 and 30 degrees on average, with maximums recorded in March and April and an annual average of 28°.

There are a few small floodable areas, which are generally dry from February to June. The permanent rivers (such as the Baoulé, Mono, Banifing III and Degou), which irrigate very fertile plains, provide Sikasso region and Bougouni cercle in particular with considerable agro-pastoral potential.

Bougouni cercle is situated in the South-Sudanian zone; its northern fringe produces supplies of firewood and charcoal for the city of Bamako. Arable land in Bougouni accounts for 70% of the territory. In demographic terms, the average annual growth rate is around 3.6% (Diallo & Diallo 2019) in Bougouni and around 3.8% in Koutiala (Kone & Camara 2019).

Cropping accounts for 71% of the income of a typical farm in Koutiala. In general, cash crops (cotton and soya) are grown alongside food crops including rice, millet, sorghum and maize. According to Diallo & Diallo (2019), it is the only region where herding makes a significant contribution (10%) to the farms' average total income. Other important income comes from self-employed activities (9%), while gathering (shea, locust bean, weda fruit [*Saba Senegalensis*], baobab, kapok) accounts for a significant share (5%) of average income. In Koutiala, cotton has been grown since the 1950s, whereas CMDT support for cotton and maize rotations only began in the mid-1980s (Ollenburger et al. 2016).

04 Land degradation and cotton production

4.1. Indicators of land degradation

Loss of soil productivity is the most significant aspect of land degradation in West Africa. Soil degradation is, however, actually very difficult to measure. Changes in productivity cannot be ascribed solely to a change in soil quality. Productivity is at least as much affected by changes in water availability, farm management practices or factors such as labour and agricultural technology (as shown in Chapter 6). Consequently, biomass production or crop yields can only serve as an initial indirect indicator of soil degradation and must be supplemented by corroborating evidence drawn from real measurements of soil condition (Mazzucato & Niemeijer 2000: pp. 115-116). Lack of resources and time means that such measurements cannot always be taken. As a result, in this study, with a view to measuring progress towards land degradation neutrality – SDG 13.3, the soil degradation seen is assessed on the basis of the three main indicators adopted by the UNCCD to analyse land degradation, for example:

- Land cover (changes in land cover);
- Land productivity (net primary productivity, in tonnes of dry matter/ha/year);
- Carbon stocks (soil organic carbon - SOC).

These three indicators are considered to show the quantity and quality of land-based natural capital and the associated ecosystem services. According to the UNCCD approach (Orr et al. 2017), land degradation in relation to the initial values occurs through:

- A negative change in land cover; or
- A net decrease in primary productivity; or
- A significant decrease in SOC.

The indicators and associated parameters are complementary elements of land-based natural capital. They are therefore quantified and assessed separately. The following section looks more closely at these indicators to assess the status of land degradation in Koutiala and Bougouni.

4.2. Land cover

Forests are ecosystems supplying important regulating (carbon, water purification, erosion control) and provisioning (timber and non-timber products) ecosystem services. Conversion of forest land for other uses, such as agriculture, principally supplying provisioning services, is considered as contributing to degradation (Orr et al. 2017).

Conversion of forests into cropland (in ha) for Bougouni and Koutiala, was calculated for the period 2000–2018 with the aid of the study by Hansen et al. (2013)[5]. Figure 1 shows that, between 2000 and 2018, 180 ha of forest were converted into cropland in Bougouni and 1.4 ha in Koutiala (coloured pink on the map). According to the methodology of Global Forest Watch (n.d.), land conversion was only taken into account in areas with tree cover in excess of 30% and where the trees were more than five metres tall.

The changes seen in Bougouni in terms of land degradation may therefore be considered as negative. As the first and long-standing area of cotton production, Koutiala has been less affected by deforestation than Bougouni since the 2000s.

5 *See the high-resolution maps reflecting changes in tree cover in the 21st century (Hansen et al. 2013): https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.6.html.*

FIGURE 1:

Land cover map 2019, Koutiala and Bougouni, and loss of forest 2000 - 2018

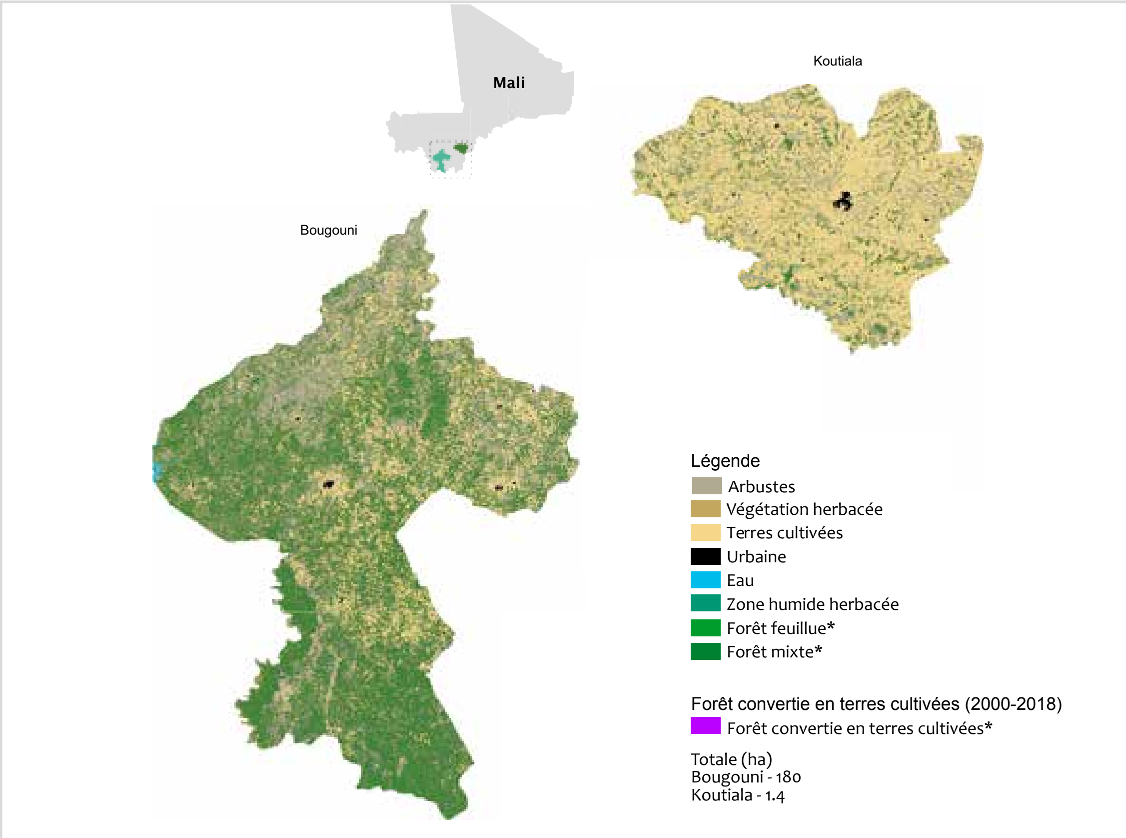
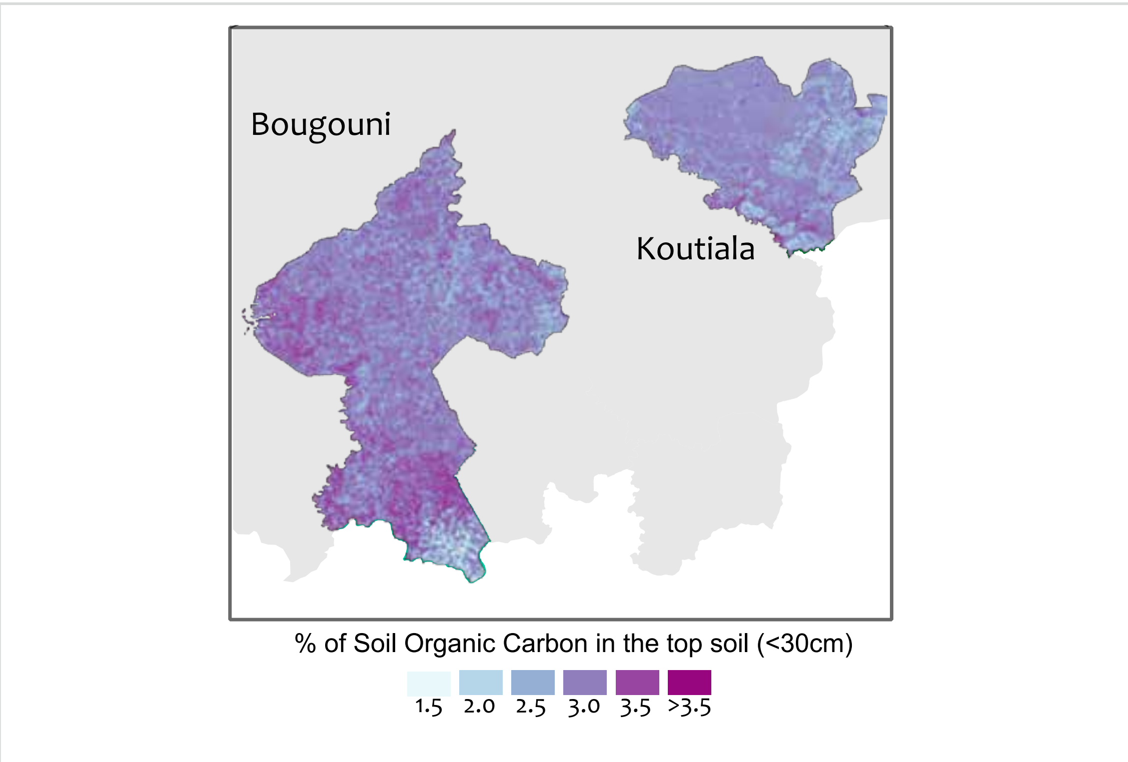


FIGURE 2:

Map of soil organic carbon, Bougouni and Koutiala



4.3. Soil organic carbon

Figure 2 shows the **soil organic carbon (SOC)** content in the cropping areas of Bougouni and Koutiala in 2019. Only the percentage of organic carbon (form of carbon available for plants), which is a better indication of soil fertility than absolute carbon levels, is taken into account (Springmann et al. 2018).

Despite the absence of observations of SOC stocks over time to confirm that degradation is occurring, the maps show that land in Koutiala has lower levels than land in Bougouni. Focusing on areas defined as cropland, **average SOC content is 2.7% in Koutiala, as against 2.9% in Bougouni.** Agricultural soils in Koutiala are therefore more degraded than those in Bougouni.

According to Springmann et al. (2018), beyond soil organic carbon content of 3%, additional quantities of SOC have only a very marginal effect on yield. As expected, the prevention of land degradation is therefore a priority concern in Bougouni region, whereas in Koutiala, land restoration and SOC increases should be a priority for Koutiala.

Finally, the maps show that SOC content is higher in forest areas (+3.5%). If deforestation is not stopped, **land degradation in Bougouni cannot be avoided.**

Box 2: Calculation of soil organic carbon content

Soil organic carbon content was calculated using SoilGrids ((https://soilgrids.org/#!/?layer=ORCDRC_M_sl2_250m&vector=1) data, referring to the fraction of organic carbon contained in the top soil, at a depth of less than 30 cm (SoilGrids n.d.). These data have been overlaid with land cover in Bougouni and Koutiala in 2018 (extracted from demonstration version for Africa; Smets et al. 2019).

4.4. Primary productivity and yields

Until the mid-1980s, the cotton sector experienced rising yields due to a number of factors and better technical control of the crop: use of inputs and equipment, literacy teaching and vocational training. Soil impoverishment, however, resulted from intensive cropping, use of chemical fertilizers, and use of phyto-sanitary products. Consequently, since the early 2000s, some producers have seen yields fall to around 800 kg/ha, whereas they were 1200 kg/ha in the 1990s (CMDT in Droy 2011).

Other data are less conclusive in relation to changing yields at the national scale (Table 1). It is more relevant to examine each region individually. Unfortunately, recent information on changing yields in Koutiala and Bougouni cercles is not accessible.

Nevertheless, as shown in Chapter 5 of this report, conventional cotton producers in Koutiala have lower yields than cotton producers in Bougouni, despite making heavier use of organic inputs (manure, compost, household waste) than producers in Bougouni. This finding is another indicator of more severe degradation in Koutiala than Bougouni.

TABLE 1:

Change in cotton seed production over 10 seasons (Maiga 2019)

Campagnes	Nombre Exploitations	Superficies (ha)	Production (T)	Rend (Kg/ha)
2008/2009	83 993	196 779	201 462	1024
2009/2010	101 814	250 294	229 023	915
2010/2011	106 968	281 951	243 582	864
2011/2012	161 368	477 817	445 314	932
2012/2013	166 718	521 436	449 646	862
2013/2014	162 755	480 541	440 027	916
2014/2015	166 524	539 652	548 696	1017
2015/2016	169 697	545 308	513 554	942
2016/2017	191 719	656 085	647300	985
2017/2018		674 704	725 000	1011

Pendant les dix dernières campagnes, la production cotonnière a connu un accroissement régulier au Mali. Elle est passée de 201 462 tonnes en 2008/2009 à 725 000 tonnes en 2017/2018.Les Rendements sont restés faibles.

Together, the three indicators of land degradation (soil organic carbon, primary productivity and land cover change) show a negative trend in land condition. The soils are more degraded in Koutiala, with no sign of improvement. In Bougouni, the soils will degrade further in the absence of preventive measures to improve the sustainability of cropping systems and reduce pressure from deforestation. To achieve land degradation neutrality, SDG 15.3 to which Mali has committed, the country must put an end to degradation in Bougouni and Koutiala or find ways to offset the losses of SOC, forest cover and yields by restoring land elsewhere.

05 Economics of conventional and organic cotton production

This section analyses and compares the economics of typical cotton producers in Koutiala and Bougouni, taking account of private and societal costs.

5.1. Methodology

The data come from four surveys, including two carried out with conventional cotton producers in Koutiala and Bougouni. A complementary survey was conducted with the CMDT in Bougouni to get a very precise estimate of the inputs it supplies to farmers, particularly herbicide, lime, insecticides and phosphate. Another survey was also conducted amongst organic cotton producers in Bougouni. There are practically no organic cotton producers in Koutiala.

Preparation of the survey questionnaire and data collection

The survey of farm households took place in March 2019 in Bougouni cercle and September 2019 in Koutiala cercle. Individual interviews were held at respondents' homes by a team of five interviewers, recruited for their command of French and the local language. Interviews lasted an average of 45 minutes. The surveys were conducted in Koutiala cercle and in the CMDT area of M'Pessoba (6122 farms), specifically in three agricultural production zones (ZPAs):

- Three villages were selected in the Zandièla ZPA: Zandièla I, Zandièla II and Zandièla Koko;
- Four villages were selected in the Dèbèla ZPA: Bramana, Dèbèla, Songuela I and Songuela II; and
- Four villages were selected in M'Pessoba : Dindiola I, Dindiola II, Nankorola and M'Pessoba I.

Farms were sampled at random based on the list of cotton farms in those villages. A random sample of 150 organic cotton producers and 160 conventional producers was surveyed in Bougouni. In Koutiala, 300 conventional cotton producers were questioned.

Methodology of the economic assessment

To assess the private and societal profit on cotton production, the surveys were designed to estimate household income from cotton production, as well as government expenditure and the cost of illness (COI) from pesticide use, for the agricultural season from June 2018 to March 2019. To do this, the standard land use budgets and COI approach were used, based on which the private profit (1) and societal profit (2) equations were developed:

Equation 1:
Non-adjusted private profit = $\sum pi * qi - \sum pj * xj$

Equation 2:
Societal profit = $\sum pi * qi - \sum pj * xj - \sum Ek - \sum Sk$

Here, private profit is income (price p multiplied by quantity q of all products) less total costs (price multiplied by quantity of all inputs purchased, such as seeds, pesticides, NPK fertilizers or wage labour). Costs to the public treasury, in terms of subsidies (S) inputs and illness-related costs for the farmer (E) are deducted to estimate societal profit from cotton production.

5.2. Illness costs resulting from direct exposure to pesticides

Although growing cotton generates jobs and income for many families, there are many risk factors, including pollution and danger to human health due to overuse of phyto-sanitary products. Cotton is susceptible to various diseases and pests. To combat these, the CMDT, which supervises conventional cotton production, advocates an average of four treatments of phyto-sanitary products per growing cycle (Banque Nationale de Développement Agricole 2014). According to the household survey undertaken as part of this project, the main products used are: Califan, Emifort, Alcator, Mofanto, Avonte, Aligator – a significantly shorter list than that of cotton producers in Benin, who obtain at least half their products on the black market (Westerberg et al. 2017).

Use of these chemicals causes contamination of the soils, water and living organisms at the time of application and then from product residues. Pesticide residues have been found in the well water and close to homes in cotton production areas in Mali (Dem, Cobb & Mullins 2007). Apart from environmental pollution, pesticide use also has a harmful effect on human health (Droy 2011) and farmers often experience health problems, as demonstrated by numerous studies on the subject (Sunding & Zivin 2000; UNEP 2013). Due to lack of training or lack of resources, producers often do not use these pesticides correctly: failure to wear masks or use the appropriate equipment during application; products kept in places accessible to children; empty packaging thrown into the fields, buried in the soil or reused for domestic purposes (Thiam & Sagna 2009). The COI approach serves to estimate the costs of illness resulting, for example, from pollution, food contamination or water contamination (Roberts & Sockett 1994; Harrington, Krupnick & Spofford, Jr. 1989). The COI approach is based on the notion that people are productive and contribute to the economy. When an illness strikes, this may not only entail direct medical expenses, but also loss of earnings. An illness prevented, therefore, means costs averted.

In the methodology described below, we account for costs that arise from acute short-term symptoms, as a result of spraying and handling pesticides over a one-year period. As the interviews were conducted at the beginning of 2019, farmers were asked about incidents relating to their health during the 2018/2019 cotton growing season. The questions were addressed solely to the interviewee (the head of the farm in around 70% of cases). The methodology does not include the costs of long-term illness (such as cancer) resulting from exposure to pesticides over several years.

5.3. Estimate of private cost during spraying or handling of phyto-sanitary products

Equations 3 - 7 show how the private costs caused by illness related to direct exposure to pesticides on spraying days have been calculated. The farmers were questioned about the number of days they went to the hospital, consulted a doctor or took medicines where they felt there was a direct link to spraying or handling pesticides. Based on the information gathered, the cost-of-illness was estimated for each affected individual. These estimates were then aggregated and divided by the number of persons, to obtain an average estimate per affected person and an average estimate for the population as a whole.

EQUATION 3

Hospital cost = Number of days hospitalization x (Cost of each day's hospitalization + costs of medicines per day) + Annual cost of laboratory analyses

EQUATION 4

Expenses relating to consultation of a traditional practitioner =
Number of consultations x (Overall cost per consultation + Transport cost per consultation) + Cost of foods prescribed during the year

EQUATION 5

Expenses relating to consultation of a doctor =
Number of consultations x (Overall cost per consultation + Transport cost per consultation)

EQUATION 6

Expenses relating to purchase of medicines during the application period =
Days under medication x amount spent on medicines + Cost of travel to the **pharmacy** over the year + Cost of self-medication

EQUATION 7

Expenses relating to the need to take on someone from outside due to inability to work =
Number of days employment of wage labour x average daily wage

06

Results of the analysis

6.1. Descriptive data on households

Looking at Tables A2.1 and A2.2 (Appendix 2), it can be seen that the majority of people in the surveyed households were born in their own cercle (65% for Bougouni and 75% for Koutiala). They are almost all Muslim (between 94 and 97%) and ethnic Bambara (65% in Koutiala and up to 90% for organic producers in Bougouni). This is a very different situation to that found in Benin, where organic cotton producers are ethnic Peul. The heads of family are illiterate in 37-55% of cases; Koutiala has the highest level of literacy. Amongst respondents, 15% of organic cotton producers are women and between 0.3% and 6% of conventional producers are female. In most cases, the persons interviewed are heads of family.

The average age of the household head is 54 years in Koutiala and 48 in Bougouni. Each household comprises an average of 22-23 members; as for age distribution per household, children under 15 account for 8 to 12% of household members. The average size of farms is 12 ha in Koutiala and 14 ha in Bougouni. Cotton is grown on 30% of the farms' land. A conventional cotton producer cultivates an average of 3 ha in Koutiala and 4 ha in Bougouni; the average area used to grow organic cotton is 0.7 ha. As regards other crops, the remaining area is mainly given over to maize, millet and sorghum.

6.2. Cotton production yields in Bougouni and Koutiala

Figures 3, 4 and 5 show the distribution of cotton yields between organic (Bougouni) and conventional (Koutiala and Bougouni) cotton producers respectively for the 2018/2019 season. Figure 3 shows that conventional cotton producers in Bougouni had average yields of 435 kg/ha, while according to Figure 4 conventional cotton producers in Koutiala produced an average of 950 kg/ha. According to Figure 5, an average of 1050 kg/ha was produced by conventional methods in Bougouni. It should be noted that the yields reported by the input supplier (CMDT) for each farmer in Bougouni differ from the yields reported by the farmers themselves during the household surveys, a result that the authors of this study cannot explain. The average yield of 1050 kg/ha is, however, the same for both samples.

FIGURE 3:

Distribution of yields of organic cotton producers in Koutiala

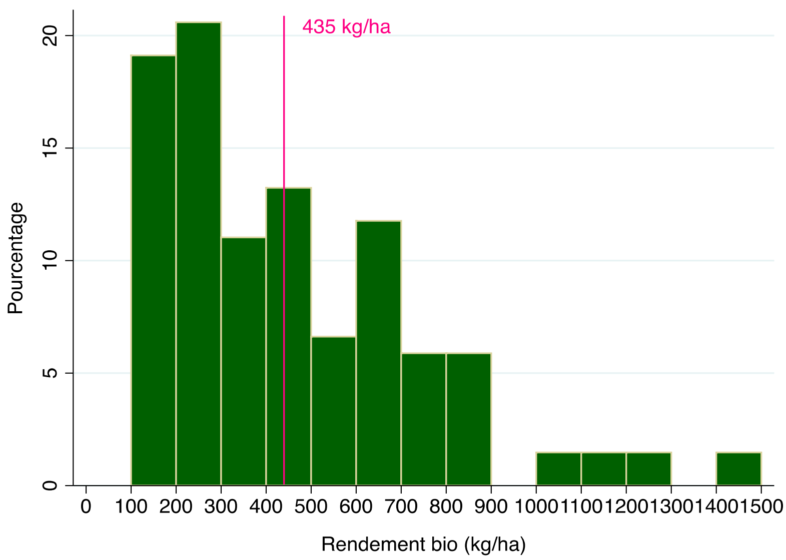


FIGURE 4:

Distribution of yields of conventional cotton in Bougouni (household survey)

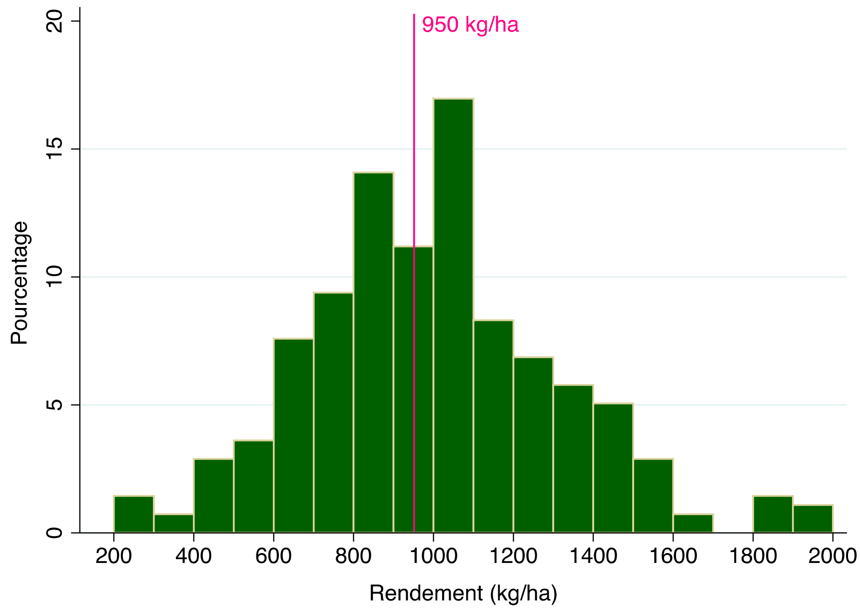
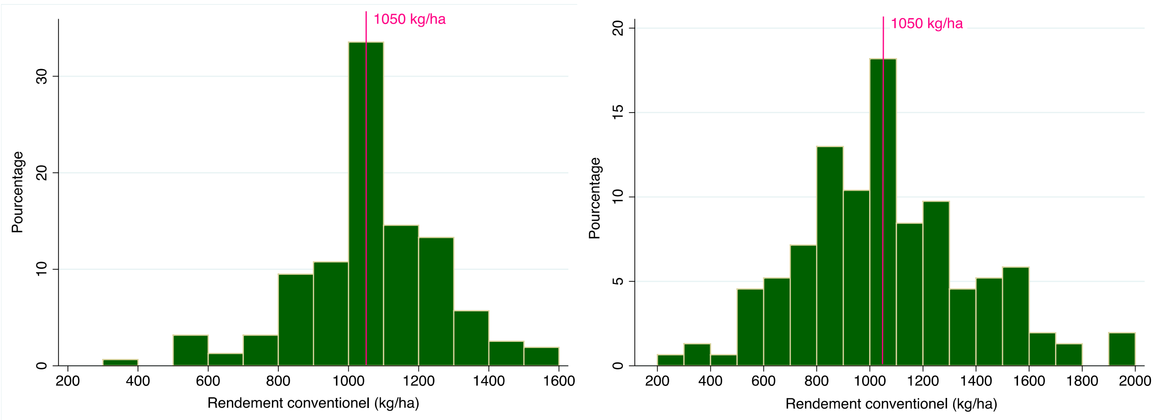


FIGURE 5:

Distribution of yields of conventional cotton producers in Bougouni, a) according to CMDT data and b) according to the household survey for the same households



6.3. Comparison of the economics of cotton production between conventional and organic cotton producers

It is important to compare producers with a similar asset base to get an objective, comparable view of cotton producers. To do this, a typology close to that used by the CMDT since 1980 (Djouara, Bélières & Kébé 2006) was adopted. Based on possession of traction equipment, three types of farms have been identified:

- Type A (well-equipped): comprising farms owning 10 or more head of cattle, with at least two pair of draught oxen;
- Type B (equipped): farms owning between two and nine head of cattle and one animal traction unit;

- Type C (less well-equipped): farms with only incomplete traction equipment (fewer than two head of cattle).

Table 2 shows the proportion of type A, B and C producers in the three surveys. Type B producers represent the majority of farmers in the three cases and so can be easily compared. Appendix 1 shows the profits of the three types of producer. Overall, for both conventional and organic producers, type A producers earn more than type B producers who do better than type C producers (A>B>C), but the difference in earnings is not very large (around FCFA 1000- 5000/ha).

TABLE 2:

Types of producers or farming unit

Table 3	Type A	Type B	Type C
Bougouni organic	24%	58%	19%
Bougouni conventional cotton	28%	61%	11%
Koutiala conventional cotton	31%	40%	30%

6.4. Farmers' non-adjusted private profit

As shown in Appendix 2 (Table A2.1), households in Koutiala devote an average of 3 ha to cotton production. For type B producers with a yield of 950 kg/ha sold at FCFA 255/kg, average takings for the 2018/2019 season were FCFA 242,000/ha. Around 60% of this amount is spent on agricultural inputs (pesticides, fertilizer, NPK, urea, etc.). The profit from cotton is therefore around FCFA 97,850/ha for the average farmer (Table 8). A conventional cotton producer in Bougouni devotes an average of 4 ha to growing cotton. Revenue is in the region of FCFA 267,750/ha and expenditure on inputs is lower than for producers in Koutiala. The net profit per hectare is therefore in the region of a considerable FCFA 147,430/ha.

Finally, organic cotton producers have low yields, with equally low expenditure; their profit is around half that of conventional cotton producers in Bougouni. It should be remembered, nevertheless, that conventional cotton production also generates costs for the State and the farmers themselves; these costs need to be counted toward establish society's interest in a given production system. The next part of the study is devoted to this topic.

6.5. Input subsidies

The Malian government has subsidized cotton inputs since 2010/2011, in an attempt to re-launch the sector (Kone 2016). Presently, urea, NPK fertiliser and diammonium phosphate (DAP) are the most subsidized fertilizers in West Africa (excluding Nigeria, RECA Niger 2019). Since the 2017/2018 season, the price of a 50 kg sack of fertilizer in Mali has remained unchanged, at FCFA 11,000. This is in contrast to neighbouring countries, such as Niger, where the price of a sack of urea has risen from FCFA 13,500 in 2018 (subsidized price) to FCFA 16,700, and the price of a sack of NPK has risen from FCFA 13,500 to 15,900 (commercial non-subsidized price, RECA Niger 2019). Table 3 shows that urea and NPK fertilizer currently receive a 45% subsidy and PNG fertilizer a 64% subsidy.

Consequently, the CMDT covers between FCFA 5000 and FCFA 7000 of the undistorted international market price. Given how much producers use (three sacks of NPK, one sack of urea and an average of 0.1 sacks of DAP), subsidies for fertilizers amount to around FCFA 20,490 per hectare of cotton. With an area of around 700,000 ha devoted to cotton production, the State's contribution comes to around FCFA 14.3 billion per year.

TABLE 3:

Price of fertilizers with and without subsidy in Mali (FCFA) (RECA Niger 2019)

	Urea, 50 kg sack	NPK, 50 kg sack	Diammonium phosphate (DAP), 50 kg sack
Non-subsidized price to CMDT/public purse	16 000	16 000	18 000
Subsidized price to the producer (Mali)	11 000	11 000	11 000
Subsidy rate	45%	45%	64%

6.6. Result of the cost-of-illness analysis

When the IPR team went to the field in Bougouni in November 2018 to prepare for the household survey, many organic cotton producers reported that they had converted their production to organic mainly because of their health problems caused by conventional cotton production. The following section of this study estimates the costs related to acute illnesses caused by spraying phyto-sanitary products. It should be pointed out that there are also other illness-related costs in the long term or costs arising from weeks of illness after the end of spraying, but these effects on health are more difficult to attribute to the use of pesticides alone, so they were not taken into account.

6.6.1. Private costs of acute illness contracted during spraying or handling phyto-sanitary products

Table 4 shows the percentage of people in the sample who took medicines, were hospitalized or consulted a traditional practitioner or doctor and were unable to work at least once on or between spraying days, in Bougouni and Koutiala respectively. It was noted that 2% of respondents in Koutiala had been to the hospital at least once during the last season (2018/2019); only 2% had taken medicines and 5% had to take on a new farm labourer because they were unable to work. In Bougouni, 8% of respondents went to the hospital at least once during the last season (2018/2019) and only 3% had to take on a labourer because they were unable to work; 8% of the farmers questioned had taken medicines and 15% of the population had been affected by at least one of these conditions.

These percentages are considerably lower than those seen in an ELD study in Benin (Westerberg et al. 2017), which shows that 70% of the population was affected by one of these conditions: almost 24% of the people questioned had gone to the hospital at least once and 60% of the farmers questioned had taken medicines during application periods. The unregulated nature of the pesticide market in Benin (in 2015/2016) could be a possible explanation; in Benin, half of all medicines are obtained on the black market. In addition, the number of treatments per season is considerably higher in Benin, with between seven and eight applications, compared to four in Mali.

TABLE 4:

Proportion of the population incurring medical costs related to application of pesticides (2018/2019 season)

Proportion of the population incurring medical costs following spraying or handling of pesticides at least once during the 2018/2019 season	Koutiala	Bougouni
Hospitalization	2%	8%
Taking medicines	2%	8%
Consulting doctor	1%	4%
Consulting traditional practitioner	1%	2%
Employing someone from outside due to inability to work	5%	3%

Tables 5 and 6 provide estimates of the private costs arising from illnesses related to direct exposure to pesticides during spraying days. All the estimates are averages for the farmers concerned and the population as a whole (second column of the table). With regard to the health expenses incurred, it is clear that the most significant costs relate to hospitalization and taking medicines. For those who were hospitalized, the average total cost was FCFA 111,500/year in Bougouni and FCFA 140,500/year in Koutiala; this amount includes the costs of hospitalization, transport, laboratory analysis and treatment. Spending on medicines was around FCFA 55,663/year in Bougouni and FCFA 97,250/year in Koutiala.

By using a conservative estimate of the daily labour wage, the average loss of income due to inability to work, is approximately FCFA 14,875/year in Bougouni and FCFA 5333/year in Koutiala. Appendix 3.1 contains precise details of each item of expenditure (costs of consulting a doctor, transport cost, laboratory charges, etc.).

TABLE 5:

Private costs of illnesses caused by spraying or handling phyto-sanitary products in Bougouni (2018/2019 season)

	Day, consultation or average cost per household, whole population	Day, consultation or average cost per affected household	Min	Max
Days spent in hospital	0.6	6	1	33
Total hospitalization cost	12 856	140 500	0	1 250 000
Consulting traditional practitioner	0.02	1	1	1
Total cost of consulting traditional practitioner	196	10 000	0	20 000
Consulting doctor	0.1	2.2	1	5
Total cost of consulting doctor	825	21 060	0	57 880
Days' medical treatment	0.3	3.6	0	10
Total cost of medical treatment	4 002	55 663	1 800	32 000
Need to employ someone from outside due to inability to work (days)	0.4	13	1	30
Cost of employing farm labourer	372	14 875	0	45 000
Total cost per household	**18 269**	**133 103**	**0**	**1 250 000**
Implicit cost per ha*	4 565	33 276	0	312 500

**For an average household with 3 ha of cotton*

TABLE 6:

Private costs of illnesses caused by spraying or handling of phyto-sanitary products in Koutiala (2018/2019 season)

	Day, consultation or average cost per household, whole population	**Day, consultation or average cost per affected household**	**Min**	**Max**
Days spent in hospital	0.04	3	1	7
Total hospitalization cost	1 461	111 500	5 500	274 000
Consulting traditional practitioner	0.025	2.3	1	5
Total cost of consulting traditional practitioner	530	30 000	4 500	92 500
Consulting doctor	0.01	2.0	2	2
Total cost of consulting doctor	245	27 600	16 080	39 120
Days' medical treatment	0.2	8.6	1	30
Total cost of medical treatment	1 729	97 250	2 500	300 000
Need to employ someone from outside due to inability to work (days)	0.3	10	2	20
Cost of employing farm labourer	1 143	5 333	1 000	10 000
Total cost per household	**3 290**	**130 671**	**5 000**	**325 000**
Implicit cost per ha	1 100	42 150	1 613	104 839

When the costs of illness are added together, the annual cost amounts to around FCFA 133,103 per affected household per year in Bougouni and FCFA 130,671 per affected household per year in Koutiala. For the whole population, the annual average cost is around FCFA 18,269 per household per year in Bougouni and FCFA 3290 per household per year in Koutiala. As farmers have an average of between three ha (Koutiala) and four ha (Bougouni) of conventional cotton (see Appendix 2), the overall cost was divided by those areas in order to estimate the value of the damage caused by the application of pesticides to one ha of cotton.

Table 7 shows the distribution of revenue, costs and profits for conventional and organic cotton producers. The societal profit takes into account the cost of the impact on health and public expenditure, amounting to:

- FCFA 74,341/ha for conventional cotton producers in Koutiala;
- FCFA 119.334/ha for conventional cotton producers in Bougouni; and
- FCFA 80,656/ha for organic cotton producers in Bougouni (based on a price of FCFA 300/kg, which is the theoretical price of organic cotton, although the majority of producers have either never received the premium or received it late).

These results are discussed in the next chapter.

TABLE 7:

Revenue, input cost, illness cost, subsidy cost, non-adjusted profit and societal profit of conventional and organic cotton production

		Koutiala - conventional producers		Bougouni – conventional producers		Bougouni - organic producers		
		Average	**Min-Max**	**Average**	**Min-Max**		**Average**	**Min-Max**
	Yield (kg/ha)	**950**	**200-2000**	**1050**	**540-1420**	**Yield (kg/ha)**	**445**	**100-1500**
	Revenue (FCFA/ha)	**242250**		**267750**			**133500**	
	General inputs	**Qty/ha**	**FCFA/ha**	**Qty/ha**	**FCFA/ha**	**General inputs**	**Qty**	**FCFA/ha**
Data from household questionnaire Bougouni and Koutiala	Tractor hire (per ha)	0.06	1571	0.5	9150	Tractor hire (per ha)	0.5	5721
	NPK (50 kg sacks)	3.0	34950	3.1	36398	Neem seed (kg)	5	1495
	Urea (50 kg sacks)	1.1	12842	1.2	14597	Biopesticides	2.7	6252
	Wage labour (days/tasks)	6.8	2977	10	7201	Wage labour	8	1750
	Seeds (kg)	36.0	1179	36.0	91	Seeds	46	1114
	Manure (wheelbarrows)	5.0	10000	1.8	3354	Manure (wheelbarrows)	3.4	4758
	Compost (wheelbarrows)	21	31619	1.2	2439	Compost (wheelbarrows)	11	13254
	Household waste (wheelbarrows)	10	10550	4.2	7440	Household waste	18.5	18500
	Penning of animals (head of animals)	0	0	1.2	106	Penning of animals	0	0
	Total		**105688**		**81606**			**52844**
	CMDT inputs	**Qty/ha**	**FCFA/ha**	**Qty/ha**	**FCFA/ha**			**FCFA/ha**
CMDT data Bougouni	DAP (50 kg sack)	0.07	1407	0.07	1407			
	Lime	0.5	1530	0.5	1530			
	Insecticides (Gi)	2	10083	2	10083			
	Insecticides (Gii)	3	15120	3	15120			
	Fungicides	0.6	1106	0.6	1106			
	Pre-harvest herbicides	0.5	2552	0.5	2552			
	Post-harvest herbicides	0.5	3644	0.5	3644			
	Total herbicides	1	3274	1	3274			
	Total CMDT costs		**38715**		**38715**			**0**
	Total input costs		**144402**		**120320**			**52844**
	Cost of input subsidies		**22407**		**23848**			**0**
	Cost of illness		**1100**		**4567**			**0**
	Societal and private profit		**FCFA/ha**		**FCFA/ha**			**FCFA/ha**
	Private profit per hectare (farmers)		**97848**		**147430**			**80656**
	Societal profit per hectare		**74341**		**119014**			**80656**

6.7. Discussion of the results

6.7.1. Comparison of conventional cotton producers

Conventional cotton producers in Bougouni have higher yields (around +10%) and therefore higher per hectare incomes than cotton producers in Koutiala. This is in line with expectations, though the difference was not marked as was predicted.

The survey results (Table 7) reveal that conventional cotton producers are able to maintain reasonable yields in Koutiala because they use more organic fertilizers than cotton producers in Bougouni. The assessment includes use of household waste, compost and manure by farmers in terms of wheelbarrows per hectare, as well as the farm gate market price of a wheelbarrow. On average, a wheelbarrow of household waste is sold at FCFA 1000, a wheelbarrow of manure at FCFA 2000 and a wheelbarrow of compost at FCFA 1500. **A 'type B' producer in Koutiala uses an average 31 wheelbarrows of household waste, compared to seven in Bougouni**. As a result, farmers in Koutiala have higher production costs than farmers in Bougouni and therefore lower profits. Regarding expenditure on insecticides (GI), herbicides, PNG and lime[6], conventional cotton producers spend an average of FCFA 36,000 per hectare on these inputs (Table 7).

Although conventional cotton producers in Bougouni have higher private profits than cotton producers in Koutiala, many fear that it is only a matter of time before soils in Bougouni are as exhausted as those in Koutiala and farmers will have to increase their investments in organic fertilizer inputs to maintain their yields.

When accounting for health costs and costs associated with subsidizing agricultural inputs, the benefits from a societal point of view are considerably reduced for conventional cotton producers.

6.7.2. Comparison of organic and conventional cotton producers

Organic cotton producers have yields half the magnitude of those of conventional cotton producers, but their expenditure on inputs is also considerably lower (around FCFA 52,800/ha, compared with a cost of between FCFA 120,000 and 140,000/ha for conventional producers in Bougouni). Although organic farmers' inputs are not subsidized, they do not face any health problems from growing organic cotton. It is therefore relevant to point out that, although organic cotton producers have low yields compared with conventional (type B) producers, on average each hectare of organic production contributes as much to the Malian economy as conventional production in Koutiala. Figures 6, 7 and 8 illustrate these findings.

6 Data obtained through discussions with the CMDT in Bougouni.

FIGURE 6:

Costs, yields, private profit and societal profit of conventional cotton production in Bougouni

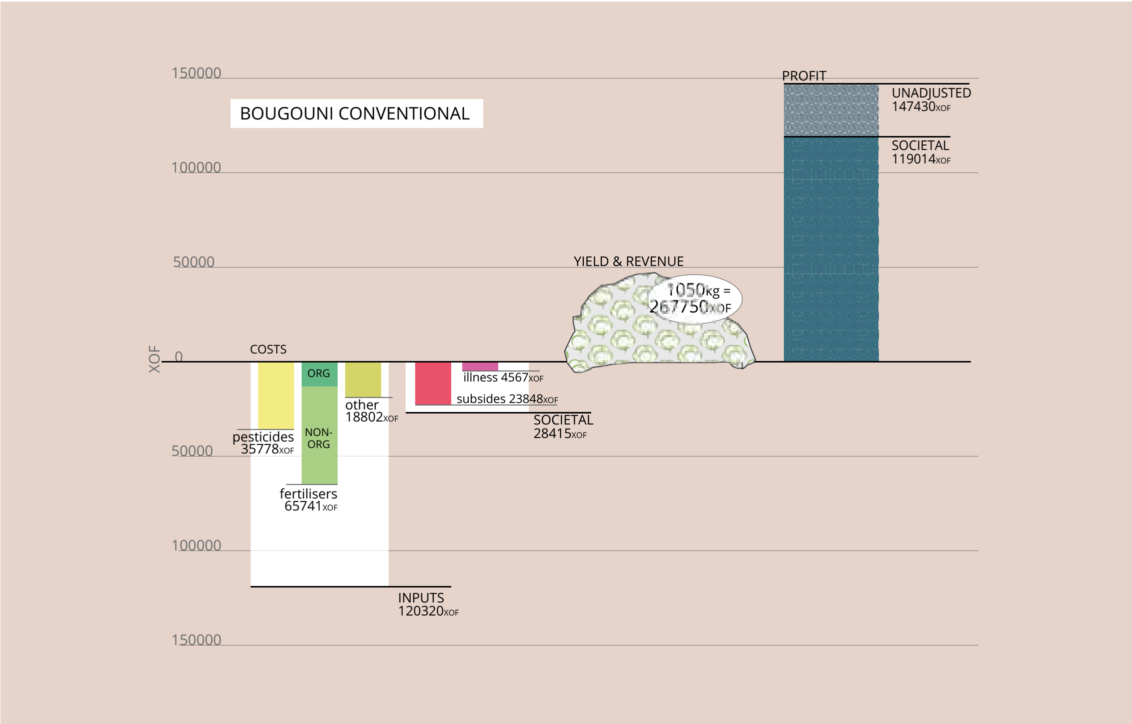


FIGURE 7:

Costs, yields, private profit and societal profit of conventional cotton production in Koutiala

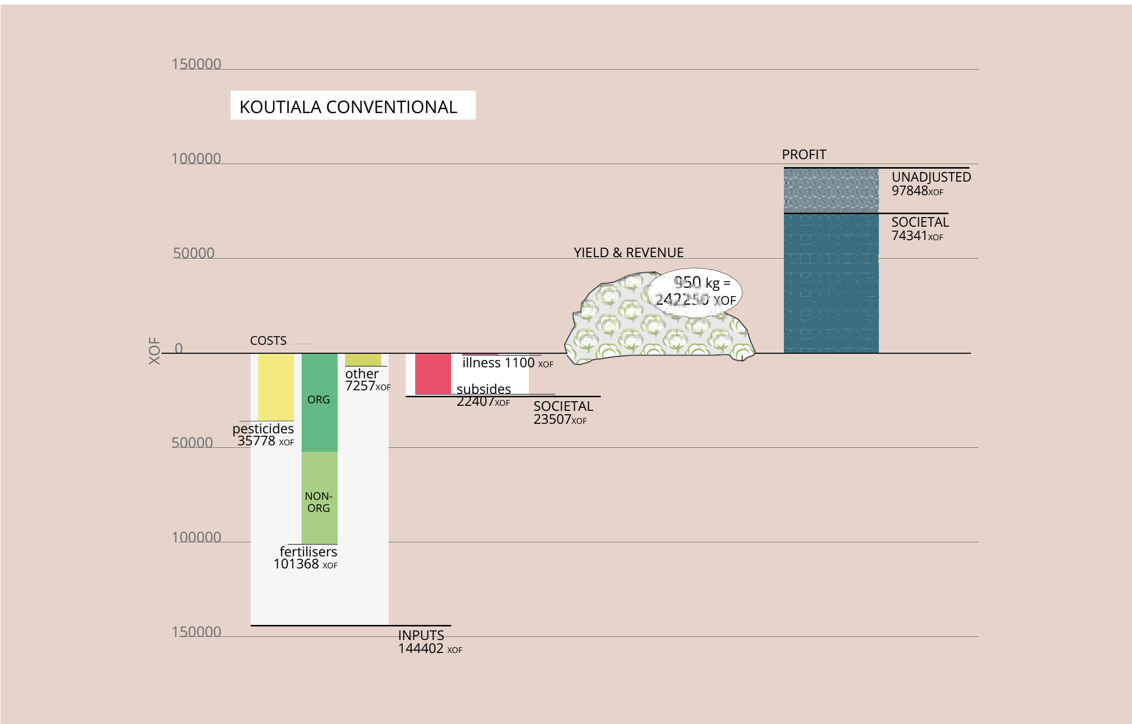
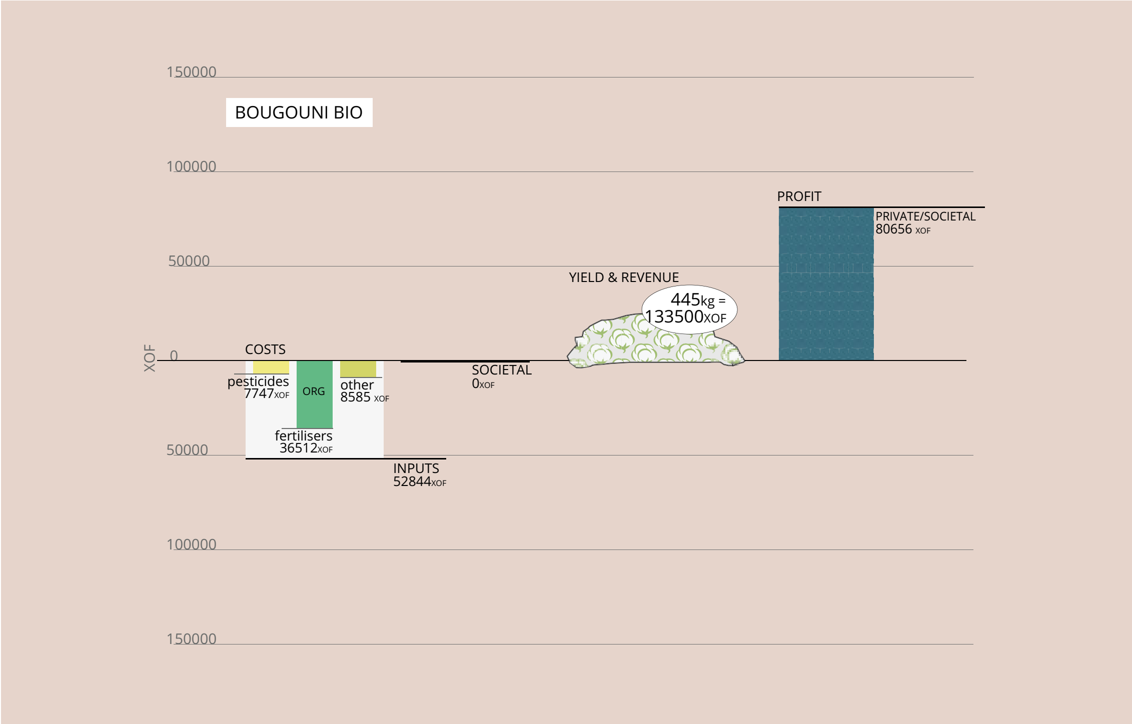


FIGURE 8:

Costs, yields, private profit and societal profit of organic cotton production in Bougouni



Moreover, it is clear that organic cotton producers could improve their yields. Figure 3 shows that some succeed in obtaining yields of up to 1500 kg/ha. The following section of the study analyses the determinants of productivity amongst organic and conventional cotton producers; the analysis is based on producers' existing practices.

07

Determinants of productivity for cotton producers

This part of the study focuses on how yields are affected by differences in cropping practices for each type of producer (A, B and C). For this purpose, all variables available to the authors relating to farmers' practices and use of inputs were used to predict yields. Many inputs and many practices were non-significant, which could be attributed to an inadequate number of observations, an imprecise explanation of the quantities of inputs used during the data collection phase, the fact that the data input had no real influence on yields or to a strong correlation between certain explanatory variables (such as the quantity of manure and the household's number of cattle). These inputs and practices were excluded from the analysis. The next paragraph therefore concentrates on the variables helping to explain farmers' yields (at a 90% confidence level).

The functions which best describe the production processes of conventional and organic cotton producers in Koutiala and Bougouni are detailed in Equations 8, 10 and 11 and the explanatory variables in Tables 8a, 9a et 10a. They are estimated using the classic least squares method, with a robust standard error. The F-test of each of the three models confirms that the regression factors are jointly and significantly different from zero.

The cotton production function for organic cotton producers is as follows:

Equation 8) Yield = 221 + 5.3 Waste + 109.6 AGF + 28.3 BOVIN -230 PA + 176 PP + ε_i

TABLE 8A:

Variables used in the regression analysis of organic producers

Variable	Explanation of variable	Min	Average/ usage rate	
Waste	Wheelbarrows household waste per ha	0.0	120	15.8
AGF	Farmer practising agroforestry (yes)	0.0	1	31%
BOVIN	Head of cattle owned by household	0.0	12	2.8
PA	Grazing of harvest residues by livestock of another household (yes)	0.0	1	25%
PP	Grazing of harvest residues by own livestock? (yes)	0.0	1	29%
PAP	Grazing of harvest residues by own livestock and livestock of another household	0.0	1	23%

TABLE 8B:

Results of regression analysis for organic producers in Bougouni

Yield	Coef. Value	t	P>t
Waste	5.3	5.02	0.00
AGF	109.6	2.05	0.04
BOVIN	28.3	2.48	0.01
PA	-230.2	-2.81	0.01
PP	176.4	2.11	0.04
Constant	220.7	5.71	0.00

#observations: 147, F=8.13, Prob>F=0.000, adjusted R2=0.26

The cotton production function in Koutiala for conventional cotton producers is as follows:

Equation 9) Ln (Revenue) = 11.9 + 0.112 AGF + 0.162 LEG + 0.000012 NPK + εi

TABLE 9A:

Variables used in regression analysis of conventional cotton production in Koutiala

Variables	Explanation	Average	Min	Max	Usage rate
LEG	Farmer using legumes (yes)	0.04	0	1	4%
AGF	Farmer practising agroforestry (yes)	0.22	0	1	22%
FUM	Wheelbarrows of manure	6.7	0	60	52%
NPK	Expenditure on NPK fertilizer per ha	35 170	6 663	81 620	100%

TABLE 9B:

Results of regression analysis for conventional cotton producers in Koutiala

Ln (yield)	Coef. Value	t	P>t
AGF	0.112	2.280	0.02
LEG	0.162	1.840	0.07
FUM	0.005	2.720	0.01
NPK (in FCFA '000)	0.012	2.700	0.01
Constant	11.89	75.24	0.00

#observations: 280, F=5.14, Prob>F=0.0002, adjusted R^2=0.12

The cotton production function in Bougouni for conventional cotton producers is as follows:

Equation 10) Revenue = 179200 + 1.8 Urea + 1.4 NPK + 1645 FUMCOMDEC + ε_i

TABLE 10A:

Variables used in regression analysis of conventional cotton production in Bougouni

Variables	Explanation	Average	Min	Max	Usage rate
FUMCOMDEC	Wheelbarrows of manure, household waste or compost used per ha	7.5	0	55	67%
NPK	Expenditure on NPK per ha	35 924	5 825	69 900	100%
UREA	Expenditure on urea per ha	14 079	1 940	46 600	100%

TABLE 10B:

Results of regression analysis for conventional producers in Bougouni

Ln (yield)	Coef. Value	t	P>t
UREA	1.8	1.84	0.067
NPK	1.4	2.14	0.034
FUMCOMDEC	1 645	2.04	0.043
Constant	179 200	7.47	0

#observations: 151, F=8.8, Prob>F=0.0000, adjusted R^2=0,10

7.1. The productivity of organic cotton farmers

From Table 8b, it can be seen that the key determinants of cotton yields in the case of organic producers are the number of cattle on the farm (as they supply a considerable amount of manure), the quantity of organic household waste, the practice of agroforestry and the grazing of crop residues. Biopesticides and use of the seeds of *Azadirachta indica* (neem) were non-significant in the model below[7]. Adjusted R^2 shows that around 26% of the variation in the dependent variable (yield and revenue) can be explained by the model.

The impact of these practices on yields is shown in Figure 9 below, in relation to a type B organic cotton producer (for the sake of illustration). Type B organic farmers use an average of 18 wheelbarrows of household waste and have four head of cattle. In these circumstances, if they use the animals from another household c (Figure 9), they can expect a very low yield (200 kg/ha). If they only use their own animals, their yield is significantly higher (608 kg/ha).

Agroforestry can help to obtain a higher yield (+107 kg/ha). Cotton producers usually have between a minimum of 10 trees/ha (typically locust bean and shea) and a maximum of 30 trees/ha. It may therefore be expected that farmers who explicitly declare that they practise agroforestry would have an average of 20 trees/ha. The average yield of a type B organic cotton producer is 378 kg/ha without agroforestry practices and 487 kg/ha with agroforestry practices. Farmers practising agroforestry can also harvest timber and non-timber forest products, such as fruit (mango, locust bean), pods for fodder (from *Acacia albida*) and nuts (such as shea), allowing them to generate additional income, as explained in Box 3.

7 In another model (of lesser statistical significance) use of neem seeds improves agricultural productivity.

FIGURE 9:

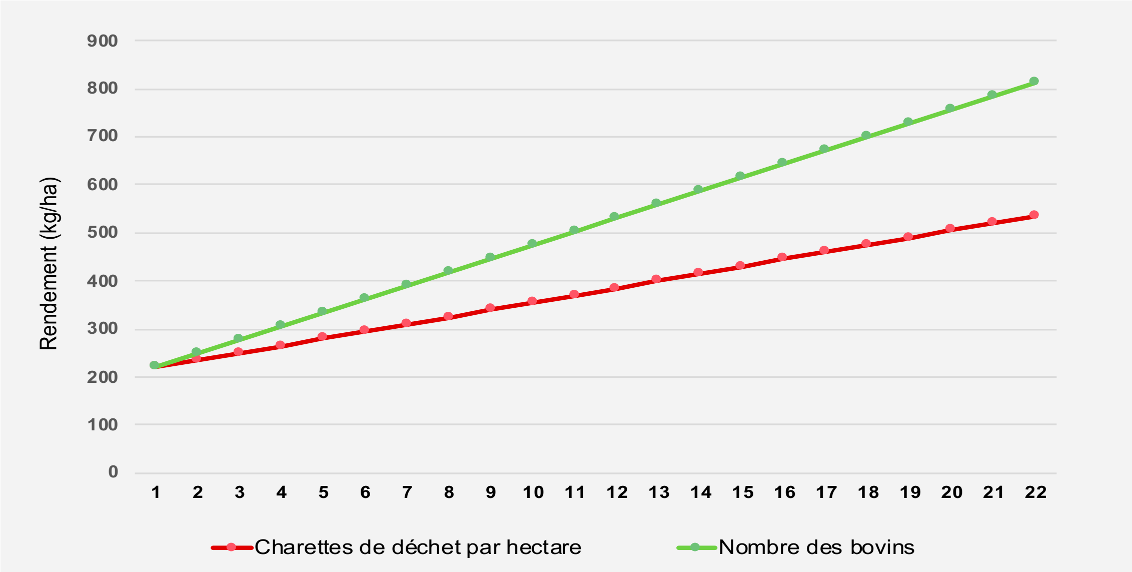
Yield according to agricultural practice and combination of practices, organic producers

Finally, organic household waste, together with cattle (and their indirect contribution in terms of dung), represents a significant source of additional organic inputs. Figure 10 shows that approximately six additional wheelbarrows of organic household waste or three additional head of cattle enable farmers to increase their cotton yields by 100 kg/ha.

Organic cotton producers typically have between 0.5 and 1 ha of land under organic cotton production, out of a total farm size of 13 hectares (Table A2.2 Appendix 2). Manure and livestock will therefore also be used in other parts of the farm. The true contribution of cattle numbers to farm productivity is therefore likely to be higher.

FIGURE 10:

Yield and contribution of organic matter, organic producers



7.2. The productivity of conventional cotton farmers

The production function, which best describes the productivity of conventional cotton producers in Koutiala, is shown in Equation 9 and Table 9b. In this production function as well as that of conventional cotton producers in Bougouni, revenue was used as a dependent variable (in place of yields), to better illustrate the relationship between expenditure on agricultural inputs and production value.

7.2.1.Koutiala

As in the case of organic cotton producers, agroforestry makes a positive contribution to cotton yields in Koutiala: farmers who practise agroforestry have FCFA 25,882 in additional revenue, the equivalent of an additional yield of 102 kg of cotton/ha (Table 11). This is similar to the results found in the case of organic cotton producers (an average increase in yield of 107 kg/ha), which confirms the significance of agroforestry in improving agricultural productivity. Furthermore, the results show that growing legumes (such as soya, groundnuts and cowpeas) in rotation with the cotton crop makes a positive contribution to productivity: farmers who adopt this practice can expect to see an average increase of 150 kg/ha in cotton yields.

TABLE 11:

Revenue and yields for conventional cotton producers in Koutiala, from zero inputs to a package of measures

	Zero manure, zero NPK, zero agroforestry	+5 wheelbarrows of manure	+1 sack of 'NPK	+agroforestry	+use of legumes, AGF, NPK, manure
Revenue (FCFA/ha)	147 267	150 911	167 680	193 562	227 655
Yield (kg/ha)	578	592	658	759	893
Additional yields		14	80	182	315
Additional revenue		3 644	16 769	25 882	34 093
Cumulative additional revenue		3 644	20 413	46 296	80 389

As suspected, use of inorganic fertilizers also has positive results. For each additional sack (of 50 kg NPK), producers can expect an increase in revenue of FCFA 16,760/ha or an additional yield of 64 kg/ha. The unsubsidized international price of a sack of fertilizer is FCFA 16,000: this means that the gain for the farmer in terms of additional revenue is more or less equal to the additional expenditure incurred by the Malian State (CMDT + farmer) in purchasing that sack.

The importance of applying a "package" of measures to increase yields should also be recognized. Notably, it is by going from a minimal effort (no use of inputs) towards the application of both organic and inorganic fertilizers, agroforestry practices and use of legumes in rotations, that yields can increase by 315 kg/ha (see Table 11).

FIGURE 11:

Revenue and agricultural practices, conventional producers in Koutiala

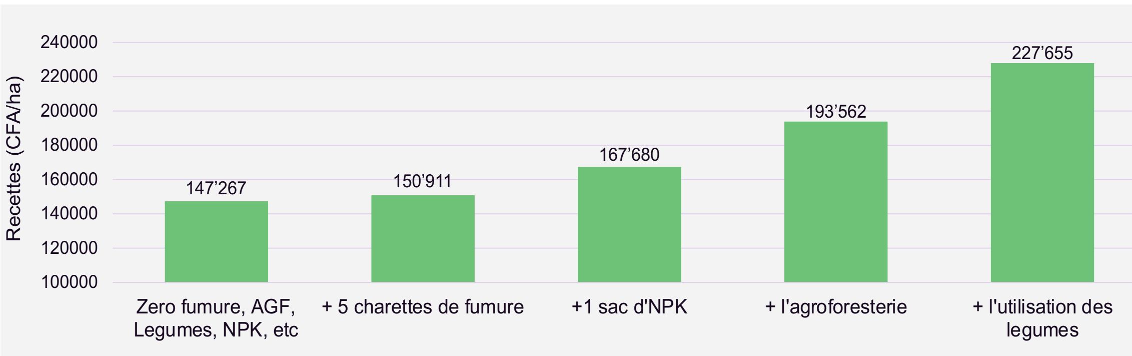


FIGURE 12:

Link between revenue per hectare and inorganic fertilizer (NPK) for conventional producers in Koutiala

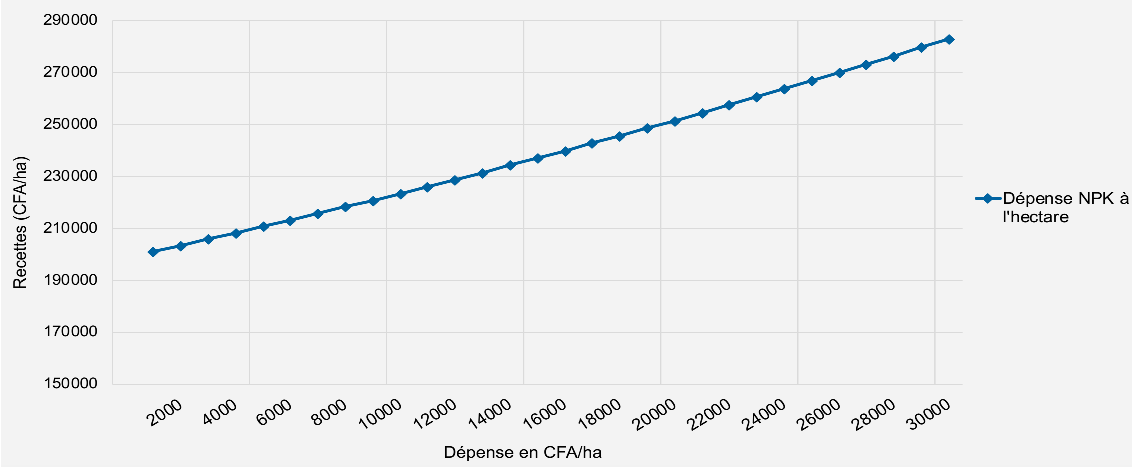
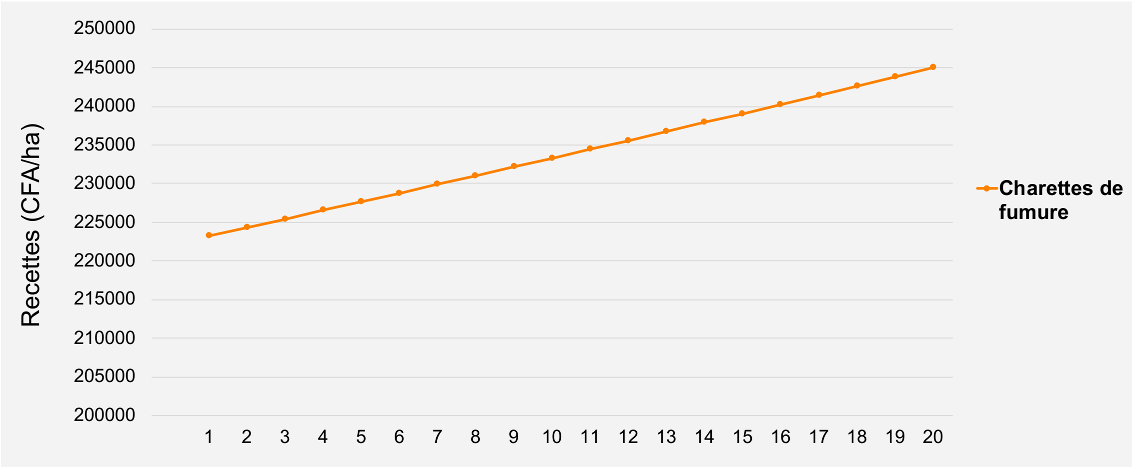


FIGURE 13:

Link between revenue per hectare and use of manure for conventional producers in Koutiala



7.2.2. Bougouni

Finally, for conventional cotton producers in Bougouni, use of urea and NPK fertilizers makes a positive contribution to yields and revenue, as expected. An additional sack of NPK increases revenue by FCFA 16,150/ha and an additional sack of urea increases income from crops by an average of FCFA 21,435/ha.

In Bougouni, farmers use fewer inputs in the form of household waste, manure and compost than in Koutiala (Table 12). Consequently, these three sources of organic fertilizer have been grouped together in a single variable in order to have enough observations to ensure a degree of statistical robustness within the regressions. The results show that, on average, for each additional wheelbarrow of manure, household waste or compost, farmers can increase their revenue by FCFA 1645 / ha (Table 9b), or around 7 kg of raw cotton per ha. This is in line with the market value of these inputs, sold for between FCFA 1000 and FCFA 2000 per wheelbarrow.

TABLE 12:

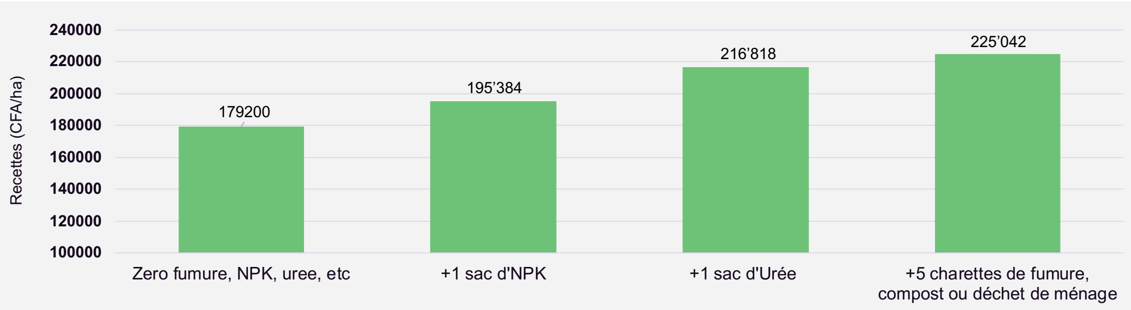
Revenue and yields for conventional cotton producers in Bougouni, from zero inputs to a package of measures

	Zero manure, NPK, urea, etc.	+1 sack NPK	+1 sack urea	+5 wheelbarrows of manure, compost or household waste	+25 wheelbarrows of manure, compost or household waste
Revenue (FCFA/ha)	179,200	195,384	216,818	225,042	266,158
Yield (kg/ha)	703	766	850	883	1,044
Cumulative additional yields		63	148	180	341
Additional revenue		16,184	21,435	8,223	41,117
Cumulative additional revenue		16,184	37,618	45,842	86,958

According to Figure 14, conventional cotton producers in Bougouni have higher revenue (FCFA 179,200/ha) and yields (703 kg/ha) without effort and without using additional inputs, in comparison with producers in Koutiala (FCFA 147,267/ha; 578 kg/ha). This confirms that the soils are more degraded in Koutiala than Bougouni.

FIGURE 14:

Link between revenue per hectare and use of manure for conventional producers in Bougouni



7.3. Summary of determinants of cotton productivity

The regression analyses of land productivity show that conventional inputs (NPK, urea) make a positive contribution to yields and revenue, corresponding approximately to between FCFA 16,000 and 20,000 in additional revenue for each 50 kg sack of NPK and urea (at FCFA 16,000 non-subsidized). As such, these inputs provide farmers with added value equivalent to the cost of their financing by society. In this context, it is important to stress the existence of local solutions not requiring the import of inputs (to the detriment of Mali's trade balance). Manure, household waste and compost are very important for productivity, together with agroforestry and use of leguminous plants: without the latter, the farmer can neither realize the full potential of his production nor ensure soil fertility in the long term.

Finally, taking into account the cost of subsidies and costs of illness related to use of phyto-sanitary products, cotton producers in Koutiala generate a societal profit similar to that of organic cotton producers, whose production involves no negative externalities. Conventional cotton producers in Bougouni currently achieve the highest private and societal profits, but unless preventive land degradation measures are taken today, such profits may be compromised in the future.

7.3.1 Limitations

In view of the differences between the information provided by farmers during the household surveys in Bougouni and that provided by the CMDT for the same farmers (concerning areas under cotton and quantity of inputs purchased), it was not possible to merge these data and analyse the contribution of pesticides, lime and DAP to agricultural yields.

Although this study was able to collect relevant data from conventional and organic farmers, it would be interesting to carry out an in-depth survey of a larger sample of farmers and account for the use of pesticides and tree density in agroforestry systems. The production functions in this study explain between 10% and 26% of the variation in yields, which is acceptable, but other exogenous factors such as pesticide use have yet to be taken into account.

Box 3: Value of agroforestry

In the household survey, 20 - 30% farmers said they practised agroforestry. These farmers have yields around 110 kg/ha higher than farmers who do not practise agroforestry. It is common practice to have 10 trees/ha in cotton production systems (a legal requirement) and the maximum quantities seen in those production systems do not exceed 30 trees/ha (B. Kone, IER agro-economist and head of the ECOFIL programme, personal communication, 2019)

Although the authors of this report do not have the exact figure for the number of trees found in farmers' fields, it is reasonable to assume that farmers who practise agroforestry have deliberately regenerated or planted more than 10 trees per ha in the baseline scenario to reach a minimum of 20 trees/ha. GIZ in Benin (2019) recommends a minimum of 25 trees/ha in the cotton fields. The typical tree species found in the Sudano-Sahelian zone are as follows: Parkia Biglobosa (locust bean), Butyrospermum paradoxum (shea), and Acacia albida (balanza). The farmers are also accustomed to planting mango trees. The trees provide valuable products, which can be harvested in the dry season when fodder and food are scarce.

The average yields and market prices of these products are drawn from various sources, particularly secondary literature and the discussion groups organized in Albogory municipality, Bougouni, in connection with this study in July 2019. For more comprehensive details, readers are invited to consult the 'Evergreening Africa' ELD study from Ghana (Westerberg et al. 2019), and the ELD study on Mopti region in Mali (Sidibé, Myint & Westerberg 2014).

Table 13 shows the income a given farmer can hope to earn from forest products. It is assumed that a farmer not practising agroforestry will have 10 trees (eight young and six old [sic] per ha) and an agroforester will have 20 (eight young and 12 old). Farmers who commit to agroforestry can expect to generate an average of FCFA 110,000 worth of forest products per year as against FCFA 54,000 for those who stick to the legal minimum of 10 trees per ha. The products will not all be collected, consumed and taken to market, so we assume that the total income from forest products is about half this amount. This means that for each hectare, a cotton producer practising agroforestry can realistically earn an average additional forest income of FCFA 27,000.

TABLE 13:
Income that a farmer can hope to earn from non-timber forest products

	Possible harvest (young trees)	Possible harvest (mature trees)	Price (FCFA/kg)	Young trees, baseline	Mature trees, baseline	Harvest value (FCFA/ha)	
						Baseline: 10 trees/ha	Agroforestry: 20 trees/ha
Acacia Albida (kg fodder)	60	125	2.33	1	2	723	1 447
Shea (kg nuts)	7	15	150	1	2	5 550	11 100
Locust bean (kg weight)	30	90	150	1	2	31 500	63 000
Mango (fruits)	65	135	250	1		16 250	32 500
Total	-	-	-	-	-	54 023	10 8047
Average	-	-	-	-	-	27 012	54 023

08

Farmers' practices and motivations and food security

Tables 14 and 15 describe some of the practices, opinions and intentions of conventional cotton producers in Bougouni and Koutiala, obtained through the household surveys. The results corroborate the previous assumption, as well as the observations concerning land cover changes in both cercles.

Land is scarcer in Koutiala, so farmers have less land available for fallowing compared with farmers in Bougouni. Moreover, Bougouni has a much higher land clearing rate: 65% of households admitted they had cleared forest land for agriculture over the last five years, compared to 7% of households in Koutiala. In fact, 65% of farmers in Koutiala stated that they have never cleared new land, compared to only 19% in Bougouni. Nevertheless, there are some signs that scarcity of land will also become a problem in Bougouni. For example, 57% of households expect that the land area inherited by their children will be smaller than their current landholdings.

TABLE 14:

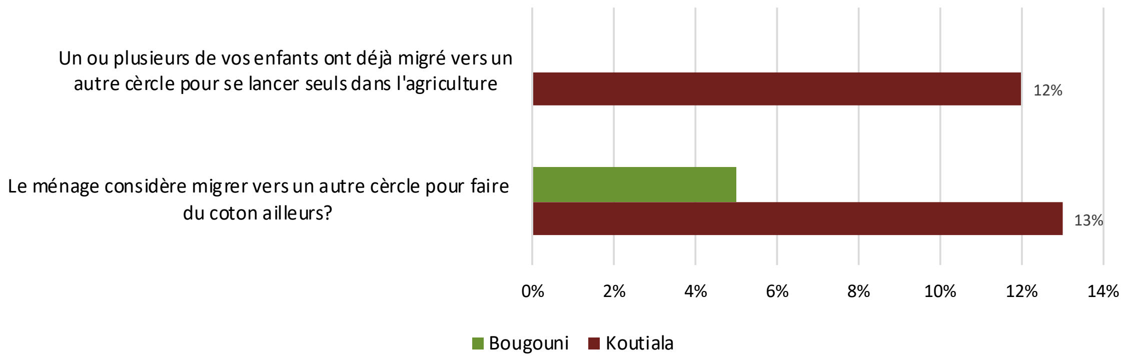
Data on farms in Bougouni and Koutiala

	Bougouni	Koutiala
Prepared to try organic farming (= Yes)	-	56%
The household currently has fallowed land	66%	25%
Has the household cleared land in the forest?		
Yes, during the last 5 years	65%	7%
Yes, 5 to 10 years ago	12%	9%
Yes, 5 to 10 years ago	3%	19%
Never	19%	65%
If several of your children inherit your land, do you think the land area available to them will be:		
Smaller than yours	57%	30%
The same as yours	11%	20%
Larger than yours	0%	6%
Don't know	30%	6%

In terms of migratory pressure, 12% of households in Koutiala have already seen at least one family member leave for another cercle with the aim of taking up farming; in addition, 13% of households are planning to move. In Bougouni, 5% of households are planning to move to another area to find better land to settle on (Figure 15).

FIGURE 15:

Migratory tendencies



Many farmers have experimented with SLM practices over the last three years, but the degree of adoption is unknown. As regards impact on yields, only agroforestry, growing legumes and use of compost have statistically significant impacts (see Chapter 7).

With regard to farmers' use of harvest residues, a striking contrast was seen between Koutiala and Bougouni. In Koutiala, virtually no farmers burn their residues; according to Abdoulya Diarra from the CMDT, this is due to the advanced state of land degradation (Abdoulya Diarra, personal communication, August 2019). Since Koutiala is also a herding area with scarce grazing opportunities, the residues are used to feed livestock, whose presence in the fields simultaneously helps to fertilize the soils. Unlike Koutiala, Bougouni does not lack pastures or organic material, so producers usually incinerate the residues to clear their plots.

TABLE 15:

Data on use of SLM measures in Bougouni and Koutiala

	Bougouni	Koutiala
What do you do with the residues from the cotton harvest?		
Incineration	73%	1.0%
Grazing by livestock (another household's livestock)	30%	28%
Grazing by livestock (own livestock)	33%	42%
Cut up and buried	24%	55%
Cut up and spread over the soil to decompose	22%	85%
Have you tried SLM measures on your land over the last three years?		
Spatial alternation with crop rotation	81%	51%
Agroforestry	36%	22%
Soil protection and restoration /Water and soil conservation	42%	48%
Use of harvest residues	44%	57%
Use of compost	62%	85%
Use of manure	77%	70%
Growing legumes and/or soil improving plants	21%	5%
Crop association	64%	44%

8.2. Why do farmers produce cotton?

Generally speaking, it seems that farmers produce cotton over other crops because of favourable market conditions and, in particular, access to credit and good quality inputs. Moreover, it is obvious that growing cotton has improved the well-being of farmers in Bougouni and Koutiala (Table 17).

TABLE 16:

Strong points of cotton production in Bougouni and Koutiala

Why did you choose cotton rather than other crops like soya or maize?	Bougouni	Koutiala
Easier to sell/There is a market	76%	51%
There is no credit for other crops	73%	67%
Access to good quality inputs	93%	78%
Premium on the price	12%	13%

TABLE 17:

Well-being and cotton production

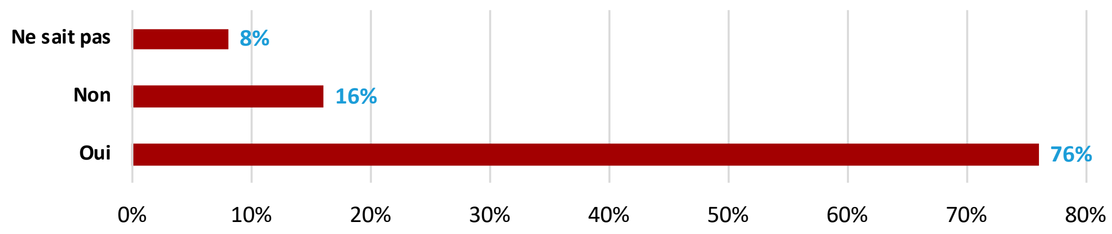
Has cotton production enabled you to increase your well-being (general satisfaction with life)?	Bougouni	Koutiala
1. Yes, a lot	60%	68.7%
2. Yes, a little	33%	28.0%
3. Not sure/Don't know	4%	1.7%

Other questions were also put to producers in Koutiala: firstly, they were asked what they would do if they could grow other plants with the same level of subsidy as cotton. An astonishing 76% said they would change their production if they could get a subsidy for other crops as high as for cotton (Figure 16) and the majority would like to grow more food crops (Figure 17).

Question: Inputs for cotton are currently subsidized by the CMDT/the State. If the subsidies were not specifically tied to cotton and you were able to access inputs (fertilizers, seeds, etc.) at a lower price, on credit, for whatever crop, would you change your farming practices?

FIGURE 16:

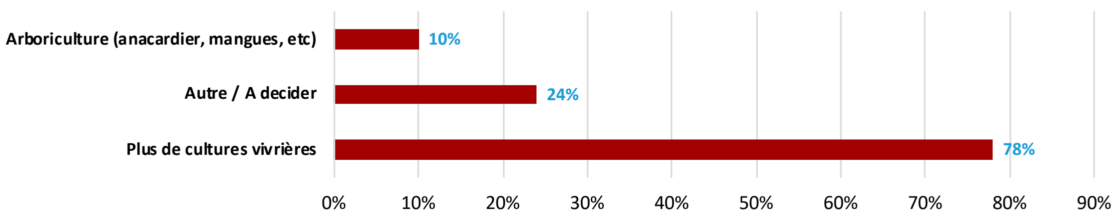
Wish to change farming practice in the event of a change in support policy



Question: If yes, what would you do?

FIGURE 17:

Change to what kind of crop

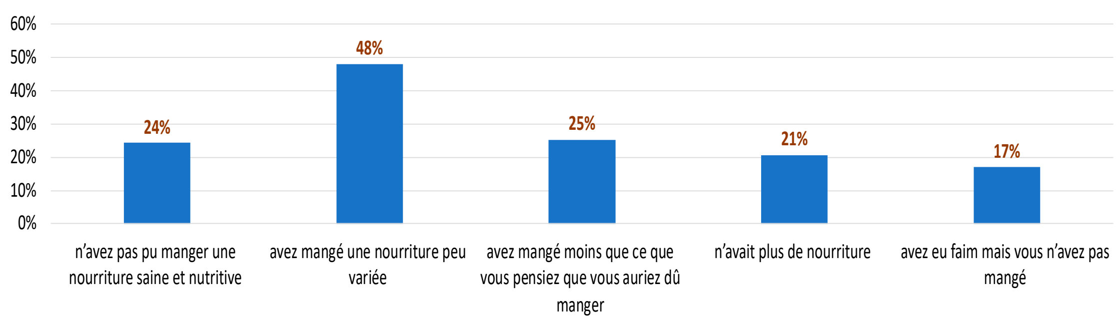


8.2. Food security

Food insecurity could be one of the main reasons why people in Koutiala wish to abandon cotton in favour of food cropping. Figure 18 shows that 17% of cotton producers had experienced times of hunger and were unable to eat due to lack of money or other resources during the year prior to the survey (conducted in September 2019). For the same reason, almost half the respondents have eaten a restricted range of food and one quarter have known times when they had no access to healthy, nutritional food.

FIGURE 18:

Food insecurity in Koutiala



Question: Thinking about the last 12 months, were there times when you or other members of your household [were unable to eat healthy, nutritional food/ate an unvaried diet/ate less than you thought you should have eaten/had no more food/were hungry but did not eat] because there was not enough money or other resources?

8.3. Sustainable land management measures in cotton production

In general, the SLM measures applied in cotton cropping systems in Mali are mainly limited to use of manure, stone bunds and composting or grazing of residues (instead of burning them).

Cotton cropping is traditionally associated with sparse tree cover, as cotton needs a lot of sunlight. Moreover, with the exception of fruit trees such as mango and guava, farmers have no tradition of planting trees (Benjaminsen, Aune & Sidibé 2010). Thanks to natural regeneration, however, *Acacia Albida*, *Parkia biglobosa* (locust bean) and *Butyrospermum parkii* (shea) are actively protected when seedlings turn up in the fields and when new land is cleared. Some farmers are more successful in retaining the trees than others and, as shown in Chapter 7 above, those who say they engage actively in agroforestry record around 100 kg/ha in additional yield. The rate of adoption of this practice is from 22% to 36% among organic and conventional producers.

There is genuine interest in increasing the rate of adoption of agroforestry, but also in investing in SLM measures. Benin, for example, is gaining experience in use of SLM measures in cotton production systems: according to Firmin Amadji, senior trainer for ProSOL/GIZ, some 1700 farmers from Banikoara municipality have seen a tripling of their yields to 3000 kg/ha (Firmin Amadji, personal communication, 2019[8]).

The technologies introduced there include:

- Agroforestry techniques based on woody legumes and maintenance of fertility based on herbaceous legumes;
- Direct sowing under vegetation cover;
- Crop association, spatial alternation and rotation practices including legumes;
- Excluding use of fire;
- Use of harvest residues and animal dung for composting, ploughing perpendicular to the contour lines and constructing dykes and stone bunds (Assogba et al. 2017: 32).

In Mali, numerous difficulties connected with the implementation of SLM practices (lack of information and knowledge of SLM, need for additional labour, bushfires, damage caused by transhumant animals, problems accessing production factors, arduousness of the task, etc.), explain the low rates of adoption. To encourage wide-scale adoption and

8 *For more information, please contact Mr. Amadji at the following e-mail address: amadjifirmin@gmail.com .*

ensure that farmers continue to use the SLM techniques, GIZ in Benin stresses the importance of genuine involvement of permanent supervisory bodies (CMDT, Water and Forestry Department, FENABE, MOBIOM, etc.) responsible for organizing and supporting rural communities.

Consequently, there is no doubt that SLM measures need to be included in the programmes and projects of those bodies if they are to fit in with the overall intervention strategy devised for each locality by the CMDT or the State. This is especially important as producers rarely make a habit of using SLM technologies. Long-term extension work is therefore necessary. Furthermore, it has been pointed out that, due to the short duration of many SLM projects run by NGOs or development organizations, beneficiaries often do not have enough time to get a real grasp of the economic benefits deriving from adoption of SLM technologies (Assogba et al. 2017: 32).

Long-term projects are therefore important in order to encourage effective large-scale adoption of the SLM technologies. In this regard, the reinforcement of agricultural extension activities, which focus on SLM, would enable movement beyond demonstration plots and bring technical support closer to the majority of producers. National producers' organizations (FENABE, MOBIOM, CMDT) have a key role to play, not only in implementing SLM projects, but also in designing organic production projects and ensuring their sustainability.

8.4. Call for reasonable use of inorganic fertilizer in cotton production

Generally speaking, cotton producers in West African countries are faced with the same fertilizer use recommendations: the recommended (pan-territorial) dose is 200 kg/ha of fertilizer, namely 150 kg NPKSB 14-23-14-5S-1B (three sacks) and 50 kg of urea (one sack). According to the present study, these values match the current practices of cotton growers in Koutiala and Bougouni (Table 7).

Several studies have shown, however, that fertilizer use practices in cotton production systems in Francophone West Africa lead to exhaustion of soil nutrients and rapid land degradation (Saïdou et al. 2012). From an in-depth spatial study in Benin, Honfoga & Parrales (2018) conclude that the recommended pan-territorial dose is neither economically nor ecologically sustainable. This is because it overlooks spatial differences in soil fertility and ignores nutrient use efficiency, which is the essence of sustainable fertilizer use (Igué, Gaiser, & Stahr 2004). Instead, the recommended doses of inorganic fertilizer should take into account the soil conditions, notably the application of relatively small quantities where the land is not degraded and vice versa, where land is degraded. Applying low to moderate doses to maintain the fertility of slightly degraded/fertile soils (like in Bougouni) is justified in the situations where SLM and agro-ecological farming is practised (Breman, 2000).

Consequently, there is a mismatch between spatial soil fertility differences and doses of fertilizer applied, leading to low efficiency and low profitability of conventional cotton farming systems (Honfoga & Parrales 2018). It is therefore important to adapt current recommendations in respect of fertilizer use to soil conditions or establish cropping practices to improve the sustainability of cotton production systems. More reasonable fertilizer use practices will be vital in future to improve the profitability of cotton production while preserving the environment.

09

Conclusion and main recommendations

In Mali, it is high time for farmers to begin to build long-term soil fertility in order to reduce input costs. The results of this study show that cotton producers in the capital of White Gold, Koutiala, achieve minimum profit margins despite the substantial support they receive (credit, technical assistance, tractors, input subsidies). Their societal profit is similar to that of organic producers in Bougouni, who nonetheless produce with minimal support. Farmers in the new cotton production frontier areas, such as Bougouni region, obtain much higher profit; without preventive measures, however, they are at risk of experiencing the same land degradation pattern as Koutiala.

As a result, it is essential that agricultural development programmes and policies are not exclusively geared towards conventional cotton production. Farmers should be in a position to freely choose the crops they wish to produce in order to find the production systems that suit them best, in the light of their preferences, labour resources, soils and climate. According to the present survey, 75% of farmers in Koutiala would produce something other than cotton (primarily food crops) if they could receive the same level of support as they get for cotton. Moreover, 25% of all cotton producers are clearly in a position of food insecurity in Koutiala: they say they have not had enough food to meet their needs and have had a poorly varied diet due to inadequate financial resources over the year prior to the interview in September 2019. Paradoxically, subsidies for cotton and maize inputs in Mali are amongst the highest in West Africa. From another perspective, numerous studies suggest that conventional fertilizer use practices in cotton production systems in Africa are inappropriate and lead to exhaustion of soil nutrients. This exhaustion is due to a mismatch between the spatial differences in soil fertility and the doses of fertilizer applied. This mismatch results in low efficiency and low profitability for farmers and places a heavy burden on the public treasury that subsidizes these inputs.

This study has shown that applying an additional sack of NPK fertilizer generates additional revenue – an average of FCFA 16,760, i.e. 64 kg of cotton/ha, equivalent to the international market price of a sack of NPK fertilizer. In other words, the additional cost is equivalent to the additional revenue generated, so that on average Malian society neither loses nor gains on the use of inorganic fertilizers. This situation suggests that scarce public funds could be used elsewhere to create more added value for Malian society.

In addition, the analyses in Chapter 7 show that some farmers are already using SLM measures to increase their yields, by:

- Introducing agroforestry practices, farmers can increase their yields by 110 kg/ha and their monetary income from forest products (cashew and shea nuts, locust bean, firewood) in the dry season by around FCFA 27,000/ha;
- Encouraging grazing of cotton residues by their own livestock (instead of burning the residues) (an additional 400 kg/ha for organic producers);
- Using legumes in rotation with cotton, an average increase in yield of 150 kg/ha can be obtained.

Furthermore, the analyses stress the fact that a package of cropping practices is required if yields are to be increased in a significant manner. It should also be noted that a wider range of SLM measures (direct sowing under vegetation cover, stone bunds, crop rotation/association with legumes, ploughing perpendicular to the contour lines, etc.) exists and these methods have helped to revolutionize cotton production amongst farmers in Benin, where yields have risen from 1000 kg/ha to 3000 kg/ha, in parallel with a fall in use of conventional inputs (Firmin Amadji, personal communication, 2019). Consequently, the German Co-operation[9] in Benin has put together a compendium of SLM and climate change adaptation measures to support State agencies[10] in carrying out their tasks to boost production in the agricultural value chains (GIZ Benin 2019).

9 Under the "Protection and Rehabilitation of Soils to improve food security (ProSOL)" project emanating from the special BMZ initiative "UN SEUL MONDE sans faim - SEWoH" (ONE WORLD without hunger).

10 Such as the Territorial Agricultural Development Agencies and Departmental Agriculture, Livestock and Fisheries Directorates.

It is also essential that SLM measures feature as part of the technical packages of permanent supervisory bodies (CMDT, FENABE, MOBIOM, etc.) in Mali and fit within an overall extension strategy, so that these methods can find a proper place within traditional agricultural practices. The matter is urgent if Mali wishes to achieve land degradation neutrality (SDG 15.3). As a semi-arid country, Mali is also significantly affected by climate change, combined with an exponentially growing population (at a rate of 3.7%), requiring ever more fertile land for subsistence.

In conclusion, many indicators, particularly soil fertility, food insecurity and the profitability of cotton production, suggest that the time has come to review current policies and introduce approaches focusing on profitability, productivity, innovation and climate change adaptation. Putting these measures into place is a real challenge. This challenge was stressed during the policy and result dissemination workshop of this study in Bamako in January 2020, where one of the participants concluded, that "our country needed this analysis, showing that the current path, practices and policies are not economically sustainable. But to have a real impact, these findings must be disseminated at all levels: Regional Councils, Cercle Councils, the National Assembly, the High Council of Local and Regional Authorities, Chambers of Agriculture and farmers themselves. Because the current support system for cotton production is non-viable. We need long-term and comprehensive action to change matters".

Following this study, the ELD team, represented by Altus Impact, IER and IPR-IFRA, in partnership with the agricultural development agencies and their partners, are to start a new "action"[11] phase to ensure that the findings and recommendations of this study are disseminated as widely as possible, to ensure a positive move towards more sustainable management of land in Mali.

11 *Action is stage +1 in the 6+1 method (ELD Initiative 2015).*

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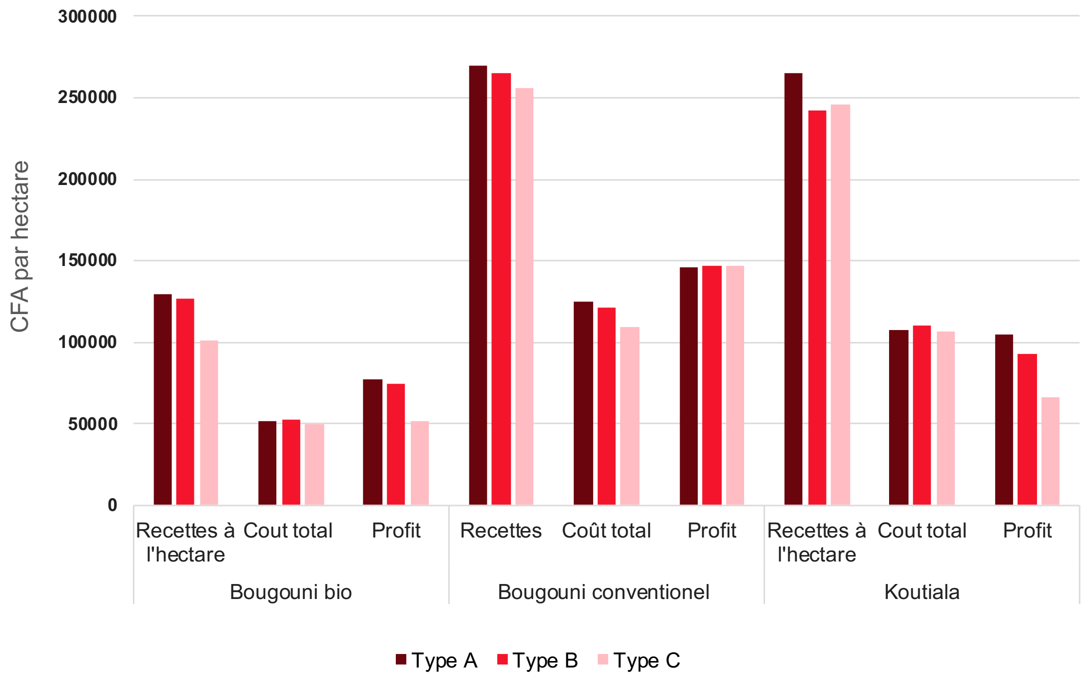
Appendix 1

This figure shows revenue, costs and profits per hectare for type A, B and C farmers. Looking at the figure, type A producers in Koutiala seem to have a comparative advantage over type B and C producers. This trend is not, however, seen in Bougouni and we cannot assert that type A producers always have higher profits than types B or C.



Appendix 2 : Socio-demographic data and cropping practices in Bougouni and Koutiala

Table A2.1 – Socio-demographic data	**Koutiala conventional**	**Bougouni conventional**	**Bougouni organic**
Age of head of household	54	48	47
Number of persons in household	23	22	23
Number of children under 16	11.7	8.5	8.3
Respondent is female	0.3%	6%	15%
Respondent is male	99.7%	94%	85%
Respondent is head of family	64%	83%	67%
Respondent is chief's son	24.3%	8%	12%
Respondent is chief's wife	1.3%	6%	12%
Head of family born in the cercle	75%	66%	65%
Respondent's ethnic group			
Bambara	64.3%	75%	90%
Peul	15.0%	9%	3%
Minianka	11.7%	6%	1%
Sarakolé	0%	8%	5%
Respondent's religion			
Christian	5,0%	2%	2%
Muslim	94%	97%	97%
Respondent is married and lives with spouse	98.3%	99%	97%
Household is polygamous	65.3%	52%	48%
Maximum educational level achieved by children			
Primary education	63.3%	41%	46%
Secondary education	17.0%	26%	29%
University education	3.0%	5%	4%
Franco-Arab school (Medersa)	3.3%	5%	6%
No qualification obtained	10.7%	16%	15%
Head of household is literate	55.3%	37%	38%

Table A2.2 – Main crops and data on farms in Koutiala and Bougouni	Koutiala conventional	Bougouni conventional	Bougouni organic producers
Total area of farm (ha)	11.8	13.9	13.6
Area occupied by conventional cotton (ha)	3.1	4.2	3.5
Area occupied by organic cotton (ha)	0.0	0.0	0.7
Area occupied by sorghum (ha)	1.9	0.5	0.5
Area occupied by millet (ha)	3.1	0.4	0,5
Area occupied by maize (ha)	2.0	3.1	2.8
Area occupied by rice (ha)	0.7	0.7	0.6
Area occupied by groundnuts (ha)	0.4	1.3	1.4
Area occupied by cowpeas (ha)	0.2	0.3	0.5
Percentage of cotton (%)	26%	30%	31%
Number of years' experience in cotton production	22	17	7.4
Number of years respondent has been in charge of the farm	17	19	18
Distance between house and furthest plot (km)	0.8	4.2	3.9
Distance between house and closest plot (km)	0.3	1.6	1.4
Increase in total area (ha) devoted to food crops since the farm began	1.5	2.1	1.8
Increase in total area (ha) devoted to cotton since the farm began	1.0	2.4	1.7

Appendix 3a: Private costs (FCFA) of illnesses caused by spraying or handling phyto-sanitary products in Bougouni (2018/2019 season)

	Day, consultation or average cost per household (whole population)	**Day, consultation or average cost per affected household (15% of population)**	**Minimum**	**Maximum**
Days spent in hospital	0,6	6	1	33
Hospital expenses (FCFA/day)	-	17 250	1 000	50 000
Transport cost over year	-	3 333	500	10 000
Laboratory analysis expenses over year	-	13 500	2 500	30 000
Total cost of hospitalization	**12 856**	**140 500**	**0**	**1 250 000**
Consulting traditional practitioner	0,02	1	1	1
Cost of consultation	-	6 750	3 500	10 000
Transport cost per consultation	-	2 750	500	5 000
Food cost over year	-	3 666	1 000	5 000
Total cost of consulting traditional practitioner	**196**	**10 000**	**0**	**20 000**
Consulting doctor	0,1	2,2	1	5
Cost of consultation	-	5 750	1 000	23 500
Transport cost per consultation	-	3 666	1 000	5 000
Value of lost working time (1h= FCFA 60)	2 880	10 000	120	2 880
Total cost of consulting doctor	**825**	**21 060**	**0**	**57 880**
Days' medical treatment	0,3	3,6	0	10
Cost of medicines	-	15 873	600	600
Transport cost to purchase medicines	-	2 917	1 000	5 000
Total cost of medical treatment	**4 002**	**55 663**	**1 800**	**32 000**
Need to take on a new farm labourer due to inability to work (days)	4	13	1	30
Cost of hiring farm labourer	372	14 875	0	45 000
Total cost per household	18 269	133 103	0	1 250 000
Total cost/ha	**4 567**	**33 276**	**-**	**-**

Appendix 3b: Private costs of illnesses caused by spraying or handling phyto-sanitary products in Koutiala (2018/2019 season)

	Day, consultation or average cost per household (whole population)	**Day, consultation or average cost per affected household (15% of population)**	**Minimum**	**Maximum**
Days spent in hospital	0.04	3	1	7
Hospital expenses (FCFA/day)	-	18 833.33	1 000	38 000
Transport cost over year	-	8 166	1 500	20 000
Laboratory analysis expenses over year	-	3 500	2 000	5 000
Total cost of hospitalization	**1 461**	**111 500**	**5 500**	**274 000**
Consulting traditional practitioner	0.025	2.3	1	5
Cost of consultation	-	3 166	1 000	7 500
Transport cost per consultation	-	4 500	1 500	10 000
Food cost over year	-	6 750	2 000	15 000
Total cost of consulting traditional practitioner	**530**	**30 000**	**4 500**	**92 500**
Consulting doctor	0.01	2.0	2	2
Cost of consultation	-	9 250	1 000	17 500
Transport cost per consultation	-	2 000	2 000	2 000
Value of lost working time (1h= FCFA 60)	-	5 100	120	10 080
Total cost of consulting doctor	**245**	**27 600**	**16 080**	**39 120**
Days' medical treatment	0.2	8.6	1	30
Cost of medicines	-	6 600	1 000	13 000
Transport cost to purchase medicines	-	1 750	1 500	2 000
Total cost of medical treatment	**1 729**	**97 250**	**2 500**	**300 000**
Need to take on a new farm labourer due to inability to work (days)	0.3	10	2	20
Cost of hiring farm labourer	**1 143**	**5 333**	**1 000**	**10 000**
Total cost per household	**3 290**	**130 671**	**5 000**	**325 000**
Implicit cost/ha	1 100	42 150	1 613	104 839

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