THE ECONOMICS OF LAND DEGRADATION

Economics of Land Degradation Initiative: **A case study from the municipality of Banikoara, Benin**

The economics of conventional and organic cotton production

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Key lessons

An increasing number of studies highlight the gravity of occupational health issues related to pesticide use in the cotton sector. The problem is recognised, but no study has demonstrated how pesticide use affects the economics of cotton production in Benin. As such, this study is the first of its kind. We have also estimated economic damage costs from the loss of livestock due to pesticide poisoning and compared the economics of organic and conventional cotton production. With reference to the municipality of Banikoara and the cotton season of 2015/2016, we find a number of interesting results:

- Health problems and loss of livestock inflict economic damages in the order of EUR 187[1] per farming household per year. Health costs vary significantly depending on the spraying equipment used by farmers.

- Government subsidies for farm inputs involve costs to the treasury. Accounting for governmental expenditures, environmental and health costs, the societal net-benefit from cotton production is reduced by 66% for an average sized farm (5 ha).

- Demand for organic cotton is on the rise. Organic cotton production involves a high learning curve for farmers, but it is a promising technology. On average, organic farmers have revenues that are similar to that of conventional cotton farmers, but input costs are only a fraction of the size.

- The resulting income was in the order of EUR 245 per ha for an average organic farmer and EUR 134 per ha for an average conventional cotton farmer for the 2015/2016 season. In the absence of subsidies for farm inputs, income from conventional cotton production would have been as low as EUR 66 per ha.

- Conventional farmers spend non-optimal amounts on pesticides and urea. Their high expenditures are not offset by sufficiently high rises in yields. Farmers could earn higher incomes, by reducing expenditures on inputs. Access to agricultural insurance schemes would facilitate that by lowering farmers' propensity to hedge against risk through unabated spending on inputs.

- To effectively confront challenges of health and climate hazards, more radical changes are needed. Sustainable land management (SLM) practices such as no-till, permanent soil cover, crop rotations, etc. can build climate resilience. Organic farmers typically employ these practices.

- However, with insufficient access to finance, farm inputs and extension services for other crop or SLM techniques, farmers are hindered from adopting or scaling-up their Sustainable Land Management efforts. Indeed, conventional cotton farmers are 'discouraged' from switching technology by the simple fact, that there is no government support and access to credit for any other crop or production technology than the conventional production methods.

- Societal welfare and economic efficiency can be improved by channelling resources from environmentally damaging and less productive land use activities towards a range of promising and climate resilient sustainable land use practices. As such, there is plenty of scope for facilitating transformational changes in Beninese farming economy.

1 *Using an exchange rate of 1 XOF=0.0015 EUR*

Table of contents

Key lessons 4

Table of contents 5

List of abbreviations and terms 7

Chapter 01 Introduction 8

1.1 Methodology and study site 9

Chapter 02 Background on organic and conventional cotton production in Benin 10

2.1 Conventional cotton 10

2.2 Organic cotton 11

2.2.1. History of organic cotton production in Benin 11

2.2.2 Global trends in the production and demand for organic cotton 11

Chapter 03 Environmental and health related impacts from conventional cotton production 12

3.1 The market for pesticides in Banikoara 12

3.2 Health impacts 12

3.2.1 Previous evidence – Africa wide. 13

3.3 Impact on livestock and other crops 13

Chapter 04 The economics of conventional and organic cotton production 15

4.1 The economics of conventional cotton production 15

4.1.1 The cost of illness 15

4.1.2 Other environmental costs – Loss of domestic animals and crops. 16

4.1.3 Input costs. 18

4.1.4 Input subsidies 18

4.1.5 Yields and revenue 18

4.2 Organic cotton farming 19

4.2.1 Input costs and labour 19

4.2.2 Yields and revenue. 19

4.3 Net-benefits from organic and conventional farming 20

4.3.1 The benefit of conventional cotton production when accounting for damage costs and government subsidies. 21

Chapter 05 Discussion and complementary results 22

5.1 Linking yields of conventional cotton to key farm inputs 22

5.2 Reasons for "going organic" 23

5.3 Barriers to scaling up organic farming 25

5.3.1 Caveats 25

Chapter 06 Concluding comments 26

References 28

Annex 1:
Detailed production budget and distribution of yields amongst organic and conventional cotton producers 30

List of tables 32

List of figures 33

List of abbreviations and terms

AFVA	Association des Femmes Vaillantes et Actives
CARDER	Centre d'Action Régionale pour le Développement Rural
CFDT	Compagnie Française pour le Développement des Fibres Textiles
COI	Cost of illness
DMC	Direct Seeding Mulched Based Cropping System
ELD	Economics of land degradation
Fulani	French: Peul; The Muslim Fulani people of West Africa are the largest nomadic group in the world. The majority is semi-sedentary today.
GDP	Gross domestic product
IIED	International Institute for Environment and Development
NGO	Non governmental organisation
NPK	Nitrogen, phosphorus, potassium
OBEPAB	Organisation Béninoise pour la Promotion de l'Agriculture Biologique
SODECO	Société pour le développement du coton
SONAPRA	Société Nationale pour la Promotion Agricole
ULVA	ultra-low volume application
XOF	The CFA Franc is the currency of the African Financial Community (Communauté Financière Africaine). The currency code is XOF.

01 Introduction

Cotton is the world's most important non-food crop supported by a relatively stable demand on the world market. In Benin, cotton is hugely important to the national economy. The sector provides a source of income to half of its population of 8 million citizens, and accounts for 40% of foreign exchange earnings and 13% of the national GDP (MAEP 2011). However, lack of diversification has made farmers, businesses and Benin's trade balance vulnerable to external shocks, in particular to climate hazards and global trade policies. Additionally, cotton is a controversial crop and difficult to grow: yields can be decimated by severe weather and the crop is vulnerable to pest attacks. Globally, cotton covers just 2.4% of the world's cultivated land but uses 6% of the world's pesticides (PAN UK). In Benin, 90% of all imported pesticides are used on cotton (New Agriculturalist 2008) and there are frequent reports of pesticide poisoning, skin, eye or stomach irritation, and other health problems amongst farmers (Williamson 2010).

The prominence of cotton in the Benin economy has encouraged longstanding government support for the sector and been used as a tool for poverty alleviation and development (Sodjinou et al., 2015). This is not without costs, whether to the government, the farmer or nature. Input subsidies for 'conventional cotton production' have also promoted overreliance on inorganic fertilisers and pesticides, as opposed to other production methods favouring crop rotations, fallow periods and use of organic manure.

Indirect consequences of single-handed support for the cotton sector include the clearance of forests and pastoral lands, causing the marginalisation of semi-nomadic pastoralists, which suffer from the loss of territory, but also from the poisoning and death of their livestock. This is a paradox in that livestock can facilitate important positive synergies in cotton production, as shown in this briefing paper.

In the context of the challenges faced by the cotton sector in Benin there is a clear scope for questioning "business as usual". For this purpose, the briefing paper provides a rigorous understanding of the current situation, by assessing the benefits and costs of producing organic and conventional cotton. With respect to conventional cotton production, a detailed assessment is made of health and environmental damage costs and costs to the public treasury. As such, this study will demonstrate some of the consequences of how conventional non-organic cotton is currently produced, so as to help shed light on the impacts of policies affecting the sector.

1.1 Methodology and study site

The assessment is made on the basis of a survey conducted with 90 randomly sampled organic cotton producers and 190 randomly sampled conventional cotton producers in September 2016 in the municipality of Banikoara in Northern Benin. More than one third of the national production is produced in Banikoara, known as the "capital of white gold".

Cotton is produced on close to 50% of cultivated surfaces and conventional cotton farmers have an average of 5 hectares under cotton production. Organic farmers cultivate on average 1 ha of cotton per household. While organic producers have less land for crops, they have more livestock; 50 heads, against only 20 heads for conventional producers. The household survey included detailed enterprise budgets that we used to elicit yields, input quantities, costs and farm gate prices for cotton for the agricultural season of 2015/2016 (June 2015 to February 2016). The questionnaire also included questions about health related incidences following the spraying of pesticides.

FIGURE 1

Municipality of Banikoara

© ELD / based on depiction from Luis Costa

02 Background on organic and conventional cotton production in Benin

2.1 Conventional cotton

Global cotton consumption has increased at 2% per year since 1940, although cotton's share in textile fibres has declined because of the increase in chemical textiles (TE 2016). Global sales from cotton exports by country amounted to EUR 54.3 billion in 2015, of which Benin's share was EUR 273.2 million, corresponding to 0.5% of world total cotton exports and the ranking as the 27th largest exporter of cotton (WTex 2016).

The Beninese cotton chain has three major functions: the production of cotton grain, the provision of inputs, and the production of cotton fibre, known as ginning (Saizonou 2008). Benin prohibits exports of cottonseeds. The seed are ground locally and exported as cotton lint or oil (Porto et al. 2010). While the Benin cotton industry actually covers the whole value chain (spinning, weaving, garment making), the activity in the textile sector processes less than 2% of lint production, due to import competition. At the industrial level, cotton represents around 60% of the industrial sector in Benin, with 20 ginning companies, 5 textile plants, 3 crushing mills and one company producing cotton wool (Porto et al. 2010).

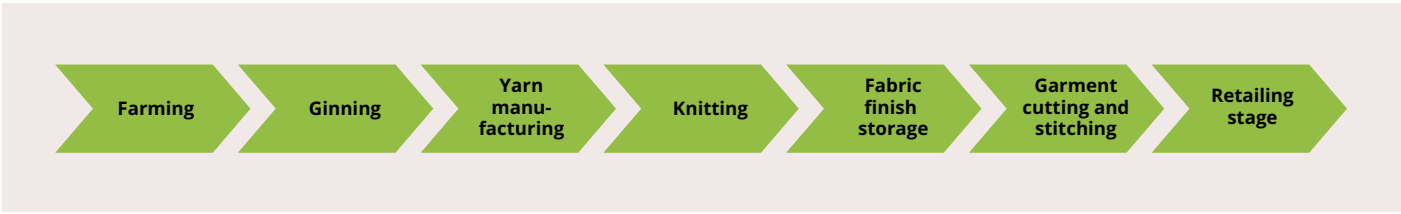
The origin of cotton production in Benin is similar to other French-speaking West African Countries. Cotton emerged as a cash crop in the 1950s in Benin, under the direction of the French parastatal 'Compagnie Française pour le Développement des Fibres Textiles' (CFDT). After independence, cotton was shifted to national monopoly (SONAPRA) managing all commercial roles. With the structural reforms in the 1990s, cotton input supply was privatised and private ginners entered the market. This phase was not without its problems, and so government increased control in the beginning of the 21st century (Gergely 2009; Glin 2014; World Bank 2005).

What is remarkable, as noted by Sodjinou et al. (2015), is that the production method with the strong use of synthetic chemical inputs has remained virtually unchanged in spite of the political upheavals and changes experienced by the sector. Will this change as a result of the election of Patrice Talon in 2016 and his government, who are 'bringing back control to private market forces' (Beninto 2016a)?

While that is difficult to predict, this study, by shedding light on the consequences of how conventional non-organic cotton is produced will improve our understanding of how agricultural policies impact on the livelihoods of farmers in Benin.

FIGURE 2

Value chain of cotton production (based on depiction from Fast Fashion)



2.2 Organic cotton

2.2.1. History of organic cotton production in Benin

The organic value chain in Benin was established towards the end of the nineties with the creation of an 'international policy network' consisting of Beninese and Dutch government agencies, transnational environmental NGOs and a local, Beninese NGO called OBEPAB, standing for the 'Organisation for the Promotion of Organic Agriculture (Kessler et al. 2003). By the time the Dutch government ended its financial support in 2004, the organic cotton network had been transformed from a small-scale and donor-dependent initiative into a market-oriented, larger scale and self-financing commodity network. The national and global NGOs imposed strict environmental requirements and played a lead role in the value chain. Therefore, although cotton is considered a global value chain per excellence, dominated by textile companies, the building and sustaining of the organic cotton chain in Benin has resulted largely from the engagement of civil society actors, rather than cotton-buying companies (Oosterveer et al. 2011).

OBEPAB is still a leading actor in the promotion of organic cotton in Benin, facilitating services such as access to organic inputs, marketing of organic seeds, storing organic cotton fibre and the negotiation of ginning services. OBEPAB has trained 13,267 organic farmers and now oversees production of around 1% of Beninese cotton, which is fairly traded under the organically certified Ecocert system.

According to the Textile Exchange (TE 2016), there are an estimated 2,682 organic farmers in Benin, and 2,065 ha of land are used for organic farming, producing 377 Mt of certified organic fibres in the season 2014/2015. In the same season, organic and fair trade cotton production in West Africa (Mali, Benin, Burkina Faso, Senegal) experienced a growth of 38% and an increase in yield rates of 7%. However, average yields in the region (500 kg/ha) remain lower than the region's estimated potential of 800-1,000 kg/ha.

2.2.2 Global trends in the production and demand for organic cotton

Since the Rana Plaza factory fire & collapse in Bangladesh in 2013, health and safety issues in the global garment industry have been under the spotlight. Reacting to pressure from NGOs, unions and politicians, some retailers are investing in improvements. The cotton industry specifically has launched schemes such as the Better Cotton Initiative[2], and fair trade cotton, organic cotton and companies are increasingly becoming certified based on traceability standards such as the Organic Exchange 100 standard (TE 2016) and the Cotton made in Africa standard (CmiA 2017).

As new consumer segments are keen to purchase chemical free and sustainably sourced materials, organic cotton is claiming its market share. The top 10 users of organic cotton include C&A, Tchibo, Inditex, Nike, Decathlon, H&M, Carrefour, Lindex, Stanley Stella and Limlliam-Sonama (TE 2016). High-street chains such as H&M and C&A aim to be 100% "more sustainable" by 2020. Both say research shows customers value organic clothes and want to buy them, but only if they cost the same as non-organic ones (Rustin 2014).

While there are evident front-runners, most big retailers have sustainability policies. But these generally stop short of full transparency through the supply chain. As argued by Rustin (2014), "the farms from which high-street chains source their fabrics are only the first link in a global supply chain and news of what is going on at the farm, do not travel far". In the meantime, an increasing number of studies highlight the gravity of occupational health problems related to pesticide use, recognising they constitute a threat to agricultural development and productivity (Kloos, J., Renaud 2014, Hurley et al. 2000; Sunding and Zivin 2000; Bwalya 2010; UNEP 2013).

2 *Works to reduce environmental impact and improve farmer livelihoods, by helping farmers adopt better farming practices and reduce spending on farm inputs. BCI aims to produce 30% of all cotton by 2020.*

03 Environmental and health related impacts from conventional cotton production

Among the continents of the world, Africa's farms receive the smallest applications of agro-chemicals. Cotton is an exception, being copiously treated with fertilisers and pesticides (World Bank 2000; Ajayi 2000).

3.1 The market for pesticides in Banikoara

In Banikoara, the commercialisation of pesticides is done through the privately owned Cotton development company known as SODECO. Prior to 2017, the sale of cotton inputs were managed by the government regulated authority CARDER. SODECO has now taken over that role. But farmers sometimes consider that the pesticides on the formal market are too expensive, available in insufficient quantities, or are ineffective, in which case they source pesticides from the black market. As part of this study, we undertook a comprehensive inventory of all the pesticides available in Banikoara. See Westerberg et al. 2017 for details.

3.2 Health impacts

Many of the pesticides found in Banikoara, contain agents that are classified as hazardous by the World Health Organisation, listed under the Rotterdam convention or banned under the Stockholm Convention[3]. For example, cypermethrine, chlophyrifos, deltamethrine and endosulfan e.g. found in Cotton Plus, Spider, Pyrinex or Thionex (CmiA 2014). These ingredients are known to cause nausea, vomiting, skin rash, paraesthesia, headache, stunning, epigastric pain, muscular contraction, loss of consciousness, paralysis, troubles with vision; all the way to death in case of ingestion or excessive exposure (EJF 2007). The worst problems are typically found in relation to the use of insecticides. These contain agents that act on the metabolism of insects through ways

FIGURE 3

On the left, the Pyrinex pesticide, containing chlorpyriphos and deltamethrin, sold by the former government regulated agency known as CARDER. Right, employees unloading pesticides.

[3] *a)* **The WHO** *list of highly hazardous and hazardous pesticides: class 1a and 1b (page 19ff): http://www.who.int/ipcs/publications/pesticides_hazard_2009.pdf*

b) Pesticides banned under the **Stockholm Convention** *on Persistent Organic Pollutants (POPs): Annex A (page 33 ff): http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPSCOP-CONVTEXT.En.pdf*

c) Pesticides listed in the **Rotterdam Convention** *on Prior Informed Consent Procedure for Certain Hazardous Chemicals in International Trade: AnnexIII (page 29 ff): www.pic.int/Portals/5/download.aspx?d=RC_Convention_Text_2011_English.pdf*

FIGURE 4

Three pesticides found on the black market of Banikoara. They contain cypermethrin and chlorpyriphos, two molecules toxic to humans and aquatic organisms, with a half-life in soil of up to 180 days (WHO 2010, Scientific American 2010).

that are common to the 'the whole of the animal kingdom' and for this reason, also affect humans.

In Benin, dramatic accidents related to the use of these pesticides are reported each year. The Organisation for the Promotion of Organic Agriculture (OBEPAP) has carried out numerous studies to identify the victims of poisoning. Between 2000–2003, a total of 577 cases of poisoning were reported. Most of these cases are related to products containing endosulfan (PAN UK 2006). Endosulfan is a persistent organic pollutant listed under the Stockholm convention, annex A[4] since 2011. In Banikoara, 3.3% of the households interviewed for the analysis presented in this study have experienced the loss of at least one family member over the last 10 years due to pesticide poisoning.

3.2.1 Previous evidence – Africa wide

As we will see in section 4.1, problems with health translate directly into lost productivity and various medical costs. The health costs from pesticide use have already been demonstrated for various parts of Africa. For example, in the Kafue watershed in Zambia, chemicals used on cotton fields led to acute pesticide poisoning, leading to an annual cost to society of USD 2.1 million. Lost labour income account for half the costs, medical and transport costs for the other half (Bwalya 2010). In Mali, Ajayi et al. (2002) evaluated the loss of productivity from pesticide use to be equivalent to 50% of the agricultural GDP per inhabitant. In Zimbabwe, Maumbe et Swinton (2006) has shown that pesticide-related acute health effects in two cotton producing villages led to annual health costs in the order of 45% to 83% of their expenditure on pesticides. Finally, using a meta-analysis, UNEP (2013) has estimated the overall cost of illness in relation to the use of pesticides in Sub-Saharan Africa to be in the order of USD 90 billion between 2005 and 2020.

3.3 Impact on livestock and other crops

In addition to health costs, fieldwork for this study revealed that another negative impact associated with pesticide use is the intoxication and death of livestock that have been drinking from contaminated water ponds or browsing in areas close to where pesticides have been sprayed. This is particularly troublesome in the case of Banikoara, which has long served transhumance routes and corridors for herdsmen and their cattle (CADTM 2005). According to the Director of rural development in the municipality of Banikoara, Mr Barte Badda Daofig (personal communication 2016), livestock numbers have halved in the last 10 years. Pastoralists are avoiding the municipality, because of the risks to their animals.

[4] *Under the Stockholm Convention, parties must take measures to eliminate the production and use of the chemicals listed under Annex A. Benin is a signatory party to the convention.*

Although these problems are acknowledged in Benin, the amplitude of the environmental and health related damages and what they entail for the economics of cotton production remain unclear. However, if the effects from pesticide use are significant, smallholder cotton farmers may be overestimating the net benefits of pesticides, in comparison to organic cotton production or other land uses. We account for these impacts in the next section, when looking more closely at the economy of cotton production by analysing so-called enterprise budgets.

The economics of conventional and organic cotton production

In this section, we compare on a per-hectare basis the economics of conventional and organic cotton production on the basis of enterprise budgets that were used to elicit input quantities, yields and farm gate market prices for 190 conventional cotton farmers and 90 organic cotton farmers. The environmental and health related costs of pesticide use are also estimated for an average-sized conventional cotton farm.

4.1 The economics of conventional cotton production

4.1.1 The cost of illness

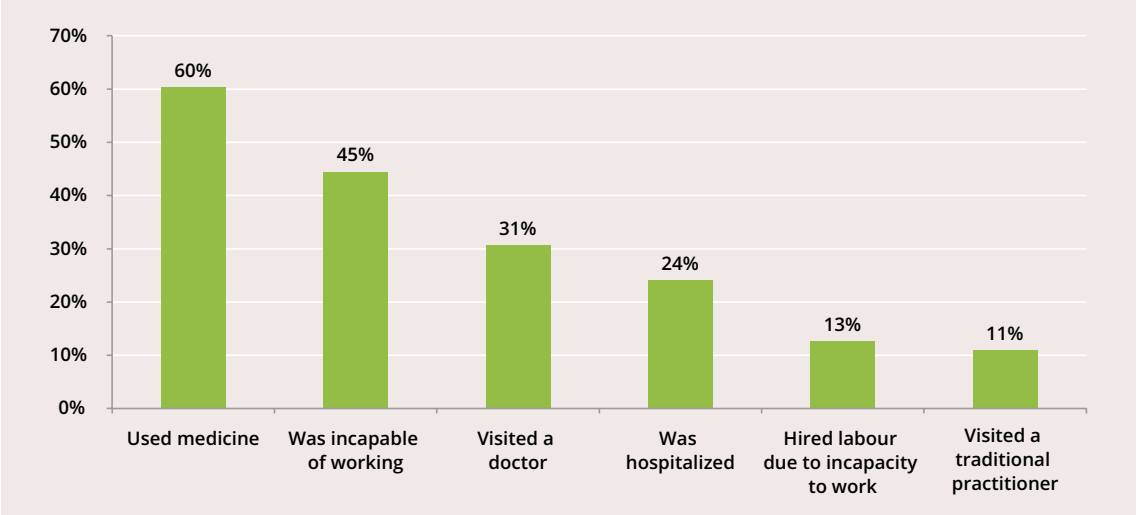
The health related costs of pesticide use have been estimated using a prevalence-based cost of illness (COI[5]) approach. The COI approach has been widely used in the estimation of costs arising from an illness related to pollution, food poisoning and water contamination (Harrington et al. 1989; Maumbe et Swinton 2006). The COI approach is based on the notion that people are productive and contribute to the economy. An illness prevented therefore means costs averted.

We accounted for costs which arise from acute short-term symptoms, as a result of spraying and manipulating pesticides. With reference to the days when farmers' had sprayed or manipulated pesticides or those immediately following, they were asked precisely how many times, if any, they had 1) bought medicine 2) visited the hospital, the doctor or the traditional practitioner or 3) were incapable of working and had to hire substitute labour. We also enquired about the unit costs associated with these activities. On this basis, we calculated the total costs associated with hospital visits (including laboratory and transport costs), the visiting of doctors and traditional practitioners and the purchase of medicine over one year, spanning the agricultural season of 2015/2016[6].

Figure 5 shows the percentage of respondents[7] across our sample that took medicine, were

FIGURE 5

Share of households who have used medicine, visited a doctor or a traditional practitioner, been hospitalised, were incapable of working and hired substitute labour – at least once during the year preceding the household survey.



5 *A prevalence-based approach measures the costs of an illness within one year and includes all medical care costs and morbidity costs for a disease within the study-year.*

6 *We calculated the value of lost production from illness using a lower-range estimate of the daily wage rate for hired labour (5.3 EUR), obtained from the ELD household survey. The same rate was used to estimate the cost of hiring substitute labour due to illness.*

7 *We interviewed the main responsible or the co-responsible for spraying within each household. These were household heads in 70% of the cases.*

TABLE 1

Cost of illness in Banikoara from short term and long term health effects

Cost of Illness (EUR/year)	Average cost per affected household	Average cost whole population	Min	Max
Cost of illness per household due to short-term illnesses, of which:	84.4	61.2	0	700
Hospitalisation costs	29.3	7.3	0	312
Doctors visit	16.2	4.8	0	165
Visiting of a traditional doctor	18.4	2.0	0	108
Cost of medicine	21.7	13.7	0	303
Value of lost work time, including hired labour	72.4	33.4	0	452
Cost of long-term illness (e.g. lost of sight, muscle pain, stomach pain, numbness of fingers)	35.0	8.1	0	150

hospitalised, visited a doctor and a traditional practitioner and were incapable of working at least once. As can be seen, 60% of all respondents interviewed have bought medicine, while 45% were incapable of working and one quarter of the population has been hospitalised. These figures confirm that the situation is critical in Banikoara.

Overall, 70% of respondents interviewed, incurred at least one of the consequences shown in *figure 5*. The average cost of illness is in the order of EUR 84 per year per household affected, or EUR 61 across the population as a whole. An attempt was also made to assess the costs incurred from long-term illnesses, arising from exposure to pesticides. 25% of the respondents have experienced long-term illnesses that are likely be attributed to pesticides, costing an average of EUR 35 per affected household per year.

The incidence of illness from the spraying or manipulation of pesticides depends on a number of factors, including use of protection when spraying, frequency of spraying, and at what time of the day spraying happens (Wilson 2002). In Banikoara, the quasi-totally of farmers do not use protective equipment. We therefore found that the most important determinant of illness is the actual technique that farmers use to spray pesticides. Farmers use three principal methods: aerosol, backpacks or ULVA+ sprayers[8].

As shown in *table 2*, farmers mainly use ULVA+ sprayers (44%) and backpack sprayers (43%), while the minority (12%) mainly use aerosol sprays. Average annual health costs associated with the spraying of pesticides varies significantly pending on what tool farmers' use. For example, those who mainly employ backpacks sprayers spend an average of EUR 84 per year (XOF 559,000 per year) on treating acute short-term illness, while those who mainly use ULVA+ have health costs of only EUR 27 per year (XOF 18,250 per year) (*Figure 6*). The importance of promoting the use of ULVA+ over other spraying methods can therefore not be underestimated.

4.1.2 Other environmental costs – Loss of domestic animals and crops

In addition to private health impacts, the spraying of pesticides also inflicts external costs on neighbouring households. The preparatory fieldwork for this study showed that many households had suffered crop loss because of spraying by a neighbouring farmer[9] or from the death of animals from intoxification. The value of lost crops is approximated by the net-benefit that the farmer would have enjoyed if his crops had come to maturity and been harvested. While lost livestock are valued at their market price[10] (from Pafilav 2015).

8 *An ULVA+ sprayer is a hand-held spinning disc sprayer designed for low volume (LV) and ultra-low volume (ULV) Controlled Droplet Application of insecticides and fungicides.*

9 *The loss of crops typically happens when one farmer's cotton crops are younger and more vulnerable compared to that of the neighbour's cotton crop who may be spraying pesticides. When corn is grown adjacent to cotton fields, they are also vulnerable to being destroyed by spraying on neighbouring cotton fields.*

10 *Price of cattle = EUR 375/head; sheep = EUR 60/head; pig = EUR 52.5/head; goat = EUR 30/head; chicken = EUR 4/head (Pafilav 2015).*

FIGURE 6

Annual COI as a function of spraying tool used by farmers (with 95% confidence intervals)

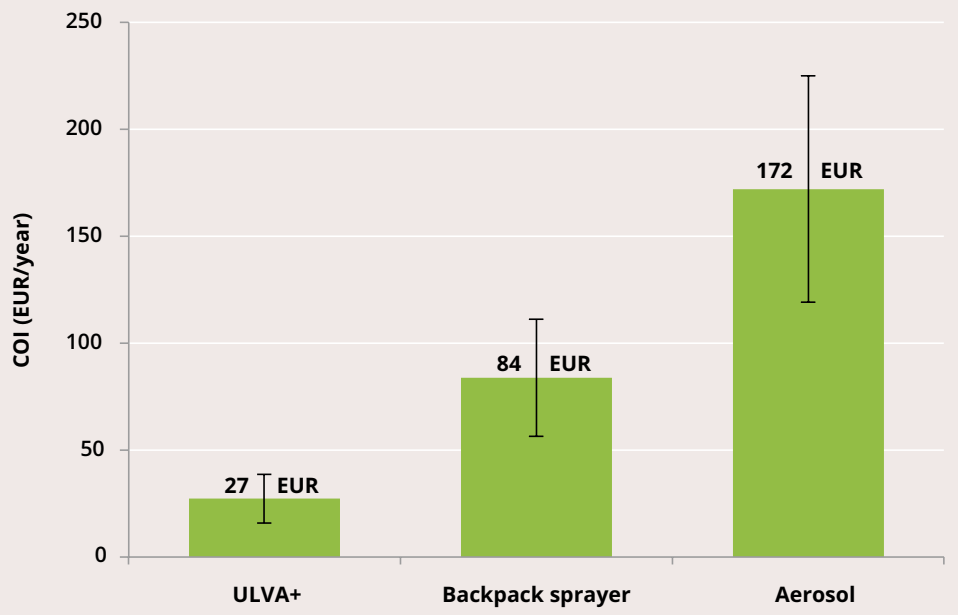


TABLE 2

Cost of illness as a function of main spraying tool used by farmers

Cost of Illness by spraying method	Share of farmers using mainly	COI (EUR/ year)	St dev (EUR/ year)	Min (EUR/ year)	Max (EUR/ year)	Confidence intervals
ULVA+	45%	**27**	55	0	356	11.37
Backpack sprayer	43%	**84**	130	0	700	27.44
Aerosol sprayer	12%	**172**	155	0	699	52.92

TABLE 3

Damage cost from pesticide pollution and poisoning

Economic damages costs	Percentage of households affected	Average cost per affected household (EUR)	Average cost per household, whole population (EUR)
Loss of domestic animals (Cattle, Sheep, Goats, Pigs, Chicken)	11%	698	77
Crop loss (corn or cotton)	14%	96	13
Total economic damage cost (COI, crop and livestock loss)			**174**

Specifically during the 2015/2016 season, 11% of households experienced the death of at least one domestic animal. *Table 3* shows the associated economic damages of affected cotton producing households and across the population as a whole.

4.1.3 Input costs

In the absence of use of integrated pest management and other sustainable land management practices, conventional cotton production is highly resource intensive, requiring farmers to invest significantly in fertilisers, urea and pesticides. Farmers are therefore dependent on reasonable yields, in order to be able to pay off their debt at the end of the season. Farm inputs are supplied on credit by national distribution structures in Benin. Loans are paid back when farmers sell their harvest. Average per hectare input costs are shown in the land use budget, *table 4*[11]. Expenditures on pesticides represent 50% of all input costs (96 EUR/ha out of a total cost of 187 EUR/ha).

4.1.4 Input subsidies

Economic analysis, contrary to pure financial analysis requires that not only private, but also societal costs or benefits be accounted for in a valuation study. The conventional cotton sector benefits from significant government support, specifically through input subsidies. However, subsidies for certain pesticides have been eliminated as of the 2016/2017 season (Commodafrica 2006a). Our calculations shows that if farmers would have paid the true market price during the 2015/2016 season their expenditures on pesticides from the formal market would have been 36% higher. The new government is still maintaining a 50% subsidy on urea and NPK fertilisers (Commodafrica 2016b).

4.1.5 Yields and revenue

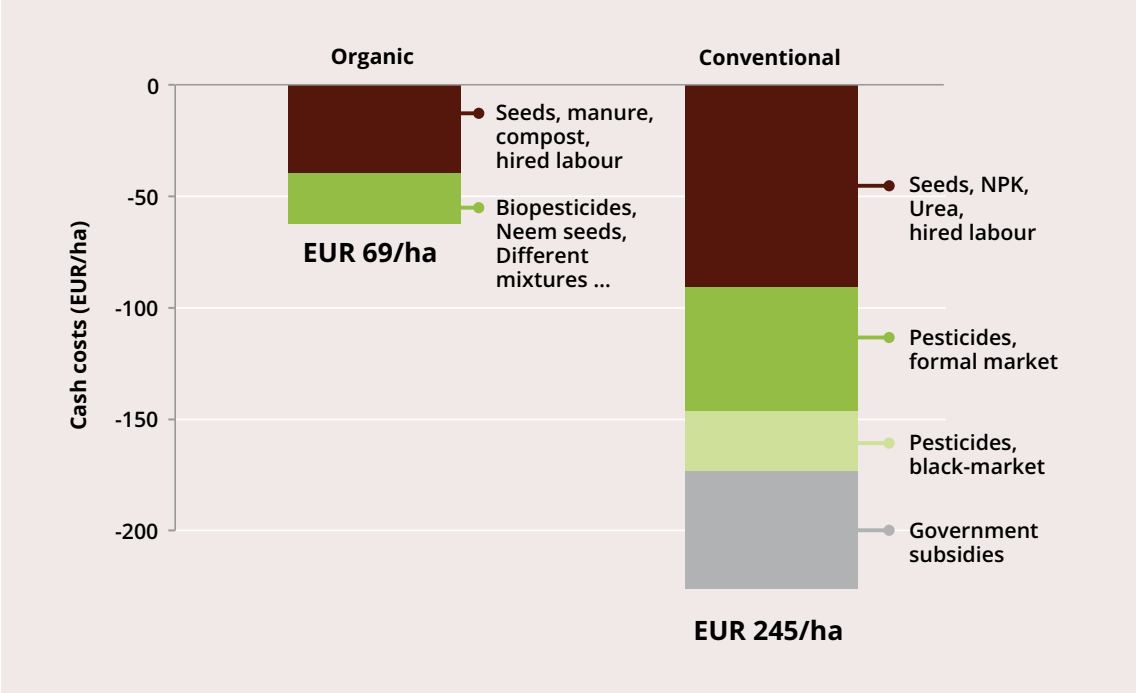
Government has fixed a purchasing price of EUR 0.32 per kg cotton (210 XOF/kg) for the season of 2015/2016. With an average yield of 1,060 kg per hectare (and a median of 880 kg/ha), the revenue from conventional cotton production is in the order of EUR 315 per ha (207'000 XOF/ha).

Annex 1 provides further detail on the distribution of yields, input costs and revenues of the conventional and organic cotton producers that were sampled in Banikoara.

[11] *Since we developed detailed enterprise budgets distinctly for cotton and corn, we have confidence that the input quantities reported here were used on cotton only.*

FIGURE 7

Input expenditures and costs to the government treasury per hectare of organic and conventional cotton



4.2 Organic cotton farming

The excessive use of fertiliser and chemical inputs can lead to a progressive decline in soil fertility and often entails numerous health impacts (as discussed above). Furthermore, certain cotton producers, especially women, are not able to participate in the conventional cotton production market, as they do not have the status or revenue allowing them to purchase inputs. In order to overcome these issues, an association of organic producers AFVA (Association des Femmes Vaillantes et Actives) was established in 2008 in the village of Gomouri in Banikoara to promote organic farming. The association is supported by Helvetas and OBEPAP and includes some 200 farmers.

4.2.1 Input costs and labour

In organic cotton farming in Banikoara, weed control is done by hand and insecticides are replaced by bio-pesticides, including seeds and leaves from Neem trees. These are either bought or collected in nature. Manure is used instead of inorganic fertilisers. With an average input costs of 68 EUR/ha, organic farmers have low cash expenditures for inputs, similar to those used for producing 1 ha of corn in Banikoara (see Westerberg et al. 2017 for more details). *Figure 7* illustrates the per hectare cash costs of organic and conventional cotton producers.

Organic farmers have more livestock than non-organic farmers, which facilitates the production of organic cotton. For example, prior to planting farmers bring their livestock to the plot, where browsing of the cattle can help clear the land and fertilise the soil with manure. Pastoralism and organic cotton farming are therefore highly complementary. The farmers also employ the management technique known as 'Direct Seeding Mulched Based Cropping Systems' (DMC) based on no-till, permanent soil cover and crop rotation. The system allows for the regeneration of soil organic matter and leads to savings of time with respect to weed control and tillage.

4.2.2 Yields and revenue

Organic cotton is certified by Ecocert International and sold at 0.45 EUR/kg (300 FCFA/kg). The Beninese government has been buying organic cotton since

TABLE 4

Enterprise budgets of organic and conventional cotton production

Conventional production – 1 ha	Revenue		Organic production – 1 ha	Revenue
Price (EUR/kg)	0.32		Price (EUR/kg)	0.45
Yield (kg/ha)	1'060		Yield (kg/ha)	697
Revenue (EUR/ha)	315		Revenue (EUR/ha)	313
Input costs (EUR/ha)	**With subsidies**	**Without subsidies**	**Input costs (EUR/ha)**	**Average cost**
Cotton seeds	5.4	5.4	Cotton seeds	6.1
NPK fertiliser	52.0	78.0	Neem seeds	4.5
Urea	23.1	34.6	Compost and manure	7.5
Organic manure	1.3	1.3	Organic manure	9.2
Hired labour	9.1	9.1	Hired labour	20
Black market pesticides	38.7	38.7	Bio-pesticides	9.2
Formal market pesticides	57.0	78.1	Other natural mixtures	12.0
Total cash cost	**186**	**245**	**Total cash cost**	**69**
Net-benefit (EUR/ha)	**Average**	**Without subsidies**	**Net-benefit (EUR/ha)**	**Average**
Net-benefit*	**134** (106)**	**77 (50)**	**Net-benefit**	**244** (190)**

** Median per hectare net-benefit provided in brackets; ** Statistically significant difference in means at 95 pct. level of confidence.*

2012. Organic farmers have an average yield of 700 kg/ha and a median yield of 630 kg/ha. With a higher price for organic cotton grain, the average organic farmer has revenue earnings in the order of 315 EUR/ha, similar to that of conventional cotton farmers.

However, as shown in *annex 1*, the distribution of yields is very uneven, with one group of farmers enjoying yields in excess of 800 kg/ha and another group producing less than 700 kg/ha. This is not surprising given that many of the organic farmers are Fulani agro-pastoralists, which attach different levels of importance to cropping. Moreover, there is a learning curve associated with being a successful organic farmer and many of the farmers have converted to organic farming recently. For more information about organic cotton farming in Banikoara the reader is referred to in a video (in FR) with the supervisor of the organic farmer association AFVA[12] in Gomouri Banikoara.

4.3 Net-benefits from organic and conventional farming

Because organic farmers have revenues similar to those of the conventional producer but significantly lower input costs, organic cotton farmers earn higher per hectare incomes overall. Specifically, during the 2015/2016 season, organic producers were earning on average EUR 245 per hectare net of all input costs, whilst conventional producers were earning EUR 134 per ha, so half of the benefit of organic producers. Accounting for the costs to the treasury associated with the subsidised farm inputs, the net-benefit for the 2015/2016 season was as low as EUR 77 per ha for the cultivation of cotton by conventional means (*table 4*). See *annex 1* for more detailed information.

As shown in *table 5*, however, organic farmers spend an additional 24 labour days/ha/year, relative to non-organic farmers. No attempt has been made to time value of family labour here, since that depends on who is working (children vs. adults) and when they work (high vs. slack season). Obtaining such information was beyond the scope of this study. Barriers to scaling up organic cotton

12 *The association AFVA 'Association des Femmes Vaillantes et Actives' has 200 members of organic farmers. The association is supported by Helvetas. Interview (in FR) with Antoinette Garadima Baké can be accessed here : https://www.youtube.com/watch?v=JxV8ypdOzAo&t=997s*

TABLE 5

Family labour in 1 ha of organic and conventional cotton production

Labour demands (days/ha/year)	Organic farming	Conventional
Land clearing, mowing, ploughing, sowing, plant separation	32	22
Fertilization, weeding, collection of neem seeds and leaves, (bio)pesticide treatments	38	25
Average total family labour time in days, excluding harvest	**70 (65)***	**47 (41)**

** Medians in brackets*

production and production efficiency are discussed in section 5.3.

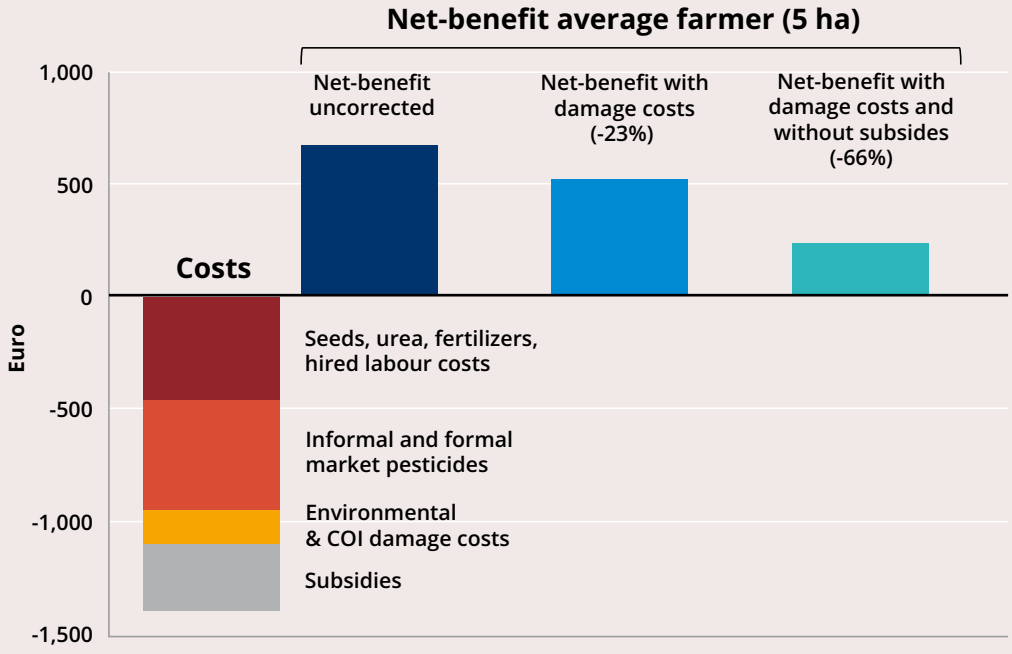
4.3.1 The benefit of conventional cotton production when accounting for damage costs and government subsidies

The societal benefit of conventional cotton production is the value added which remains once production costs, the costs of the environmental damage and government expenditures, in form of subsidies, have been deducted from the sales value. *Figure 8* shows the breakdown of these costs for a farm with 5 hectares of cotton (average size) and the resulting net-benefit for the agricultural season of 2015/2016.

When accounting for the damages of pesticides to health and the environment, the net-benefit to farmers from 5 ha of cotton production is reduced by **23%**, from EUR 670 to EUR 518. Additionally, when accounting for the costs to taxpayers from subsidising farm inputs as well as environmental costs thereof, the true net-benefit for the agricultural season is reduced by **66%** to a mere EUR 226.

FIGURE 8

Private and societal costs and net-benefits from conventional cotton farming



05 Discussion and complementary results

The above-presented results reveal that conventional cotton farming does not bring significant societal benefits compared to the production of organic cotton and other food and cash crops (see ELD analysis from Bantè and Banikoara)[13]. The main reason is the high input costs involved in producing the crop. This puts farmers in a vulnerable situation in case of poor yields, since most inputs are obtained on credit and are paid back when the cotton grains are sold to the cooperative. A recent study by IIED in Zambia found similar results, arguing that 'farmers simply make too little income after paying back the loans for inputs' (Weng et al. 2017).

5.1 Linking yields of conventional cotton to key farm inputs

By making farm inputs cheaper, government subsidies encourage excessive use of pesticides. An econometric 'production function' analysis,

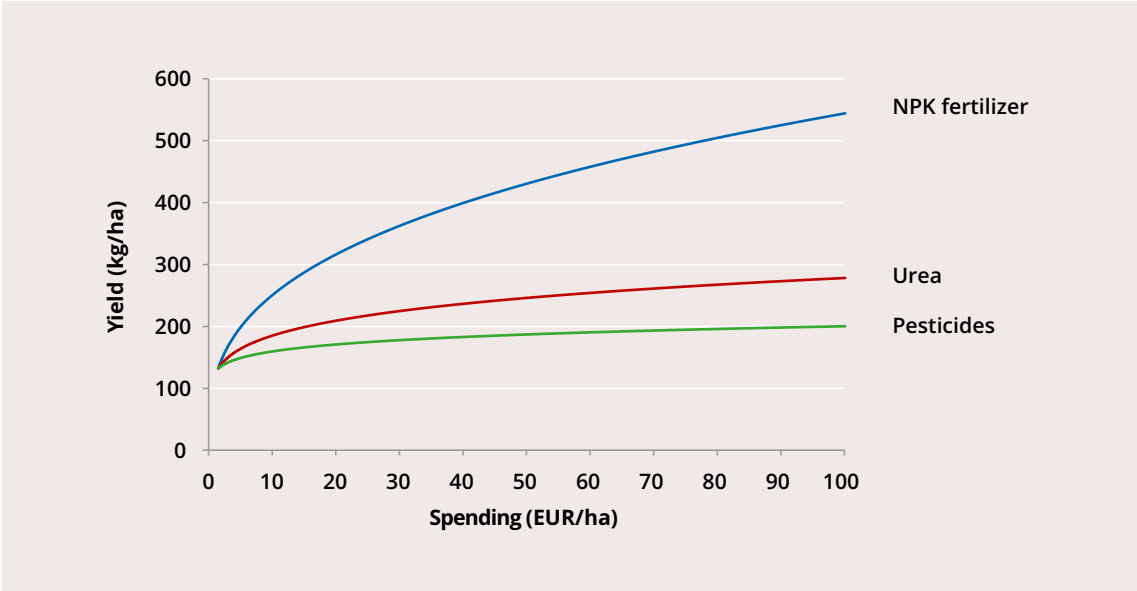
TABLE 6

Optimal and actual spending on farm inputs

Expenditure in EUR/ha	Optimal expenditure	Actual average expenditure
Black market pesticides	5	39
Urea	11	26
NPK fertiliser	46	54

FIGURE 9

Cobb-Douglas production function – Relationship between yields and expenditures on farm inputs (NPK fertiliser, urea and black market pesticides[14])



13 *The results presented here are from the 2015/2016 cotton-growing season; however, evidence shows that the yields of this season were similar to previous seasons, according to MAEP (2016) and survey results (more detail in Westerberg et al. 2017).*

14 *It was not possible to establish a statistically significant relationship between yields and use of pesticides sold on the formal market. This does not imply that formal market pesticides do not contribute to yields, but rather reflect problems of matching data from households with pesticide data provided by the government agencies on those households.*

undertaken for this study showed that farmers in Banikoara spend too much on farm inputs (*figure 9*). Above 5 EUR/ha for black market pesticides, 11 EUR/ha for urea and 46 EUR/ha for NPK fertiliser, any additional spending on these inputs is not offset by sufficient increases in yields (*table 6*). Farmers are therefore making unnecessary losses, spending far more than what is economically optimal, especially on pesticides and urea.

The results shown here are not unique to Benin. A recent study published in the magazine Nature, analysed 1,000 farms across France and showed that virtually all farmers could significantly cut their pesticide use while still producing the same amount of food (Lechenet et al. 2017). Farmers using low levels of chemicals employ other method to control pests, such as rotating crops, mechanical weeding, resistant crop varieties and carefully managing sowing dates.

A previous study on the competitiveness of the Beninese cotton sector suggests that excessive use of inputs was also the norm a decade ago (Matthess et al. 2005). In particular, Matthess et al. (2005) shows that in certain production zones, the quantity of fertilisers available for an agricultural season were 300 times larger than the recommended doses per hectare.

The recent reduction in subsidies for fertilisers and pesticides under the Talon government is therefore welcomed (see section 4.1.4). However, since there is a risk that this may cause farmers to substitute to black-market pesticides, it is advisable that the reform is accompanied with awareness raising campaigns about the danger of using pesticides, their ineffectiveness beyond a certain consumption level, as well as alternative methods and equipment that can be used to control pests.

5.2 Reasons for "going organic"

Above-mentioned results and discussion indicates there are many reasons – both financial and environmental – for cotton farmers to change their production systems to organic farming. Looking at the motivations amongst organic producers in Banikoara (*figure 10*), it can be seen that the most important reason for producing organic cotton instead of conventional cotton is the absence of adverse health effects. Many farmers – especially those with substantial cattle numbers, such as the Fulani people – also find that it is easier to produce organic cotton.

FIGURE 10

Why farmers are producing organic cotton rather than conventional cotton?

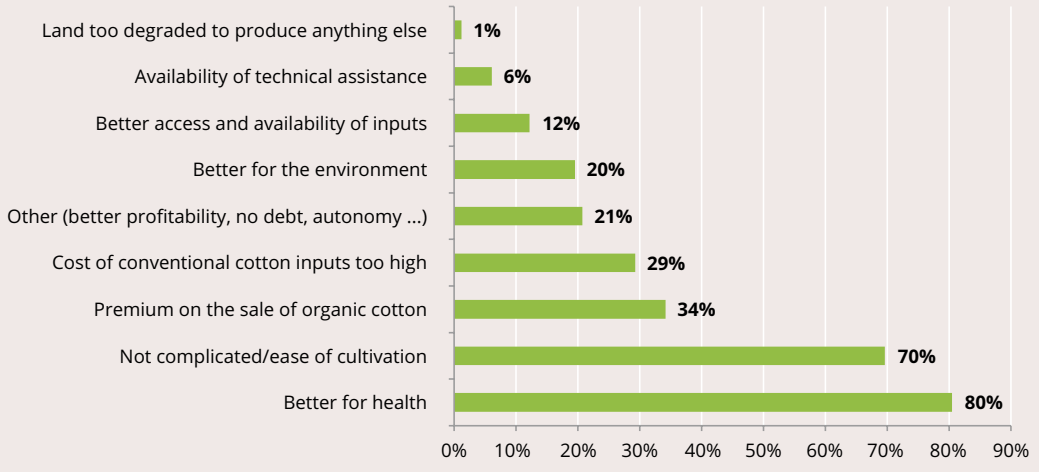
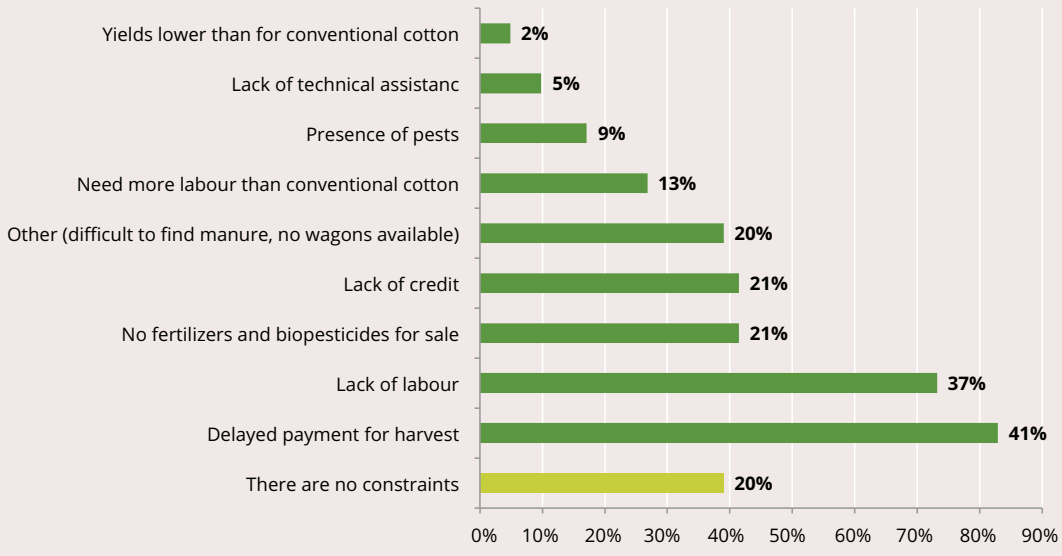


FIGURE 11

Picture of the 'agropastoralist' Fulani people in the village of Gomouri, where the organic producer association AFVA is located.

FIGURE 12

What are the principal constraints to organic farming?



5.3 Barriers to scaling up organic farming

If organic farming is better for household economies and health, one may question why are there less than 1% organic producers in Banikoara? Amongst the organic producers, *figure 12* shows that availability of labour, credit and inputs (wagons, manure, biopesticides) are perceived as important constraints to scaling up their operations.

Indeed, during fieldwork for this study, we observed that conventional cotton producers talked about themselves as locked into conventional cotton production, because it is the only government-assisted sector, and therefore the only crop for which they can obtain farm inputs or loans. The cultivation of conventional cotton is therefore the choice by default for most farmers. As similarly argued by Matthess et al. (2005), efforts should be made in Benin to ensure that farmers can obtain access to credit for other crops than cotton and other production methods.

5.3.1 Caveats

Organic farmers have less land and more livestock compared to conventional producers. A key question is therefore whether organic farmers would be able to maintain the high margins that we have demonstrated above, if they had larger surfaces? This would undoubtedly depend on their capacity to invest in key farm inputs such as wagons to help them transport manure to the field or hire extra labour. At this stage however, the above-presented analysis does not provide a perfect like-for-like comparison of the economic situation of organic versus conventional farmers.

Additionally, it is important to note that the Beninese government purchases cotton grain from conventional and organic producers above global market prices. Government spending on these price floors have not been accounted for in this study, linked to difficulties in finding accurate information on the matter.

Finally, it should be mentioned that the situation in Banikoara is not illustrative of other cotton producing municipalities in Benin. It is well known for being an 'extreme' case with respect to how much cotton is produced, the presence of a well-developed black market for pesticides and the associated damages to health and the wider environment. Moreover, the relative importance of cotton as a cash crop within the municipality of Banikoara also implies that Banikoara enjoys a higher level of service provision, e.g. better-equipped schools than in other municipalities within Benin (Bertenbreiter, personal communication 2017).

05 Concluding comments

Health risks in agricultural production are a growing problem facing Africa (World Bank 2000; Ajayi 2000; UNEP 2013). In Banikoara, we have shown that the annual environmental and health related damage costs are in the order of EUR 174 (XOF 114200) per household. With an estimated 16,600 cotton producing households, the global damage cost for Banikoara amounts to EUR 2.9 million per annum.

We also showed that the net value of cotton production is reduced by 66% for an average sized farm when accounting for government subsidies for inputs and environmental damage costs. This is an important insight, because if significant amounts are spent inefficiently, then public funds should be invested in order to achieve greater societal benefits in another sector or on other production methodologies.

In particular, we argue that this is the case for adopting sustainable land management practices such as crop rotation and direct seeding mulch-based cropping, as these can help reduce farmer's reliance on costly inorganic and chemical production inputs. The adoption of SLM approaches could be done incrementally and prepare interested farmers for organic production.

Indeed, the international demand for organic cotton is on the rise. Moreover, this study has shown that average per-hectare incomes of organic farmers in Banikoara are nearly twice as high as those of conventional cotton farmers, and triple

when excluding input subsidies for conventional farmers.

Furthermore, the sustainable land management practices used by organic farmers helps build up soil organic matter and is highly complementary to pastoralist activities. This makes organic farming systems more resilient to climate variability (Kloos and Renaud 2014) and a tool for managing conflicts between pastoralists and farmers in Northern Benin. As such, organic farming can help contribute to the Sustainable Development Goal 'life on the land', in particular target 15.3, by restoring degraded land and promoting land degradation-neutrality.

Currently, organic farmers in Banikoara have small landholdings (average of 1 ha), and they depend on access to finance, labour and farm inputs to allow them to scale-up their farm-holdings and overcome bottlenecks. Meanwhile, conventional cotton farmers need to become aware that they can also be supported in their efforts to produce cotton differently.

For this purpose, a more level playing field is needed, involving enhanced access to knowledge and investment opportunities in sustainable land management. The government's recent initiative to reduce subsidies for conventional cotton inputs is a step in the right direction, though care needs to be taken that farmer's do not substitute towards increased use of black market chemicals.

As such, the reduction of distortionary subsidies should go hand in hand with the provision of extension services, teaching farmers about ways to adopt integrated pest management and soil fertility management. Moreover, we have seen that the costs of illness from pesticides spraying can immediately be reduced through the use of high-precision low volume spraying tools such as ULVA+ (as opposed to a backpack sprayers or aerosols). Again, better information campaigns are needed to ensure farmers adopt best practices.

In conclusion, through increasing consumer awareness, Benin's national commitment to the sustainable development goals and ever-pressing challenges of climate change have created a momentum for change. It is an opportune moment to leap forward and generate policies and economic incentives in a direction that can transform rural landscapes, and improve the livelihoods and prospects of the farmers – the true pillars of the Beninese economy.

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Annex 1:

Table A 1.1: Enterprise budget – conventional cotton

Conventional production – 1 ha	Mean		Std dev	Min	Max
Price (EUR/kg)	0.32		0.0	190	220
Yield (kg/ha)	1'060		0.9	170	3250
Revenue (EUR/ha)	315		201	78.8	1134
Input costs (EUR/ha)	**Mean**	**Without subsidies**	**Std dev**	**Min**	**Max**
Cotton seeds	5.4		3	1	15
NPK fertiliser	52.0	78	35	0	258
Urea	23.1	35	19	2	120
Organic manure	1.3		5	0	45
Hired labour	9.1		18	0	113
Black market pesticides	38.7		30	0	168
Formal market pesticides	57	78	49	2	288
Total cash cost	**186**	**245**	**82**	**95**	**614**
Net-benefit (EUR/ha)	**Mean**		**Std dev**	**Min**	**Max**
Net-benefit*	**134**	**77**	**127**	**-158**	**755**

Figure A 1.1 Distribution of yields amongst conventional cotton farmers (#190), truncated

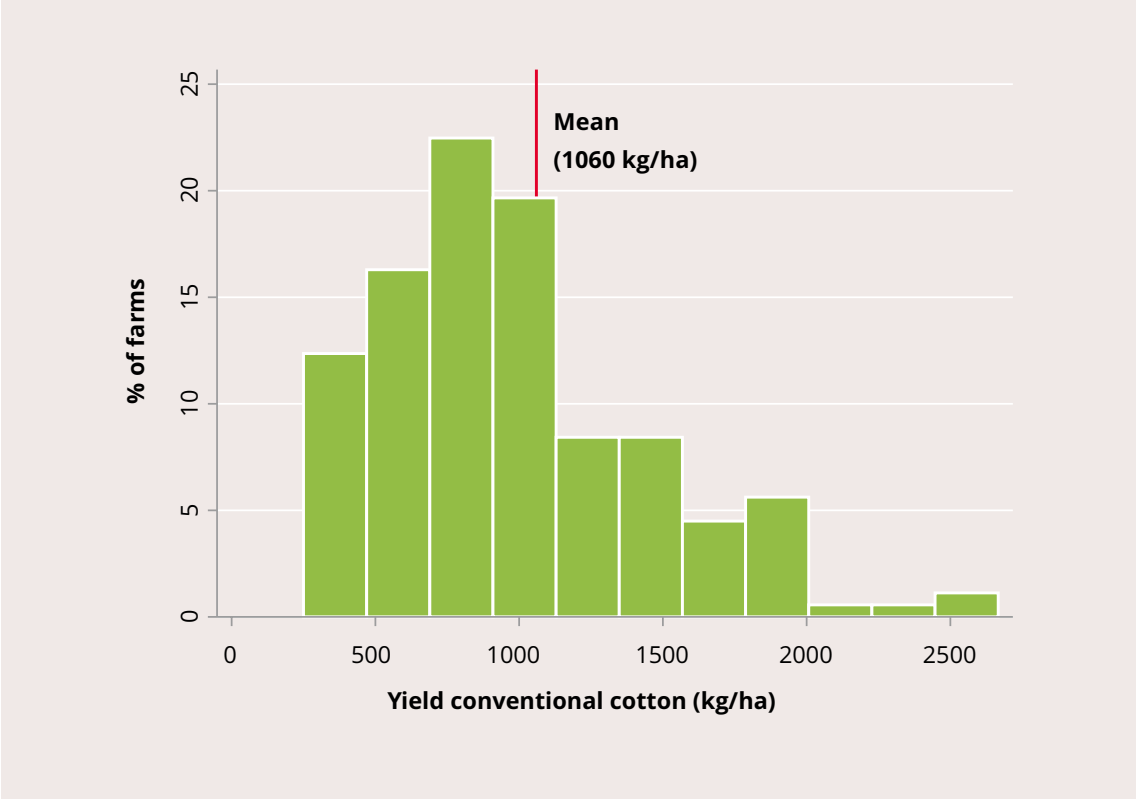
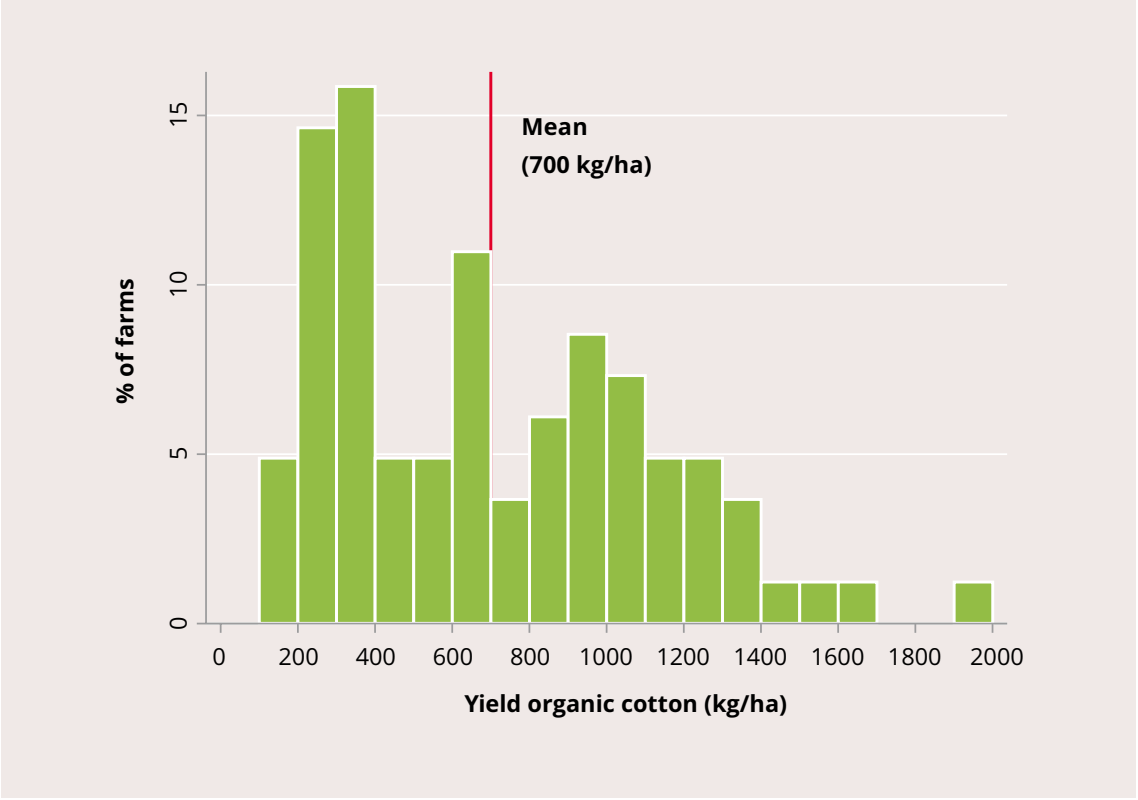


Table A 1.2 Enterprise budget – organic cotton

Organic production – 1 ha	Mean	Std dev	Min	Max
Price (EUR/kg)	0.45	32	213	360
Yield (kg/ha)	697	415	100	2000
Revenue (EUR/ha)	313	190	53	927
Input costs (EUR/ha)	**Mean**	**Std dev**	**Min**	**Max**
Cotton seeds	6.1	5	0	23
NPK fertiliser	4.5	5	0	31
Urea	7.5	31	0	315
Organic manure	9.2	17	0	90
Hired labour	20	40	0	252
Black market pesticides	9.2	15	0	67
Formal market pesticides	12	18	0	86
Total cash cost	**69**	**58**	**2**	**376**
Net-benefit (EUR/ha)	**Mean**	**Std dev**	**Min**	**Max**
Net-benefit	**244**	**190**	**21**	**675**

Figure A 1.2: Distribution of yields amongst organic cotton farmers (#90)



List of tables

Table 1	Cost of illness in Banikoara from short term and long term health effects	16
Table 2	Cost of illness as a function of main spraying tool used by farmers	17
Table 3	Damage cost from pesticide pollution and poisoning	17
Table 4	Enterprise budgets of organic and conventional cotton production	20
Table 5	Family labour in 1 ha of organic and conventional cotton production	21
Table 6	Optimal and actual spending on farm inputs	22
Table A 1.1	Table A 1.1: Enterprise budget – conventional cotton	30
Table A 1.2	Table A 1.2 Enterprise budget – organic cotton	31

List of figures

Figure 1	Municipality of Banikoara	9
Figure 2	Value chain of cotton production (based on depiction from Fast Fashion)	10
Figure 3	On the left, the Pyrinex pesticide, containing chlorpyriphos and deltamethrin, sold by the former government regulated agency known as CARDER. Right, employees unloading pesticides.	12
Figure 4	Three pesticides found on the black market of Banikoara. They contain cypermethrin and chlorpyriphos, two molecules toxic to humans and aquatic organisms, with a half-life in soil of up to 180 days (WHO 2010, Scientific American 2010).	13
Figure 5	Share of households who have used medicine, visited a doctor or a traditional practitioner, been hospitalised, were incapable of working and hired substitute labour – at least once during the year preceding the household survey.	15
Figure 6	Annual COI as a function of spraying tool used by farmers	17
Figure 7	Input expenditures and costs to the government treasury per hectare of organic and conventional cotton	19
Figure 8	Private and societal costs and net-benefits from conventional cotton farming	21
Figure 9	Cobb-Douglas production function – Relationship between yields and expenditures on farm inputs (NPK fertiliser, urea and black market pesticides[14])	22
Figure 10	Why farmers are producing organic cotton rather than conventional cotton?	23
Figure 11	Picture of the 'agropastoralist' Fulani people in the village of Gomouri, where the organic producer association AFVA is located.	24
Figure 12	What are the principal constraints to organic farming?	24
Figure A 1.1	Distribution of yields amongst conventional cotton farmers (#190), truncated	30
Figure A 1.2	Figure A 1.2: Distribution of yields amongst organic cotton farmers (#90)	31

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