'Pesticides are our children now': cultural change and the technological treadmill in the Burkina Faso cotton sector

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Abstract

Amidst broad debates about the "New Green Revolution" in Africa, input-intensive agriculture is on the rise in some parts of Africa. This paper examines the underlying drivers of the recent and rapid adoption of herbicides and genetically modified seeds in the Burkina Faso cotton sector. Drawing on eight months of ethnographic fieldwork in the Houndé region, this article contends that economic and cultural dynamics – often considered separately in analyses of technology adoption – have co-produced a self-reinforcing technological treadmill. On the one hand, male farmers seek to increase cotton production in response to an economic squeeze. At the same time, broader cultural shifts toward individualism have created labor shortages as a result of families splitting apart, parents putting their children in school, and some women and young men refusing to provide free labor. Male cotton farmers thus increase production by turning to labor-saving inputs like herbicides, but these inputs create more debt, further locking farmers into intensive production. This article thus expands on the classic concept of the technological treadmill, demonstrating how economic and cultural processes *intersect* within a process of agrarian change to drive labor-saving agricultural technology adoption in the Burkinabè cotton sector. This expanded treadmill concept illuminates the complex dynamics compelling farmers' choices to opt into input-intensive agriculture, and also helps explain rising farmer differentiation, as poorer farmers struggle to stay afloat and wealthier farmers expand.

Keywords: Green Revolution; agricultural technology adoption; herbicides; Bt cotton; labor shortages; Africa

Abbreviations:

Bt: *Bacillus thuringiensis*, refers to genetically modified Bt cotton

CFA: The West African Franc (currency denomination); roughly 500 CFA to 1 US dollar.

GM: genetically modified

GPC: Groupement des Producteurs du Coton, or Cotton Producer Group

SOFITEX: Société Burkinabè des Fibres Textiles, the parastatal cotton company in Burkina Faso

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Acknowledgements: I would like to thank my funding agencies: the Fulbright Foundation, the National Science Foundation, the American Association of University Women, and the University of Colorado Boulder Dean's Office. Also thanks to insightful comments from Jill Harrison, Daniel Ahlquist, and anonymous reviewers. I extend deep appreciation to my research assistants and to all of my research participants. Also thanks to Mike Simsik, Gabin Korbeogo, folks at the American Association of Geographers annual meeting, and exchanges at the Pesticide Politics in Africa conference in Arusha, Tanzania in 2019.

Introduction

For decades, the conventional wisdom of agrarian "crisis" in Africa has revolved around the idea that Africa was skipped by the Green Revolution, and the key to unlocking agricultural development resides in expanding input-intensive agriculture (Berry 1984; Moseley et al. 2017). This view has been revived in the recent push for a "New Green Revolution for Africa," which offers an updated version of the input-driven Green Revolution, with a new focus on the private sector and value chains (Patel 2013). The overall assumption, however, remains the same: that African farmers do not sufficiently use agricultural inputs such as synthetic fertilizers, pesticides, mechanization, or high-yielding seeds. Many scholars are concerned that this technology-driven approach will reproduce the same shortcomings of the Green Revolution, increasing overall production while exacerbating environmental degradation, inequality, and poor households' food security (Kansanga et al. 2018; Gengenbach et al. 2018; Moseley et al. 2017; Nyantakyi-Frimpong and Bezner Kerr 2015; Scoones and Thompson 2011; Rock 2019).

However, alongside these debates, and to the hope or dismay of some debate participants and observers, many regions in sub-Saharan Africa are undergoing what Houssou et al. (2018) call a "quiet transformation." That is, farmers in many – albeit highly uneven – contexts are increasing their use of purchased agricultural inputs (Williamson et al. 2008; Sheahan and Barrett 2017). For scholars and observers of African agrarian change, this raises the question: why now? What are the specific conjunctures that help explain the growth in input-intensive agriculture in certain places in Africa? Certainly, there is no single answer to this question. We know from broader literatures that technology use depends on complex interactions of political, economic, social, environmental, and individual factors in particular places (Glenna et al. 2011; Galt 2013). This article examines a particular set of interactions in a particular place: Burkina Faso's cotton sector, where over the last fifteen years farmers have been rapidly increasing their use of herbicides, synthetic fertilizers, mechanized equipment, and (from 2008-2015) genetically modified seeds (Faure and Vognan 2012; Gray and Dowd-Uribe 2013). This paper seeks to explain why farmers are engaging in this rapid process of technology adoption.

In seeking to explain this rise, we are aided (and overwhelmed) by vast but fragmented literatures on technology adoption. While economic approaches and "adoption and diffusion" research have sought to isolate variables that explain adoption (Rogers 2010; Feder and Savastano 2017), cultural approaches have argued that identity and status performances shape

farmers' decisions (Bell 2004; Burton 2004; Luna 2018). In another vein, political economists have posited a "technological treadmill" wherein economic pressures produce self-reinforcing dynamics of technology adoption (Cochrane 1979; Ward 1993). However, despite the strengths in each approach, few scholars have explicitly explored how economic and cultural processes *intersect* within processes of agrarian change to drive technology adoption. This paper builds on the concept of the technological treadmill, examining how processes of cultural change feed into the treadmill to drive technology adoption.

Drawing on eight months of ethnographic fieldwork and 125 interviews with cotton sector actors in 2016, I contend that male cotton farmers' choices to use new technologies – specifically herbicides and genetically modified (Bt) cotton – are driven by two mutually compounding processes: economic pressures to increase income (an economic treadmill of production), and cultural changes associated with capitalism and aspirations for modernity. These processes have fed into each other in a cyclical process that further compels technology adoption. This paper thus makes two broader contributions. First, it expands the theory of the technological treadmill to explicitly include culture. Second, by drawing culture into the technological treadmill, it helps explain the expansion of input-intensive agriculture in some parts of contemporary Africa. In particular, numerous scholars have pointed to rising agrarian labor shortages in multiple contexts (Berry 1993; Oya 2007; Hull 2014; Addison and Schnurr 2016; Houssou et al. 2018). My findings reveal the partially cultural drivers of labor shortages in Burkina Faso, and demonstrate how these labor shortages feed into and intersect with the economic treadmill. By showing how these economic and cultural processes weave together in a cyclical way, I show that farmers are making choices, but (as Marx famously wrote) not in conditions of their own choosing. Identifying those conditions is critical for understanding technology adoption as well as broader pathways of agrarian change in Africa.

Agricultural technology adoption and changing labor dynamics in West Africa

Before examining the specific case of West Africa, it is worth briefly considering the wider literature on technology adoption in agriculture (Feder et al. 1985). Broadly, this research has undergone two major waves: adoption and diffusion research in rural sociology from the 1940s to 1970s (Ruttan 1996), followed by micro-economics literature that treats farmers as rational decision makers. This research often seeks to isolate variables that influence technology adoption, such as farmer characteristics, technology characteristics, prices and access, or even

social network attributes (Rogers 2010; Feder and Savastano 2017). In contrast to this micro-approach, macro-economists zoom out from the individual-level to examine characteristics of a region. "Factor scarcity" and "induced innovation" models (Boserup 1965; Hayami and Ruttan 1970) posit that farmers innovate (or adopt new technologies) when faced with population pressures, or a change in the cost or availability of a major factor of production such as land or labor.

A very different macro-level approach comes from political economists of agrarian change, who have theorized a "technological treadmill" (Cochrane 1979; Buttel et al. 1990; Ward 1993), wherein farmers adopt new technologies because of the escalating economic pressures of capitalism. In this perspective, technology adoption is seen not as a rational choice made by free actors, but as more of a necessity for economic survival. In Cochrane's (1958; 1979) classic formulation, as more farmers adopt a new technology, overall farm output increases and prices fall, further compelling farmers to adopt the technology in order to stay afloat. In broader usage, the treadmill refers to the myriad political-economic drivers that necessitate shifts toward ever more input-intensive agriculture (Galt 2013; Stone and Flachs 2018). Some scholars have also drawn explicit parallels between the agricultural technology treadmill and the environmental sociology concept of capitalism's "treadmill of production" (Bell 2004; Buttel 2004). The technological treadmill also parallels the idea of technological "lock-in," whereby farmers continue to use an inefficient or damaging technology (Cowan and Gunby 1996; Wilson and Tisdell 2001), and the concept of the "reproductive squeeze" (Bernstein 2010; Li 2014), wherein farmers are pinched by rising costs and falling incomes.

While agrarian political economy offers an important counterbalance to mainstream economic approaches to technology adoption, both of these approaches can still overlook non-economic processes that shape technology adoption. Stone (2016), for example, has differentiated between different types of farmer learning, including social (learning by watching others), environmental (learning by doing), and didactic (learning as a result of external actor influence, such as lobbying by agri-businesses or the state). In the social or cultural realm, rural sociologists have argued that farmer behavior is shaped by cultural ideals of what constitutes a "good farmer" (Burton 2004; McGuire et al. 2013), farmer aspirations for status or prestige (Bell 2004; Burton et al. 2008; Harrison and Lloyd 2013), or performances of masculinity (Saugeres 2002; Campbell et al. 2006). Farmers may adopt – or avoid – technologies or practices to

perform racial or ethnic identity and status (Gidwani 2008; Yeh 2013) or to go along with social fads (Stone 2007). In Burkina Faso, technology choices are influenced by farmers' aspirations for the status of Western modernity (Luna 2018). In sum, this scholarship contends that farmers' technology choices are shaped by efforts to perform identities or achieve status within specific cultural settings.

Despite these myriad insights, most literature on farmer behavior and technology adoption remains fragmented, and relatively little attention has been paid to the *interactions* between economic and cultural components. However, we cannot assume that economic and cultural components simply add together or matter independently of each other at different times. Instead, we must interrogate *how* they fit together and interact, situating technology adoption within historical and contingent processes of agrarian change. This is particularly relevant for understanding the current expansion of labor-saving technologies in Africa south of the Sahara: while labor shortages may be a proximate driver of technology adoption, a more complete explanation would also examine the drivers of labor shortages.

For this, we can turn to scholarship on agrarian change, which offers insight into historical processes, contested relationships of power, and changing labor dynamics in West African agriculture. This literature shows that West African farmers have historically faced labor rather than land shortages (Berry 1993; Hill 1997; Bryceson 2002), and mid- to large-scale farming has depended on mobilizing low-cost labor (Guyer 1997; Oya 2007). This often meant a male household head procuring family labor from combinations of wives, offspring, extended family and mutual-aid workgroups. Family labor remains critical, despite widespread wage and contract labor across the continent (Cordell et al. 1996; Ponte 2000). However, the control of family labor has always been subject to power contestations – what Berry (1993, p. 137) terms the "micropolitics of labor mobilization and control." This includes "culturally constructed understandings of authority and obligation" (Berry 1993, p. 138), wherein the household head (typically male) occupies a position of seniority, and in return provides junior household members with social and material goods (Berry 1985; Berry 1993; Toulmin and Guèye 2003). Labor control – and, correspondingly, labor scarcity – is thus not just a question of wage labor rates, but is enmeshed in cultural understandings and social relationships of power, which are subject to constant negotiation, contestation, and change.

There are two notable trends in rural West African labor dynamics. First, in many places, including West African cotton zones, previously extended-family farming operations are splintering into smaller family units as a result of intergenerational conflicts, land pressures, crises in male cash crop production, and rising opportunities/necessities for off-farm employment (Becker 1990; Berry 1993; Gray and Kevane 2001; Toulmin and Guèye 2003; Bernstein 2004; Bryceson 2019). Individualized farming operations reduce farmers' access to labor from extended family members, particularly when accompanied by a reduction in mutual-aid work groups. Second, many farmers struggle to mobilize labor *within* the nuclear family, resulting from the individualization of livelihoods, changing reciprocal obligations within families, young people migrating for work, and parents putting their children in school (Berry 1985; Oya 2007; Hull 2014). This scholarship reveals the deeper processes of change affecting male farmers' ability to mobilize labor, and I draw on these insights in examining how economic and cultural factors interact to shape technology adoption in the Burkina Faso cotton sector.

Case background and methods

Cotton farming is the leading edge for agricultural modernization and technology adoption in many West African countries (Gray and Moseley 2008). In Burkina Faso, cotton has been the primary agricultural export for decades, and was only recently surpassed by gold as the leading source of export revenue. Following forced production for France during the colonial era, Burkinabè cotton production was organized by a state marketing board (SOFITEX) in the late 1970s. Although Burkina Faso partially liberalized the cotton sector in 2004 under pressure from the World Bank, SOFITEX has retained control over the southwest region, which continues to produce roughly 80% of the country's cotton (Dowd-Uribe 2014a).

Agricultural technology adoption in the southwest has been facilitated by SOFITEX's efforts in agricultural extension, marketing, and credit services. In the 1980s, SOFITEX introduced and financed animal traction and plows (Gray and Kevane 2001), and obtained external credit and donor support to extend credit to farmers to purchase inputs like pesticides and fertilizers. Currently, SOFITEX farmers are organized into groups (GPCs), often based on kinship. Through extension agents, SOFITEX provides GPCs with inputs (seeds, fertilizer, pesticides) on credit at the beginning of the farming season, and later picks up farmers' harvested cotton. After weighing the cotton, SOFITEX pays the GPC a lump sum for the amount they are owed minus their credits. This system helps SOFITEX recoup costs, but also means that farmers

pay for other farmers' debts, which can lead to significant in-fighting within families and GPCs (Gray et al. 2018; Luna 2019). SOFITEX also withholds credit and inputs from indebted farmers and GPCs, which is more frequently smaller-scale and resource-poor farmers (Gray et al. 2018).

In recent years, agricultural inputs – and herbicides in particular – have become more widely available via market channels. Market chemicals are often cheaper than SOFITEX products because they don't include a credit fee, are illegally imported (Toe et al. 2013), or are generic products from China. However, market chemicals often require cash up-front, which many farmers do not have at the start of the farming season. Because of this, farmers still use SOFITEX to get many of their inputs on credit. Overall input use has been rising in recent decades (Faure and Vognan 2012), and herbicide use in particular has risen substantially in the last ten to fifteen years (Bationo 2017). A pesticide salesperson in the regional city of Houndé, for example, told me that in 2003 there were only three pesticide sellers, and demand was low. In 2016, the Houndé markets were jam-packed with pesticide stalls. A SOFITEX extension agent in the Houndé region called farmers' level of herbicide use "frightening." The Plant Protection division of the Ministry of Agriculture, which tracks pesticide imports in Burkina Faso, also reports dramatic increases in herbicides. Nonetheless, data on the quantity and change in herbicide use in Burkina Faso is still limited (Ouédraogo et al. 2011).

The second – more internationally visible – agricultural technology in Burkina Faso has been genetically modified Bt cotton that (initially at least) reduced insecticide use from six sprays to two sprays (Dowd-Uribe 2014b). Bt cotton seed was sold to farmers by SOFITEX on credit, costing CFA27,000 (roughly US$50) per hectare. Farmers began growing it in 2008, and up to 70% of cotton farmers had adopted Bt cotton before the state ended production in 2016 due to a short fiber length and declining export receipts (Dowd-Uribe and Schnurr 2016). Farmers' adoption of Bt cotton decreased their labor in the particularly grueling (and hazardous) labor of spraying insecticides, although it may have increased labor needed at harvest time (Sanou et al. 2018).

Methods and field site

This paper draws on eight months of qualitative research conducted in Burkina Faso between February and December 2016. I conducted 125 interviews with cotton sector actors, including cotton company employees, government and non-governmental agency employees, and farmers. The crucial data for this paper come from five months of fieldwork conducted in two farming

communities: Kongolekan and Dougoumato in the Tuy Province of the Hauts-Bassins region, part of the Houndé region in the SOFITEX organizational system. Houndé is portrayed by SOFITEX officials as one of the leading regions in terms of technology adoption and agricultural modernization. Kongolekan and Dougoumato are adjacent communities of predominantly Bwa farmers, with a combined population of roughly 4,000 people. Based on my data, farms range from two to fifty hectares, with most farmers growing three to fifteen hectares (often on multiple plots of land). Most farmers concentrate on cotton and corn, and grow what they call "small crops" on the side (such as beans and peanuts) and occasionally other crops like soy. The majority of farmers use animal traction, and a dozen or so now own tractors. Some farmers do not have or have lost their oxen, primarily due to debt. Farmers without oxen tend to pay other farmers or trade their labor in exchange for borrowing oxen or having a tractor till their field.

Gendered structures of property and labor significantly shape farming practices. In general in Burkina Faso, men control land and access to land (Kevane and Gray 1999). Unlike some areas of Burkina Faso (Haider et al. 2017), male Bwa farmers in Kongolekan and Dougoumato do not subdivide their fields into household and individual fields. Instead, most fields are controlled by the male household head. Cotton production is also a predominantly male-controlled activity as a result of the colonial shaping of the cotton sector (Gray and Moseley 2008). However, a few women (often widows) do run their own cotton farms, and on all farms, women provide substantial amounts of labor. Small numbers of women have left their husbands to pursue alternative livelihoods or to farm on their own, while others engage in more hidden forms of resistance (Luna 2019).

To understand technology adoption processes, I draw on 43 interviews with male farmers and 24 interviews with rural women, representing a wide range of ages and socio-economic attributes. Although I focus on male cotton farmer decisions to adopt technologies, female perspectives help inform my understanding of the changing family, cultural, and labor dynamics in the community. I first interviewed a set of wealthier and larger-scale male farmers who manage the cotton farming organizations (GPCs), then proceeded to interview farmers I met at random in social settings, and later sought out interviews with women and smaller-scale and indebted farmers. In these 1.5- 2 hour interviews, I asked open-ended questions about the changes people had seen in the community during their lives, and more specific questions about their farming practices, farm change, technologies, difficulties, and aspirations for the future.

These interviews were conducted in Dioula (the local trade language, which I speak nearly fluently), with part-time research assistance from two Burkinabè Master's degree students from the University of Ouagadougou. I also draw on extensive fieldnote data from five months of participant observation fieldwork: going to farmers' fields, farming, drinking tea, attending religious events, and spending many evenings chatting with small groups of people. In these informal settings, I spoke with large numbers of farmers of all ages, and sought to understand peoples' views on their changing social world. Finally, my research assistants transcribed my recorded interviews and I re-listened to the tapes while reading the transcripts. I coded my interviews and fieldnotes for themes in an iterative process (Lofland et al. 2006), examining my findings in light of pre-existing theories and literature.

New agricultural technologies: a solution to increasing production with declining labor

Describing a cyclical process presents the conundrum of where to begin. Given the explanatory aim of this paper (technology adoption), I begin by describing farmers' proximate explanations for adopting agricultural technologies, and then work backwards to explain the dynamics driving those proximate conditions. In explaining technology adoption, many farmers identify a desire to increase their income and farm production in the face of labor shortages. In this section, I discuss these economic drivers, which correspond with the classic technological treadmill of capitalist agriculture. In this treadmill, technology becomes essential for staying afloat, yet also locks farmers into a productivist and competitive farming system in which some farmers get ahead and others fall behind. In the latter section of the paper, I examine how cultural changes feed into this system.

The economic treadmill

Farmers face economic pressures that originate in both the global political economy as well as local processes of "micro-capitalism" (Bernstein 2010; Li 2014). The economic squeeze farmers face – costs rising faster than incomes – is partially a result of global political economic forces: U.S. cotton subsidies depress global cotton prices (Gray and Moseley 2008); the devaluation of the CFA franc in 1994 effectively raised the price of imported goods such as fertilizer (Noble 1994); and structural adjustment programs forced African nations to remove or reduce subsidies on education, health, and agricultural inputs. These neoliberal policies increased costs for many rural families in West Africa (Bryceson 2002), thus creating state- and individual-level pressures to increase production of export goods like cotton (Gray and Moseley 2008).

Farmers report that their expenses have been rising, which creates pressure to increase their incomes. Some of these expenses are off-farm, such as school fees, medical bills, transportation and gas, clothing, funerals and marriages, religious costs (such as animal sacrifices or tithes), and goods such as motorcycles, metal roofs, solar panels, TVs and cable TV subscriptions, cell phones, and cell phone service (which costs roughly US$0.25/minute). Other rising expenses result from the farm changes I describe in this paper. Women report that with greater herbicide use, they grow fewer "sauce crops" within and beside their fields, so families must purchase more sauce ingredients than before. Women and men also explain that in the severe labor crunch they face, women rarely pound corn anymore, and increasingly pay to use the mechanical grinders now available in the village.

On-farm expenses are also rising. Faure and Vognan (2012) document an overall trend of rising input costs, alongside fluctuating prices received for cotton (Bassett 2014). They find that cotton production's profitability margin (already slim) is likely declining over time. My own research suggests that cotton farming is more economically precarious than often claimed in official reports from SOFITEX and in some agronomic publications. Based on interviews and focus groups, I estimate that farmers with two cows and a motorcycle have fixed operating costs of *roughly* CFA185,000 per year, plus CFA109,500 per hectare for inputs, not including labor costs.[1] Thus, an "average" farm of three hectares of cotton, making SOFITEX's average yield of 915 kg/hectare, receiving CFA235 per kilogram of cotton (2016), would net only CFA132,000, *not including* labor costs.

The resulting struggle to cover expenses is reflected in story after story I heard from farmers. For example, one small-scale farmer in his thirties told me: "One year, I sat down to evaluate my expenses, and I realized that …It's like we work for free. Even if you had a good yield, if you really look at your costs, your yields, there's not profit in it. The sweat that you spent, you didn't get a profit." A mid-size farmer told me that he farms more hectares, and gets higher yields than before, and yet he feels like he is standing in place (an apt description of a treadmill). A larger-scale farmer with a tractor explained: "We do earn a little bit of money, but it all goes back into purchasing inputs and equipment. Nothing is left." These concerns about

[1] This includes costs for: backpack sprayers, motorcycles, gas, carts, corruption (paying the cotton conditioner), UNPCB (union) fees, cows, cow vaccines, cow food during the dry season, and a cow plow. Per-hectare costs include seed, fertilizer, insecticide, herbicides, meals for harvest laborers, and GPC fees. Costs can vary *significantly*. These cost calculations are based on group discussions with male farmers.

narrow margins are further confirmed by a recent study of GPC records in the Tuy Province (near where the present study was conducted), where roughly 45% of farmers growing less than five hectares of cotton had incurred debt during the 2004–2010 period (Gray et al. 2018). Given these low – and sometimes negative – incomes, many farmers find themselves in what Bernstein (2010) calls a "simple reproduction squeeze" – with overall costs rising faster than their incomes.

Increasing cotton production in the face of labor shortages

In the face of this squeeze, many farmers seek to increase cotton production – which, through SOFITEX, has a guaranteed price and provides access to inputs on credit. Many farmers have tried alternatives to cotton (including soy, sesame, and expanded corn production), but say that price volatility, uncertain markets, striga weed, and lack of access to inputs on credit become problematic. Furthermore, options for wage employment or off-farm income are scarce, though some farmers engage in petty trading (notably herbicide sales) or pursue occupations such as clothes tailoring or masonry in addition to farming. Wealthier farmers operate grinding mills or transportation services, and the few who own tractors use them to till fields and shuck corn for non-motorized farmers. However, for many farmers, increasing cash crop production is a key strategy to try to increase income, provided they have access to land.[2] For example, one woman explained expanded cotton acreage as a strategy for farmers "to increase their revenue. They want to increase their revenue to go forward. You see now, when you have a lot of children in school, if you don't have big yields you can't pay their fees." Like many others, this woman ties yields to larger fields, and to the need to meet rising expenses.

However, expanded acreage – particularly of cotton – requires more labor, which is increasingly hard to come by, and expensive to hire. Labor shortages in the early season are time-sensitive, as farmers rush to get their fields cleared, tilled, planted, thinned, and weeded. Hiring labor in the early season is thus particularly expensive and often cost-prohibitive. In this context, controlling and exploiting family labor is the crux of farm profitability for male cotton farmers. This became vividly clear to me through interviews with SOFITEX employees. Whereas previously many of them had farmed cotton by hiring labor, by 2016 many had left

[2] Until recently, access to land was not a major constraint for most farmers in this area, although "older" families controlling the land have more land than more recently arrived or migrant families. However, with increasing farm size, forest conservation enclosures, rising numbers of migrant farmers, population growth, and families splitting, land is becoming limited. Thus, the strategy of increasing farm size to increase production may shift. However, pressures on land may be offset by rising social differentiation, as in U.S. farming communities, where some farmers fall out of the system and other farmers then incorporate their land (see Bell 2004).

cotton farming, explaining that: "If you have to pay for all the labor, for a tractor owner to come plow your fields, and then for people to come plant, and then people to weed, or to spray, and the chemicals, and then the people to come harvest, you look at all those expenses, and it's better to just keep your money at home. It's not profitable." In other words, cotton is *only profitable* when men can appropriate the poorly-paid or unpaid labor of their family members. This assertion, echoed by many interviewees, is also supported by data I collected on labor costs.[3]

Farmers describe labor supply as a major factor shaping their production. The following interaction with a middle-aged male farmer in his fields illustrates a common theme:

> I asked how much cotton they grew. He said not much… only five hectares… He said they couldn't do more – it was just him and his wife now, and his boys were in high school now and weren't around to work for all of the farming season …"We're just trying to do our best." He said, "If our kids weren't in school, we could farm more."

Even farmers who want to hire labor have difficulty doing so. Farmers explained that mutual-aid work groups (*ligili*) between families have largely disappeared, with the remaining groups (women and a church youth group) working "only for money" and only at certain times of the year. In terms of hiring contract or wage laborers, a relatively wealthy middle-aged male farmer told me: "Sometimes you can find hired labor, but the last two years it has been difficult, there isn't anyone to hire." Some community members think migrant workers are now working in artisanal gold mines (see Werthmann 2009). Others, particularly poorer farmers, point out that the problem is lacking both people *and* the money to hire people. As one man in his mid-30s put it: "When you farm alone (split up) there are difficulties… If you have enough money, you can hire people to work for you, because there are a lot of people around… But when you don't have the money, it's very difficult. Because you don't have the people. You don't have the people." In essence, the Catch-22 for poor farmers is that making money requires people, but hiring people requires money.

Labor-saving technologies

[3] I found (CFA) wage/service rates *per hectare* of: 25,000 (tilling, tractor), 10,000 (delivering inputs to farm), 13,750 (seed planting/re-planting), 5,500 (thinning), 10,000 (weeding, oxen), 12,500 (hilling, oxen), 6,000 (spraying), 25,000 (harvest), 5,000 (transportation of harvested cotton). This adds up to CFA117,750 per hectare. At CFA215,000 net income per hectare, and additional per-hectare input costs of CFA109,500, it is not profitable to hire all labor. (This calculation excludes the aforementioned fixed costs, assuming the farmer hires out all these services).

Enter labor-saving agricultural technologies. Herbicides in particular are often explained as a necessity for maintaining or increasing production of cotton and corn while "not having the people." One older woman explained:

> When you see the fields of one person, you have the impression that it must be a huge number of people farming those fields, but no, it's just one person. Because now, when the weeds come up, we have products (meaning herbicides). … There are many things now, which is why the fields are getting bigger and bigger.

Similarly, the male farmer above who discussed his children being in school told me that "*pesticides are our children now*," using the local term (*fura*) that farmers use for all pesticides, but referring specifically to how herbicides had replaced his children's weeding labor. A middle-aged woman commented: "You see how the fields are growing? It's not because of the strength of people. It's the products, which help people by reducing their manual tasks. This allows us to increase our field size... The number of people you would have needed…" The woman trailed off, as if overwhelmed by the thought of weeding that many fields.

Answers were similar when I asked farmers why they had adopted genetically modified Bt cotton. In particular, they talked about their desire to reduce the noxious labor of spraying insecticides. Larger farmers said Bt cotton had enabled them to increase their field size because of the reduced labor requirements (also see Dowd-Uribe 2014b; Sanou et al. 2018), whereas smaller-scale farmers said Bt cotton helped them maintain their small production. For example, one small-scale farmer (2 hectares of cotton) in his early thirties said:

> [I grow Bt] because I'm farming alone. It is just me and my cows. With regular cotton it is exhausting. The GM [genetically modified] cotton is less work, so you can rest a little bit, you don't have to spray [insecticides] a lot. For example, you can spray the GM cotton only twice. That's why I chose to grow GM.

Thus, in the case of both herbicides and Bt cotton, farmers explain that they opt for these technologies as a way to maintain or increase farm size despite rising labor shortages.

However, increasing field sizes results in a severe labor crunch at harvest time. Farmers estimate that harvesting cotton (by hand) requires thirty days of labor per hectare. It costs CFA25,000 to hire this labor, but farmers are cash-strapped at this time, as school fees are due, and they haven't sold their farm products yet. However, cotton doesn't spoil (although it loses weight from drying and there are risks of damage) and can be harvested slowly. Poorer families

often take months to finish harvesting their cotton. Some farmers hire groups of women and promise to pay them later once the cotton money comes in. Other farmers harvest and sell early-maturing (and quick harvesting) corn in order to pay people to harvest their cotton. This latter system actually operates as a sophisticated labor-saving system, wherein farmers grow input-intensive corn to replace labor for the cotton harvest. Most farmers depend on SOFITEX-supplied fertilizer for their corn (SOFITEX supplies corn fertilizer on credit to farmers who grow more than three hectares of cotton), and/or siphon cotton fertilizer into their corn fields (Gray and Moseley 2008). Corn and cotton farming are thus intimately linked – with cotton production helping corn (access to inputs), and corn production helping solve the cotton labor crunch (money for harvest labor). This strategy, however, further ties farmers into the technology treadmill, as they grow input-intensive corn in order to produce cash to hire labor for their cotton harvest.

These processes operate as a technological treadmill, in that farmers' increased reliance on agricultural inputs increases their expenditures, further reinforcing pressures to increase their income. Most farmers purchase inputs on credit from SOFITEX. Although herbicides are frequently purchased with cash in the market, a few farmers sell SOFITEX inputs (fertilizer and insecticide) in order to purchase herbicides. This money is thus, in a sense, still obtained on credit. Yet credit, or debt (the Dioula word *juru* refers to both), creates additional pressure to increase production. As one older man insightfully put it:

> It's debt that pushes farmers to increase their hectares. We think "the only way I can pay back my credit is if I increase my production." But that's not true! We just end up more indebted, continually running to try to pay our debt back! And we increase our acres and we tire ourselves out.

And so the economic treadmill turns (Figure 1). In the face of an economic squeeze, farmers seek to increase production, and they do so by maximizing the size of their farming operations. Increased farm size exacerbates existing labor shortages, which further drives technology adoption (on both cotton and corn fields) and increases debt. The increasing debt, in turn, keeps the cycle going, as farmers feel continued pressure to increase their incomes.

[INSERT FIGURE 1 HERE]

There is a significant difference between wealthier and poorer farmers in this process. Poor farmers struggle with a vicious cycle: many sell their SOFITEX-provided inputs (such as fertilizer) at the beginning of the season, often to repay other debts and buy food. However, if they don't fertilize their fields they may have low yields. Low yields, in turn, mean they fall in debt with SOFITEX, and may have to sell their oxen to pay off their debt. Farmers without oxen often labor for a better-equipped farmer in exchange for access to a tractor or oxen. This often means they plant late, which can also lower yields. Furthermore, SOFITEX routinely denies credit to indebted farmers. Poor farmers can thus find themselves in a vicious treadmill of declining yields and rising debt, struggling to mobilize either labor *or* labor-saving technologies. In contrast, wealthier farmers benefit from their neighbors' misfortune: they purchase inputs from poorer farmers at below-SOFITEX rates, they charge poor farmers for their services (such as tilling, corn shucking, or grain grinding), and buy products like herbicides in bulk in regional cities and re-sell them locally for a mark-up. There are thus two very different treadmills for rich and poor farmers that help explain rising rural differentiation (Gray and Dowd-Uribe 2013).

Cultural change and labor shortages

The story I have told so far, focused on economic drivers, provides a first-level explanation of technology adoption in relation to labor shortages. I now turn to further unpacking the question of *why* farmers are experiencing labor shortages. In this section, I explore three cultural drivers of labor shortages: extended farm families splitting up, parents putting children in school, and some women and young men refusing to provide free labor. Each of these shifting labor dynamics is part of a broader process of cultural change.

Cultural change: individualism, money, and aspirations for modernity

I heard repeatedly from rural residents that their community has shifted away from a culture of hierarchical communalism toward a culture of individualism and aspirations for Western modernity and material wealth. I want to tread carefully here to not essentialize a static, traditional African social fabric being ripped apart by an externally imposed global capitalism or modernity (Berry 1993; Piot 1999; Hart 2004). While recognizing the dynamic and historical interplays between the constructed categories of global/local and modern/traditional, I *did* hear stories of a splintering social fabric over and over again from my research participants, male and female, young and old. These stories resonate with Tania Li's (2014) characterization of the emergence of capitalism in the Luaje highlands in Indonesia: rather than capitalism and

individualism being foisted upon people from the outside, local processes of change interact with the broader political economy to drive the emergence of an individualist culture and capitalist relations.

In describing change in their community, many people described a recent and major shift in how people think about themselves and each other – often described as "people evolving," and "now having their eyes open" *(nyeyelelen/la)*, expressions which are tied to conceptions of Western modernity and individualism. The following interview excerpts illustrate these themes:

> The changes that have come concern how people get along. When I was a kid, everyone in a family shared the same field and we worked together. At the harvest we built a granary where we stored our harvest. We ate from this until the end of the season. But a time came when… it's like people's *hakili* (minds/way of thinking) changed to a certain model, where people changed and each person now only thinks of their individual interest. This is what is at the base of all the divisions in the families. Everyone seeks their own (Man in late 20s).

> Today we no longer respect each other…Today there are many people, they don't love each other, and everyone is standing by himself, compared to before when we ate out of one bowl. Peoples' ideas are different, and we no longer respect the elder men. The world has changed (Middle-aged male).

> We used to all be together in the same field … But today it's, we say that the world is ruined, but really the world isn't ruined, it's humans who are ruined… My husband says he will farm by himself, and the next man says he will farm by himself, and the next. And if he gets a good yield, he will put it in his house, and who is there to tell him not to sell it?... (*and thus leave the family hungry*). Before, we were united. We held each other. But today we are no longer united. We don't even like each other anymore. Even if you were to die, that would please your neighbor (Middle-aged female).

People often explained the shift as a new way of thinking about people as autonomous, rather than as embedded in social relations of mutual dependence. People older than thirty often talked about young people challenging authority and hierarchy (based on age or gender) and shirking

traditional social responsibilities toward others (such as caring for dependents, elders, or the vulnerable). Although most people view this shift negatively, many also express ambivalence: they are nostalgic for the solidarity of the past, but enjoying newfound autonomy and possibilities for wealth.

Families splitting

In previous generations – dating to the 1950s (Lacoste 1966), but extending into recent decades – large extended families farmed together under a household head. The patriarch controlled the food and money and distributed to family members as he saw fit. Many people (especially women) described stark inequalities in this hierarchical system: women and junior men had few options for obtaining money and little room for questioning the decisions of older men. These inequalities became more apparent to people (and viewed as problematic) as wealth increased, as new opportunities for making money emerged, and as new ideas arrived about individualism. As many people explain it, over time women and junior men became frustrated with this system of hierarchy and communal sharing, and increasingly sought to earn their own money and control their own decisions about how to use it. Furthermore, disputes between men became more common, centering on how to spend money (on and off the farm), and on who deserved money based on how hard they had worked.

In response to these frustrations and disputes, families began to split apart to farm separately: sons from fathers, brothers from brothers. As one middle-aged man explained it: "If there are many of you in the field, there will be some who don't like to work. In this case, if you don't separate, it is not going to go well. One day there will be fights, and it is better if you separate." This process began decades ago in Burkina Faso (Marchal 1987; Gray 2005) yet is still underway. When splitting, families often carve up their plots of land so that each brother or son has an equal share, and then each man can – to some extent – make his own decisions and control his own money (this apparent autonomy is undermined by the collective debt repayment structures of SOFITEX). Nonetheless, once farms split, the division of labor on the farm changes dramatically. With a smaller labor pool, the husband and wife/wives must perform all farm tasks themselves. In some cases, the line between men's work and women's work blurs, as people increasingly share tasks to keep the farm afloat. Polygamy is also relevant here, as some men try to marry more wives in order to obtain more field labor (Luna 2019).

As families split, many older men and women also find themselves farming alone. Some explained that, "our children no longer give us food," so they have to farm small plots of land for food and income. Some older farmers explained that new technologies like GM cotton and herbicides were helping them stay afloat, given the labor constraints of a single elderly person farming. In contrast, the small number of families that had not split apart (by 2016) appeared to be wealthier than the split-up families, as they were able to pool resources to purchase tractors (which are more economically viable for larger-scale farms) and for labor activities. In some sense, it is ironic – in the face of long-standing arguments about African farmers being insufficiently individualistic – that the *less* individualized farmers are perhaps doing better (though this observation needs further evidence). Nonetheless, family splintering continues.

Women and young men refusing to work

A second major change in family labor dynamics has occurred *within* the nuclear family: a decline in labor from young adult male children and from some women. Some young men (older teenagers and men in their early twenties) are refusing to do farm work for their parents, for reasons quite similar to those that lead to families splitting: they want to make money for themselves. One twenty-year-old man told me: "You see all the young people in town who say they don't go to the fields anymore? They aren't just lazy. They are sick of cotton. They are sick of working for free." Some young men leave to work in the burgeoning (formal and informal) gold mines in Burkina Faso and others migrate to look for work in the Ivory Coast, a long-standing yet increasingly difficult tradition for Burkinabès (Cordell et al. 1996; Newell 2012). These findings are also supported by the rising urbanization rate – from 5% in 1960 to nearly 30% in 2018 (World Bank 2018), and broader scholarship that has documented increasing youth migration to cities in Burkina Faso (Thorsen 2009), male and female migration to sites of artisanal gold mining (Werthmann 2009), and increasing independent female migration (Werthmann 2009; Piché and Cordell 2015).

In my conversations with rural young men, nearly all of them told me that they wanted to get out farming. They see farming as low-status, hard, poor, dirty, and backward (Luna 2018). Many young men told me they would migrate to the "white people" countries if they could, and one older teenager was baffled by my decision to do research in Burkina Faso: "Why on earth did you come here? You left paradise to come to hell. Why would you do that?" For these young men – increasingly exposed to television and social media – the Western (and urban) world looks

a lot more interesting than working in their dad's fields all day in the hot sun for a pittance of money.

Additionally, small numbers of women are refusing to work for their husbands if they feel they are not receiving a fair share of income. Men refer to these women as *"muruti musow"* (rebel or protesting women), and some men remarked to me that African women today don't know their place anymore. In contrast, self-identified *muruti musow* explained that they are refusing because their "eyes are open" now, and they are "more evolved" – they have seen how things can be for women elsewhere, and they want more autonomy and power. Increasing economic opportunities also play a role: as one woman told me, "Today women can make money on their own, so they can leave their husbands. Before, that just wasn't an option." For women, these opportunities include selling food, working as contract farm laborers, making and selling alcohol, working at gold mines, and other market activities. In this case, cultural and economic changes intersect to produce a shift in the "micropolitics of labor mobilization and control" (Berry 1993, p. 137).

Putting children in school

The third major cause of labor shortages is that most families now put all of their children in school. This is arguably more of a cultural than an economic decision, given the high unemployment rate and the crisis of young unemployed graduates in Burkina Faso (Calvès et al. 2013). Nonetheless, echoing the sentiments of young men, farmers told me they did not want their children to become farmers, because farming was seen as failure. Instead, they want their kids to get "white people jobs" (*tubabu baara*), referring to office jobs or salaried jobs, in contrast to jobs based on physical labor. This particularly applies to sons (who would then be expected to give remittances), but also in some cases for daughters (who leave the parents' household with marriage but usually retain ties). Nonetheless, despite these desires and many years in school, it appears that many children continue to farm for lack of other options.

The contemporary embrace of the French education system (Burkina Faso's education system is modeled on the French system imposed during colonialism) is a reversal from previous generations, when people resisted French schooling just as they resisted colonialism and schemes of forced labor. Some people told me that when families were first forced to send kids to "the French people's school," they "gave up" the least-liked child, which was viewed as a form of

punishing the child.[4] One younger man told me that, "before, school was seen as losing our own culture and being indoctrinated by white people. But now, everyone wants to go school." A middle-aged man told me, "Our fathers didn't like the *tubab*s (white/French people). They didn't want their kids going to the *tubab* schools and didn't want them getting *tubab* jobs. But now it's different. (Now) everyone wants a *tubab* job."

Today, most rural families go to great lengths to put their kids in school. In doing so, they give up two of their most precious resources: money and labor. Following structural adjustment program reforms in the 1990s, Burkina Faso requires parents to pay primary school fees, and parents must also pay for uniforms, books, and transportation or lodging for children attending secondary schools in regional towns. Furthermore, the school year runs from mid-September to mid-July. This overlaps with planting in May and June, and the harvest from October to January. School thus exacerbates farmers' money-labor Catch 22: they need more money to pay for school fees, but they have less labor to farm – which reduces their ability to make money. Putting kids in school thus directly contributes to the feedback loops of intensification, technology adoption, and debt.

Furthermore, some people see school as re-enforcing the cultural shift towards individualism. They see Western education – both formal (in school) and informal (via media) – as contributing to why young people today no longer respect tradition or elders and increasingly seek individual wealth and status. As one middle aged-woman explained, following a discussion of a traditional practice, "School has stopped all of that. You know if you put a child in school, he is more 'awakened' (*nyeyelelen* - eyes open) than you are… When we put our kids in school, that is what explains that now if we tell a child to go over there, he/she says, no I won't go." This woman associates Western schooling with an individualistic attitude associated with modernity and the West, and links this attitude with young peoples' disrespect for elders. As noted earlier, these attitudes can contribute to labor shortages, as when young men refuse to work for their parents or families splinter into smaller units. Thus, in addition to the direct labor loss from putting kids in school, schooling may also reinforce the cultural shift towards individualism, creating another feedback loop of declining labor control.

Conclusion

[4] The theme of Western school as a cultural threat is echoed in other historical and literary works in West Africa (Kane 1961).

As scholars and development practitioners seek to understand contemporary challenges and changes in African agriculture, the question of whether, how, and why some African farmers have adopted input-intensive farming warrants deeper attention. This article sought to explain *why* a particular set of farmers has increased their use of purchased inputs, despite the fact that these inputs are costly and often result in debt. Building on previous – but fragmented – literatures on technology adoption, I argued that economic and cultural dynamics *combine* to produce a cyclical and compounding process that results in increasing labor shortages and drives ongoing technology adoption. My novel contribution was to show that processes of cultural change can directly feed into and exacerbate the economically-driven technological treadmill. While this finding is case-specific, it is likely to be instructive for other settings.

[INSERT FIGURE 2 HERE]

Figure 2 illustrates how these economic and cultural drivers create a self-reinforcing system of labor shortages, technology adoption, and monetary demands. On the economic side, male farmers are in a reproductive squeeze (Bernstein 2010), struggling to meet their expenses. In response, they seek to expand cash-crop production, yet they also struggle to mobilize labor. Labor-saving technologies help replace labor, but these technologies also cost money, further driving the treadmill. This cycle should be familiar to scholars of agrarian change in many contexts. What is arguably less familiar is how processes of cultural change feed into this treadmill. In the second half of the paper, I examined how aspirations for modernity and individual wealth have led to families splitting, farmers putting their children in school, young men migrating away, and some women withholding their labor. These cultural changes help explain increasing labor shortages, and also exhibit feedback loops of their own. Putting children in school may reinforce cultural changes toward individualism and add economic pressure on farmers to pay school fees.

As I hope is clear, the economic and cultural sides of the treadmill are more intertwined than depicted in Figure 2. For example, economic pressures *also* compel farmers to put their kids in school (i.e. the hope of remittances), and economic opportunities shape peoples' decisions to split apart or refuse to provide labor. On the other side, cultural desires *also* shape farmers' perceived needs and expenses. This blurriness is precisely my argument: economic and cultural

drivers of technology adoption do not operate in isolation (nor are they easily isolated), and future work should continue to explore the contextually specific ways in which economic and cultural dynamics intertwine. Future research should also embed these dynamics in changing ecologies and political/ policy contexts. In Burkina Faso, ecological questions about pesticide treadmills are paramount. The introduction of Bt cotton was ostensibly a response to insecticide-resistant insects, a problem that itself was the result of extensive cotton cultivation – quite similar to the case of India (Stone 2011). Yet Bt cotton, if it had continued production, may have also created problems of pest resistance. Similarly, as herbicide use expands (particularly glyphosate), herbicide-resistant plants will likely emerge, creating new challenges for farmers. Additionally, technology options are profoundly shaped by political context. For example, the state cotton sector stopped offering Bt cotton seeds in 2016, due to Bt's shorter fiber length and resulting weaker international cotton sales (Dowd-Uribe and Schnurr 2016). In 2016, many farmers expressed concerns about the increased labor (for spraying) that would accompany the return to conventional. It is possible that farmers will shift toward more intensive corn production, but in doing so they face constraints in accessing inputs on credit. There thus remain important questions about how the treadmills I have described are shaped by both ecological and political changes.

One important finding of this paper is that cultural dynamics of individualism and farmer aspirations for autonomy have ironically produced structural constraints on farmers' choices, similar to cases of farmers adopting technologies that result in their own deskilling (Stone 2007; Glenna et al. 2011). We might revisit Marx's famous maxim that people make their own choices, but not in conditions of their own choosing. In this case, farmers' culturally shaped actions have contributed to producing the constraining structures they now face, as when families choose to split up but then face severe labor shortages. The result is that farmers "choose" to adopt new technologies but in a context of severely constrained options. Most farmers I talked to, even those who were concerned about the health and environmental consequences of pesticide, or who had fallen repeatedly in debt due to input expenses, felt they had few options but to use purchased inputs. Purchased labor-saving technologies have thus become less of a choice and more of a necessity. My key point is that this situation results from the current conjuncture of cultural and political-economic structures.

This finding is particularly important for current debates and scholarship surrounding the New Green Revolution in Africa. Proponents often assume that farmers are rational, calculating actors freely choosing to adopt technologies out of self-interest (Paarlberg 2008), while critics sometimes assume that farmers will reject or resist these technologies (Holt-Giménez and Altieri 2013). This paper argues that neither of these stories sufficiently reflects the complex dynamics shaping farmer behavior. My findings temper proponents' narrative of free and rational choice, showing how farmers feel compelled to use technologies. On the other hand, my findings also speak to critics of input-intensive agriculture, showing that farmers may be embracing or producing this path *despite* many negative outcomes, as a "strategic response to their limited livelihood options, using whatever tools are available to them" (Shilomboleni 2018, p. 115). Notably, alternatives to input-intensive agriculture are often more labor-intensive. Efforts to promote sustainable agriculture would do well to consider the broader dynamics shaping farmers' access to and control over farm labor, and thus the limitations on farmers' choices. Bezner Kerr et al. (2019), for example, argue that labor-intensive methods of agro-ecology can be beneficial, but close attention must be paid to gendered labor dynamics and decision-making processes. In sum, critical questions need to be asked about who is laboring, and the power dynamics of labor allocation.

Finally, a significant outcome of the process I have described is that larger, wealthier farmers are more easily able to stay afloat, while poor farmers slip behind, contributing to rising rural differentiation. Differentiation has been well-documented in the Burkinabè cotton sector (Gray 2005; Gray and Dowd-Uribe 2013; Gray et al. 2018), and in Green Revolution and capitalist agriculture transformations more broadly (Bernstein 2010; Patel 2013), undermining the promise of scale neutral technologies. My findings suggest that technology expansion in the Burkinabè cotton sector is not just a case of outside actors dispossessing small-scale farmers, nor a case that is solely explained through the economic forces of capitalism. Instead, it is a case where farmers' own choices amidst processes of cultural change – shaped by a broader political-economy – have ironically contributed to their own differentiation and integration into capitalism.

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Figures

Figure 1: Cyclical economic pressures driving technology adoption

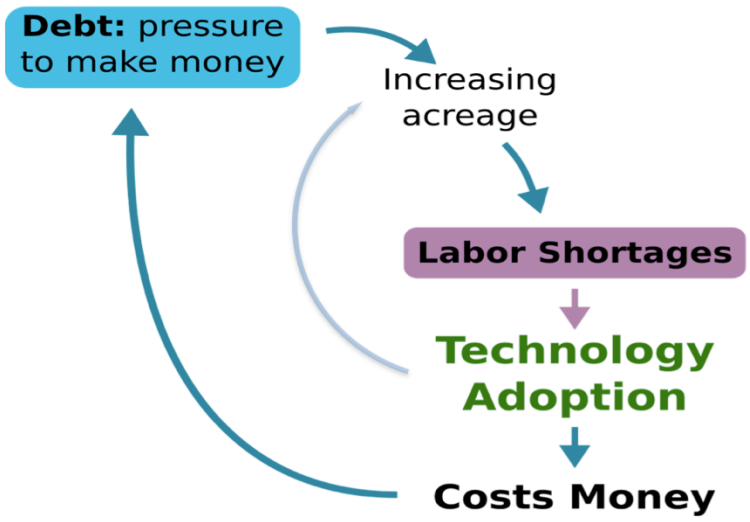

Figure 2: Changing labor dynamics and treadmills of technology adoption in the Burkina Faso cotton sector