

Goetghebuer, Tatiana

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# Productive inefficiency in patriarchal family farms: evidence from Mali

By Tatiana Goetghebuer (University of Namur-CRED)

**Abstract:** In Mali, there exist various farm-cum-family structures, so that agricultural production occurs on plots controlled by different members of the household. In this paper, we want to lay emphasis on the under-researched differentials between collective and individual plots (attended by male or female farmer) in the context of extended family farms using input and output first hand data collected in the south-eastern part of Mali. First, we find that land yields are significantly larger on (male) private plots than on common plots with similar characteristics planted to the same crop in the same year after all appropriate controls have been included. And, second, we bring strong suggestive evidence that a moral-hazard-in-team problem exists on the collective fields (yet only with regard to care-intensive crops) that could explain their relatively poor performance.

*Keywords:* Land productivity, family structure, moral-hazard-in-team problem, collective fields

*JEL classification codes:* D13, D57, J12, O12, O13, Q12, Q15, R20

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## 1. Introduction

There has been a recent surge of interest in African family farms where common plots that are collectively managed and worked coexist with private plots held and cultivated by individual members. On the one hand, economists have tried to understand the rationale behind the existence of various forms of farm-cum-family structures. Their theories aim at explaining either the shift from a pure collective farm to a mixed structure in which private and common plots coexist, or the split of the collective farm into individual units (see Fafchamps, 2001, for an explanation of the former, Foster and Rosenzweig, 2002, for an explanation of the latter, and Guirkinger and Platteau, 2011a, for an explanation of both). On the other hand, many studies have compared the productivity of plots (with similar

characteristics) controlled by different types of farmers across households or more frequently within the same household. A large number of these studies have identified systematic gender productivity differentials: *ceteris paribus*, men tend to be more productive than women (Udry et al., 1995; Udry, 1996; Bindlish, 1993, all dealing with Burkina Faso; Goldstein and Udry, 2008, for Ghana; Sidhar, 2008 for Nepal; Holden et al. (2001) for Ethiopia; Jacoby (1992) for Peru; Koru and Holden, 2011 for Uganda).<sup>1</sup>

Much fewer studies have compared land yields between collectively and (male) individually cultivated plots. Kanzianga and Wahhaj (2010) compare productivity of senior male plots (assumed to be collectively farmed) with junior male private plots and female private plots using first-hand data from Burkina Faso. They show that plots owned by the household head (common plots) are farmed more intensively and achieve higher yields than plots with similar characteristics owned by other household members. Yet, they do not find any gender differences in productivity once they compare male and female family members who do not head the household.

In this paper, we want to lay emphasis on the under-researched differentials between collective and individual plots (male or female) in the context of extended family farms. There are three different views or theories explaining why such differentials may exist or not. First, if certain activities are subject to scale economies while others are not, it seems natural to practice the former on collective plots and the latter on private plots. This consideration is used by Foster and Rosenzweig (2002) to explain the persistence of large collective farms when scale economies (and savings associated with the financing of household public goods) outweigh the advantages of land tenure individualization (split households) stemming from diverging preferences over these household public goods. On the other hand, Boserup (1965) finds that when farmers adopt relatively land-saving and labour-using techniques for which quality of labour matters (labour is costly to monitor), so that significant management diseconomies exist, the advantage of private farming on individual plots increases. Interestingly, it has been shown that in Hungarian cooperatives before the collapse of communism, care-intensive activities were left for households to conduct on their private plots whereas activities easy to standardize and monitor remained the province of collective work on the cooperative fields (Swain, 1985; Guillaume, 1987; see also Chayanov, 1991:

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<sup>1</sup> Note that in these studies, male plots include both collective and private holdings without the authors being able to distinguish systematically between them. As for female plots, the problem is more simple since they are private, except for the rare cases of female-headed households.

Chap. 13). If this line of interpretation is correct, we should observe that different crops are grown on collective and private fields and we should not expect significant differences in land productivity between them.

Second, Kanzianga and Wahhaj (2010) emphasize the public character of the good produced on the family field while potential scale economies are ignored. The main originality of their theory consists in assuming the existence of social norms that govern production on this collective field. Since collective production is thus aimed at providing a public good at family level, the members of the household are expected to be more willing to work on the collective field than on their private plots. It follows that common plots managed by the household head should use family labour more intensively, and achieve higher yields than plots with similar characteristics farmed by individual members. This prediction is confirmed by their results obtained from an analysis of data coming from a survey of agricultural households in Burkina Faso.

Finally, guided by field observations in Mali, Guirkinger and Platteau (2011a) argue that production on the collective plots is plagued by the moral-hazard-in-team problem while first-best efficiency is achieved on private plots where members have optimal incentives to work. The possible coexistence of the two types of plots is explained as the outcome of a trade-off between rent capture and efficiency considerations: acting as a patriarch, the head is concerned with extracting a rent from collective production since he is unable to enforce transfers from the private plots managed individually by the (male) members. These private plots are awarded to members when land scarcity becomes high enough to compel the patriarch/head to pay attention to efficiency considerations owing to the need to meet the members' reservation utilities. This particular prediction has been put to test and confirmed in another paper based on first-hand data collected in the south-eastern part of Mali (Guirkinger and Platteau, 2011b). In complete contrast to Kanzianga and Wahhaj's argument, the other prediction of the theory of patriarchal family is that land yields should be larger on private than on common plots. It is worth stressing that, given his concern to reap a rent from the collective field, the patriarch is not interested in achieving first-best allocative efficiency on the whole family farm. Efficiency considerations enter (partly) into the picture only as a constraint imposed by scarce land endowments.

In the same line, the theory of agricultural cooperatives has advanced the idea that collective farming acts as a mechanism of insurance to the extent that its output is shared equally among the members, thus redistributing income from lucky to unlucky members (Putterman and DiGiorgio, 1985; Carter, 1987). At the same time, the rule of equal sharing gives rise to a

moral-hazard-in-team problem, hence a trade-off between efficiency and risk-sharing considerations. This line of reasoning has been recently extended to family farms (Delpierre et al., 2011). The prediction regarding productivity differentials is exactly the same as under Guirkinger and Platteau's argument: yields are expected to be smaller on the collective fields and these lower yields are the price to pay for insurance.

On the basis of a detailed analysis of input and output data collected from the same survey as that used in Guirkinger and Platteau (2011b), this paper aims at testing whether there are significant differences in land yields between collective and (male) individual plots. The next step consists of investigating the possible causes of yield differentials if they turn out to exist. We find that yields are higher on private than on collective plots with similar characteristics and planted to the same crop within the same household. We also find strong suggestive evidence that a moral-hazard-in-team problem exists on the collective fields, yet only with regard to care-intensive crops.

The remainder of the paper is organized as follows. In Section 2, the characteristics of the original survey that yielded the dataset used in this paper are described, and basic information about farm and family structures as well as about patterns of land allocation between crops in the study area is provided. In Section 3, the input and output data available to us, and their limitations, are discussed in detail before descriptive statistics about the key variables used in the subsequent econometric analysis are presented and briefly commented. In Section 4, we address the first aforementioned question, that is, we test for the possible existence of yield differentials between (male) individual and collective plots. In Section 5, we attempt to determine whether the lower yields obtained on collective plots can be attributed to the moral-hazard-in-team problem. The last section concludes.

## **2. Key information about the survey and the structure of the sample farms**

### *The survey*

The data used in this paper is first hand data collected in the southeastern region of Mali in 2007. An interesting feature of this region is that family farms appear to be in a state of flux: traditional collective farms headed by a patriarch are still widespread although there is an increasing tendency toward more individualized forms of cultivation. We randomly sampled 17 villages in the three districts of Koutiala, Sikasso and San, which belong to the old cotton zone of Mali. Within each village, we randomly selected 12 households from a complete listing of the local household population. Two survey instruments were used to elicit the

required information. First, a questionnaire was administered to each household head. In addition to detailed information on the composition of the household, we collected information on the size and structure of the associated farm, which includes the listing of the common fields managed by the family as a whole, as well as all the family members who cultivate private plots.

Second, a questionnaire was addressed to a random sample of private plot holders. We initially intended to cover all these individual farmers, yet due to our time and budget constraints only two-thirds of them (68%) could be interviewed.<sup>2</sup> The selection of the sampled individual farmers was made randomly by a qualified researcher from the CRED (Centre for Research in Economic Development, university of Namur) acting as field supervisor.<sup>3</sup> A significant portion of the interview time was allotted to the collection of output and input data. Information regarding all the common plots was obtained from the head within the framework of the general household questionnaire while data pertaining to the private plots were gathered from their holders within the framework of the individual questionnaires. In order to have a more complete view of the household *modus operandi*, precise qualitative questions were asked about the different rights and duties of the household members, and about the pros and cons of collective versus mixed farm structures.

### *Farm and family structures*

A household is a group of individuals who “work jointly on at least one common field under the management of a single decision-maker and draw an important share of their staple foodstuffs from one or more granaries which are under the control of that same decision-maker” (Matlon, 1988 cited in Udry 1996: 1016). “Traditionally, a West African rural household is large and complex. It extends both vertically (in the sense that married sons continue to live with their father) and horizontally (brothers of the head, their wives and children are part of the household)” (Guirkinger and Platteau, 2011b). In our sample 41.2% of household heads live with their brothers while, at the other extreme, only 21.6% have neither brothers nor married sons around (strictly speaking, they are nuclear households). Moreover, more than half of the household heads are polygamous. On average, the sample households count 11 individuals above 12 years old with a maximum family size of 30.

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<sup>2</sup> On an average, the interview of a household comprising only collective family fields lasted half a day while the interview of a household with a mixed farm structure lasted a whole day, the second half being devoted to the interviews of private plot holders.

<sup>3</sup> We believe that we do not have any biased sample of private plot holders since we do not find any systematic differences between interviewed individual farmers and those who have not been selected.

Extended households managing collective farms remain a characteristic feature in Mali and, in particular, in the study area. However, over the last decades mixed farm structures have emerged in which individual plots coexist with the collective family field. On the latter, members continue to work as a team and the output is shared among all the co-workers after the head has retained his own portion. The incomes that have been individually obtained are rarely transferred to the patriarch.

It deserves to be noted that the practice of private plots granted to women is much older than the practice of private plots granted to men, and in fact, the rationale behind the two practices differ. Women holding private plots (also called “garden plot”) are expected to use them at least in part for the benefit of the family (producing condiments for collective meals) and are generally freed from the duty to work on the collective field. Male private plots holders are typically allowed to keep the whole output for themselves (mainly used for non-food expenditures), but still contribute to the family production on the common plots. It is somewhat revealing, in this respect, that nearly nine-tenths of the male members of the household who are older than 18 years of age work on the collective fields, as against only hardly more than half for female members. Also to be noted is that in mixed farms, all male members above a certain age are typically granted a plot and that we do not observe any adoption of new agricultural techniques among these individual farmers.

Our sample includes 204 farms evenly spread over 17 villages. As it is evident from Table 1, 58 households (28.5%) are purely collective farms. It means that their cultivated land exclusively consists of jointly managed fields. Out of the remaining 146 households, 69 (47%) have distributed individual plots to female members only, while 63 (43%) have awarded such plots to both male and female members.

*Table 1: Structure of the sample farm households.*

Type of family farms	Number of observations	Percentages %
Purely collective farms	58	28.5
Mixed farms	146	71.5
<i>With male and female IP*</i>	63	43.1
<i>With only male IP*</i>	14	9.6
<i>With only female IP*</i>	69	47.3
Total	204	100

*\*IP: Individual Plots*

In Table 2, we provide information about the number of plots distinguished on the basis of three characteristics: whether they are collective or individual; in the latter instance, whether they belong to male or female household members; and whether they are of a high or a low quality. In addition, the number of respondents corresponding to each land plot category is supplied in column 4. We thus see that our sample includes 488 collective fields and 535 private plots, out of which 71% belong to female household members and 29% belong to male household members. From a comparison of the third and fourth columns, it is apparent that, on average, a private plot farmer holds slightly more than one plot in the mixed farms (94% of these individual farmers hold a single plot). In contrast, there is an average of 2.4 collective fields per farm household. In the last two columns of the table, we provide the average size of collective and private plots and the average size of collective and private holdings when all the plots forming them are aggregated. Two facts emerge: (i) the average size of collective landholdings is considerably larger than the average size of private holdings, and (ii) the average size of private male plots is nearly twice as large as that of female plots.

*Table 2: Description of the sampled plots*

	(1) Nr of dry land plots	(2) Nr of bottom land plot	(3) Nr of plots	(4) Nr of interviewed farmers	(5) Average size of plot in ha (std. dev.)	(6) Average size of holding in ha (std. dev.)
Collective Plot	439 (90%)	49 (10%)	488	204	4.44 (5.18)	10.62 (7.19)
Individual Plot	268 (50%)	267 (50%)	535	459	0.44 (0.79)	0.52 (0.93)
<i>Male plot</i>	83	71	154	133	0.66 (1.22)	0.77 (1.46)
<i>Female plot</i>	185	196	381	326	0.35 (0.50)	0.41 (0.56)
Total	707	316	1023	663	2.35 (4.13)	3.62 (6.18)



Any study dealing with land productivity has to give great attention to quality variations between plots. Usually, farmers are well aware of differences in land fertility and quite able to precise the quality characteristics of each of their plots according to features that they are familiar with. During our field survey, farmers were unable to point to any subtle grading of land quality that did not verge on the idiosyncratic. What they all agreed on was the critical importance of the distinction between dry lands and bottom lands. Dry lands are lands that can be farmed only during the rainy season because they entirely depend on rainfall for bringing moisture to the soil. Bottom lands, by contrast, correspond to plots located in a flood-recession area or irrigable with a well, so that they can be possibly cultivated beyond the rainy season and allow the growing of more water-demanding crops, such as vegetables. The difference in allocation of land with respect to quality is considerable when we compare collective with private plots: whereas 10 percent of the former consist of bottom lands, the proportion works out to 50 percent for the latter (a proportion that does not perceptibly vary between male and female plots). The difference in land area between the two types of plots would thus be significantly reduced if we would allow for quality variations. As will be explained later, we have a reliable way of overcoming the rough definition of our land quality variable, and this way consists of controlling for the kind of crop grown on particular plots. Table 3 that depicts the type of relationship existing between the individual plot holder and the head of the household shows that, in our survey area, families may have quite a complex structure. In particular, they may not only extend vertically by including several successive generations, but also horizontally by including brothers of the head with their wife (or wives) and children. About half of the female private plots belong to spouses of the head while male private plots are more or less equally distributed between sons, brothers, nephews of the head, and the head himself. We may incidentally note that in purely collective farms, the total land area and the total family size are significantly smaller than in mixed farms. In the latter, the family has typically a more complex structure than in the former.

*Table 3: Individual farmer's relationship to the household head*

Relationship to the head	Nr of Individual farmers	%
Head himself	37	8.1
Spouse	142	30.9
Sister/ sister in law	60	13.1
Mother	16	3.5
Daughter/daughter in law	63	13.7
Cousin/niece in law	45	9.8
Brother /step brother	28	6.1
Son	39	8.5
Cousin/nephew	29	6.3
Total nr of individual farmers	459	100

It is also noteworthy that when private plots are awarded to male members, all of them typically receive a plot provided that they are married. It directly follows that the head does not earmark private plots for members with special characteristics, relatively skilled and hard-working members, for example.

#### *Land allocation between crops*

Table A.1, displayed in Appendix A, supplies a detailed account of the distribution of the lands of the household between the available crops during the rainy season. Bearing in mind that a given plot, whether collective or individual, may be dedicated to more than one crop, we note a number of tendencies. When all types of plot are clubbed together, sorghum appears as the most important crop in terms of frequency of cultivation, followed by groundnuts, millet, maize, rice and cotton. In terms of area, cotton stands foremost, followed by sorghum, millet, and niebe. Rice and groundnuts are generally cultivated on relatively small areas (about half a hectare). On the collective fields, sorghum comes first, followed by millet, maize, cotton and groundnuts, if frequencies of cultivation are considered. In terms of area, cotton precedes sorghum, niebe and millet. On the private plots, we have, respectively: groundnuts, rice, red chili, and sorghum in frequency terms, and cotton, maize, sorghum, and millet in area terms. Women tend to specialize in rice and groundnuts (but in terms of cultivated area, rice and maize are predominant) whereas men tend to give preference to the production of groundnuts and red chili (but cotton, sorghum, maize, and groundnuts dominate in terms of cultivated area).

Two features revealed by Table A.1 deserve special attention. First, cereals are produced not only on the collective fields but also on the private plots. Second, we do not observe any

complete crop specialization according to the type of plot. Groundnuts and sorghum, in particular, but also rice, maize, and millet to a lesser extent, are cultivated on both collective fields and private plots. In the light of this finding, we can dismiss the hypothesis according to which the coexistence of collective and individual plots is due to the operation of scale economies on the former and scale (management) diseconomies on the latter.

Table A.2 (in Appendix A) completes the picture by showing the cropwise distribution of household lands during the dry season. Since farming is only feasible on the bottom lands during the rainy season and there are not many of those lands that are collectively cultivated, Table A.2 essentially describes the situation on private plots. Onions appear as the most commonly cultivated crop in terms of frequency (for both men and women), followed by sweet potatoes and groundnuts, whereas potatoes predominate in terms of cultivated area.

It remains to compare the output mixes on dry lands and bottom lands during the rainy season. This is done in Table A.3 (Appendix A). Sorghum is most frequently grown on the dry lands, followed by groundnuts, millet, maize, and cotton. By contrast, rice is by far the most important crop grown on the bottom lands, but if we look at the situation in terms of cultivated area, maize is more or less at par with rice.

### **3. Input and output data**

#### *Measurement procedures and problems*

The crop pattern adopted by the sample farms is even more complex than what the above presentation suggests, leading to tricky measurement problems that need to be discussed in detail. Over a particular season (rainy or dry), our data show that, by subdividing a plot, a farmer can plant as many as eight different crops. In addition, given the possibility of intercropping, there exist additional combinations of crops that can be adopted on a plot. In comparing land yields between collective and individual plots, we can use either crop-specific physical yield measures or an aggregate monetary measure that takes into account all the crops grown on one plot. While the former approach considers crop choice decisions as exogenous, the latter allows for the possibility that yields vary from plot to plot because of differences in the crop mixes selected by the farmer. Our empirical strategy will follow both approaches.

The practical difficulties in implementing them are considerable, not only because of the amount of data to deal with, but also because of the heterogeneity of the measurement units

used in each village (sometimes in each household) to report physical quantities of produce harvested and sold. We have therefore spent quite an important amount of time to express in kilograms the various reported measures of crop quantities (such as the cartload, the tin, the box, the plate, the handful, etc.), which may themselves be differently defined depending on the village where they are used. In the case of some crops, hopefully minor crops (e.g., cassava, taro, tobacco, cashew nuts, salads, bissam, and fruits), we could not find a proper way to convert the harvested amount to a single measurement unit and have therefore decided to keep them out of the analysis (which implies that the afferent cultivation areas have also been left out).

Price data are likewise complex since the harvest of a given plot may have been disposed of at different points in time and a portion may have been retained for self-consumption purposes. The strategy followed consisted of using the price reported by the farmer for the most substantial sale and to value the entire harvest of a given crop on that basis. An alternative solution could have consisted in calculating the median price obtained for each crop over the whole sample area and use those prices for value the quantities produced everywhere. Unfortunately, this option did not turn out to be feasible for the aforementioned reason that, owing to the great heterogeneity of physical measurement units, we could only derive unit prices (prices per kilogram) for the most common crops, that is, seven out of forty-one different crops found in our sample. Evaluating in monetary terms the entire production was nevertheless possible since most respondents supplied us with homogeneous quantity and price information (quantity and price per tin, for example).

Two last remarks deserve to be made. While computing the yields per hectare, we divide the production value or quantity by the area actually cultivated<sup>4</sup> after subtracting the area devoted to crops for which we lack crucial information (see above). Furthermore, wary of double counting cultivated areas, we avoided to count an area twice when it was cultivated both during the dry and the rainy seasons, or when it was allocated to inter-cropping.

Measuring the inputs used in agricultural production proved to be as complex as measuring the outputs. Data about chemical fertilizers were collected on a plot basis. We then had to add up quantities of various fertilizers applied at several points of time and to value them at the reported prices. When fertilizers were acquired from the CMDT ("*Compagnie Malienne pour le Développement des Textiles*"), a public agency in charge of marketing cotton and

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<sup>4</sup> It implies that fallow land area is not taken into account in our yield computation. Note incidentally that fallow practice is seldom in the survey area, most of the sample plots have not been left in fallow for the last five years.

cereal fertilizers, prices were uniform over our study area. When, on the other hand, they were purchased from private traders, we chose to apply the median price calculated over the whole sample in order to minimize measurement noise. Data about organic fertilizers are unfortunately unavailable. However, we know that this input has a significant impact on production only if it can be applied in sufficient quantity and quality. Our field observations have suggested that this condition remains typically non-satisfied.<sup>5</sup> Nowhere could we thus note the presence of manure pits on the farm sites. In the best of cases, farmers use animal dung to fertilize their fields. To take this possibility into account, we will then use the size of the cattle herd as a proxy for organic manure applied on the collective fields.

Regarding seeds, the main point is that, except for cotton, the sample farmers do not seem to buy improved seed varieties as most of them use self-generated seeds. We have ignored cotton seeds altogether because quantities applied are standardized and actually fixed by the CMDT on a per hectare basis. Finally, concerning agricultural equipment, our data enable us to discern whether a household owns at least a pair of oxen and a plough (nobody was observed to have any mechanical equipment in the survey area). We also know when a household has rented these draught animals.

The most problematic input is labour. To be meaningful, indeed, a measure of labour inputs should provide information about effective labour use or effort (labour in efficiency units). Nominal units of labour time are not of much help because they may conceal quite different amounts of effort. We know that there are rules enforced by the head, varying from village to village and from household to household, that prescribe the nominal amount of work to be performed on the common fields by their household members or, conversely, the amount of time that they are residually allowed to devote to the cultivation of their private plots. Yet, the heads themselves are well aware that there is a long way between a nominal and an effective allocation of labour effort between common and individual plots. Revealingly, when queried about the best ways to improve yields on the collective fields, the household heads have mentioned enhancing the quality of labour efforts together with greater application of organic fertilizers and better access to water.

This being said, even the nominal amounts of time spent working were so hard to collect, that they were unreliable. This is largely due to the fact that farmers may split their time between several fields (in mixed farms especially) and between different parcels within each field.

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<sup>5</sup> It is estimated that in order to restore soil fertility in the area a minimum of ten tons of organic fertilizers per hectare should be applied (personal communication of field agronomists working in the area).

Moreover, the time allocation across fields and crops may vary significantly depending on the agricultural calendar. In fact, the only information that we could reliably elicit from the respondents regarding labour inputs is who works on the common fields and who works on each individual plot, and whether they have hired labour to help them cultivating their fields. Such a paucity of data prevents us from comparing labour efforts between common and private plots, and between male and female individual plots. As a result, we will only be able to infer relative labour intensities from an analysis of comparative land yields between collective and individual plots, in which other complementary inputs are duly controlled. In other words, if our results show any significant yields differential between the two types of plots while controlling for plot's and farmer's characteristics, for complementary inputs, and for crop and household fixed effects, we could then assume that the labour input causes this difference. At this juncture, it deserves to be emphasized that on the face of it the constraints imposed by the heads on members regarding the time they are allowed to work on their private plots (during the rainy season when there is potential competition between common and private plots) are often quite tight<sup>6</sup>: male members are granted only one day (the rest day) or two days a week for private work in 42 percent and 15 percent of the households, respectively. Men have the permission to work for themselves each and every day (in addition, possibly, to the rest day) but only before and after the prescribed time of work on the common fields (typically the best coolest hours of daytime -before sunrise and after sunset-) in 15 percent of the sample households. In the remaining cases (28 percent), which refer mainly to household heads and their brothers, they are allowed to work on their private fields more or less freely. Female members are granted more freedom to cultivate their individual fields, the production of which is partly consumed by the household. For them, we obtain the following figures: 22, 13, 22, and 43 percent, respectively. The answers provided for male members clearly suggest that labour time allocation rules tend to be unfavourable to the cultivation of private plots: therefore, if land yields are comparatively high on the latter, this would indicate that intensity of labour effort on them is markedly larger than on common fields (controlling for land's characteristics and other complementary inputs).

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<sup>6</sup> Lallemand (1977, p.46), an anthropologist also mention the existence of such a rule in Burkina Faso.

### *Descriptive statistics*

Table A.4 (see Appendix A) presents descriptive statistics for key output and input variables used in our empirical analysis. It comprises several blocks. Yields expressed in money value in FCFA (Francs issued by the “*Communauté Financière Africaine*”), and crop-specific physical yields are displayed in the first and second blocks, respectively. The third block includes different measures of farming areas, and the fourth block reports information regarding the various inputs used. For each block, aggregate figures for the whole sample are provided side by side with figures that are obtained for each type of plot (common or individual, and male or female).

In terms of gross monetary yields, private plots appear to be about four times as productive as the common plots, and this gap persists if yields are computed net of the expenses incurred on chemical inputs. The difference in land productivity between common and private plots is observed with more or less the same magnitude whether we consider dry lands or bottom lands separately. As expected, yields on the higher quality land, bottom lands, are considerably higher than on dry lands, and this is true for common fields as well as for private plots, whether male or female.

When a distinction is made between the main care-intensive crops<sup>7</sup> (rice, groundnuts, maize, cotton, and onions) on one hand, and traditional (subsistence) crops (millet and sorghum) on the other hand, a striking difference emerges: while yields on common fields are significantly smaller than yields on private plots for the former, they are roughly similar for the latter. This observation is broadly confirmed when we look at crop-specific physical yields. There is thus no statistically significant difference between yields on common and private plots for millet and sorghum while there is a marked difference for groundnuts, rice, and maize. The difference also exists for cotton and onions, yet it is not statistically significant because of the small number of observations made on one type of plot (common plots for onions and private plots for cotton). According to these various measures, male individual plots often turn out to be more productive than female plots. The third block contains information that has already been partly summarized in Table 2. We also learn there that the average size of a bottom land plot is considerably smaller than that of a dry land plot. Moreover, the advantage of common fields in terms of plot area holds whether we consider traditional or care-intensive crops.

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<sup>7</sup> Care-intensive crops are crops for which quality of labour plays an important role, all through the agricultural seasons, in the form of careful application of fertilizers, diligent weeding, proper land management, row planting, etc.

Regarding the last block, it is noteworthy that total expenses on chemical inputs are significantly larger for private plots than for common fields, and for male private plots than for female plots. While chemical fertilizers applied to common fields come in more or less equal proportions from the CMDT and private traders, those used on private plots come almost exclusively from the latter. This is an important finding because modern inputs acquired from the CMDT (through the channel of local farmer associations “*Associations Villageoises*”) are repaid after the harvest<sup>8</sup> whereas those acquired from private traders must typically be paid cash. Two last observations deserve to be emphasized. First, hardly 15 percent of individual plots have benefitted from the services of rented capital, mainly draught animals. This recourse to rented animals and plough is generally made by individual members who do not have easy access to the equipment of the household. Second, land tenure security as measured by the right to plant trees is stronger on common fields than on private plots and, concerning the latter, it is stronger for men than for women.

Two last comments deserve to be made regarding another available measure of the land quality. We know whether or not a plot was lying fallow for at least one year over the last five years. Information related to this latter variable is displayed in Table A.5 (see Appendix A). It reveals that first, only 17.5 percent of collective plots were lying fallow for a minimum of one year over that period and it is important to note that 86% of them belong to the household head. As for the private plots, their holders have never declared that their plot lied fallow over the last five years. Note that only 2.3% of these farmers are the owners of the plots they cultivate. Second, collective plots which have lied fallow for at least one year over the past five years seem to be less productive than those which have been cultivated without resting during the same five year period. We are then tempted to believe that collective plots which lie fallow are of less quality than those which are cultivated every year. However, we cannot say that an individual plot is systematically of better quality because it rarely (never) lies fallow. Indeed, the individual plot holders do not practice fallow period on their plots since they suffer from a land security problem: fallow individual land might be claimed back by its owner (remember that only 2.3% of the individual plots belong to individual farmer).

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<sup>8</sup> The value of the chemical inputs is subtracted from the proceeds paid to the farmer by the CMDT which acts as an exclusive purchaser of cotton produce (in 2007).



#### 4. Econometric results: plot-level differentials in land productivity

From the above observations, it appears that compared to the common fields, land productivity is larger on individual plots that are also smaller in size, of a higher quality (higher proportion of bottom land), and to which greater quantities of chemical inputs are applied. In this section, we first want to check whether the superiority of individual plots in terms of productivity remains after controlling for the intrinsic characteristics of the plots, that is, their area, quality, location, and the extent of land rights. This implies that we do not control for variables that potentially reflect strategic choices by the farmers.

In a second step, we do introduce these controls measured by crop choices and the use of non-labour inputs. The former dimension is taken into account in order to allow for the possibility that holders of individual plots make more profitable crop choices since they are presumably less subject to the constraint of providing foodstuffs used in family consumption. As regards the latter, we need to consider the contribution of material inputs to production to determine whether land productivity differentials subsist and, if yes, which theory is best able to account for them. If the Kanzianga/Wahhaj (2010) hypothesis is true, one should observe a reversal of the direction of the land productivity differential: private plots become less productive than common fields once the intrinsic characteristics of the plot and the role of all complementary inputs except labour are taken into account. It could then be inferred, as these authors have done in their own empirical study, that the productivity advantage of common fields stems from a better application of labour efforts. Conversely, if the Guirkingier/Platteau (2011a) hypothesis is true, we should not observe any such reversal: because effort incentives are distorted on the common fields, private plots should remain more productive even after allowing for the contribution of non-labour inputs.

In this section, we use a simple OLS model on our most disaggregated data, measured at the plot level. In accordance with the two-step empirical strategy highlighted above, we estimate the two following equations:

$$(1) Y_{ijh} = \alpha + \beta_1 female\_plot_{ijh} + \beta_2 common\_plot_{ijh} + \beta_3 area_{ijh} + \beta_4 location_{ijh} + \beta_5 land\_rights_{ijh} + \eta quality_{ijh} + \gamma farmer\_charact_{jh} + \omega HH_h + \varepsilon_{ijh}$$

$$(2) Y_{ijh} = \alpha + \beta_1 female\_plot_{ijh} + \beta_2 common\_plot_{ijh} + \beta_3 area_{ijh} + \beta_4 location_{ijh} + \beta_5 land\_rights_{ijh} + \eta quality_{ijh} + \chi nonfam\_labour\_input_{ijh} + \gamma farmer\_charact_{jh} + \delta CROP_{ijh} + \omega HH_h + \varepsilon_{ijh}$$

in which  $Y_{ijh}$  is the money value of the production per hectare of plot  $i$ , cultivated by farmer  $j$ , belonging to household  $h$ . The intrinsic characteristics of a plot are described by the following variables: three dummy variables indicating the type of land plot, the first one is *male private plot* (the reference category), the second is *female private plot*, and the third is *common plot*;  $area_{ijh}$ , the land area measured either continuously (in ha) or categorically (in quartiles);  $location_{ijh}$ , a continuous variable measuring the amount of time (in minutes) needed to cover by walk the distance between the plot and the farmstead; and finally,  $land\_rights_{ijh}$ , a binary variable which is equal to one if the farmer is allowed to plant trees, and to zero otherwise; and finally  $quality_{ijh}$ , a vector of two dummy variables, the first one, *bottom*, takes on value one if the land is of high quality and value zero if it is dry, then a dummy labeled *fallow\_5years* with value one if the plot was lying fallow at least once during the last five years, and zero if the fallow on that plot dates from more than five years ago. As for the farmer's intrinsic characteristics, they include his/her *age*; his/her level of *education*<sup>9</sup>, which is a binary variable equals to one if the farmer completed primary education and zero otherwise<sup>10</sup>. In this first estimation, to control for unobserved household characteristics, we allow for household fixed effects,  $HH_h$ , a vector of dummy variables that identify each household of the sample. Finally,  $\varepsilon_{ijh}$ , are the robust standard errors clustered at the household level.

In our second estimation, we add a vector ( $nonfam\_labour\_input_{ijh}$ ) of non-family labour input variables such as *chemical inputs* which measures the expenses on chemical inputs, and two other binary variables related to the possible recourse of the farmer to externally-provided productive services, *hiring labour* which is equal to one if the farmer has hired outside labour, and *renting equipment* which equals one if the farmer has rented in draught animals and a plough. In this second estimation, we allow for crop fixed effects,  $CROP_{ijh}$ , a vector of dummy variables for each crop grown on a specific plot, so as to control for the possibility that holders of individual plots make more profitable crop choices<sup>11</sup>.

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<sup>9</sup> For collective plots, we use the age and the level of education of the household head.

<sup>10</sup> In the sample area, the average level of education is extremely low: 85.5% of our sample individuals have never been to school, and only 2.5% of the sample farmers have their primary school degree.

<sup>11</sup> We include 14 crop dummies which are the most frequent crops grown and/or crops cultivated on a relatively large area (more than half an hectare).

The results are presented in Table 4. In the first column, we display the results that are obtained when equation (1) is estimated and land area is measured continuously. In the second column, the latter is measured with the help of a categorical variable based on a distribution in quartiles. The third column presents the results based on equation (2), with land area measured continuously, and the fourth column presents the same with land area measured categorically.

From columns (1) and (2), it is evident that, controlling for plot size and land quality in particular, male private plots have a significantly higher productivity than female plots and common fields. Incidentally, this finding is not consistent with the idea that common fields benefit from scale economies. Land quality and the extent of rights held over the plot turn out to have a positive effect on land productivity. These results continue to hold when plot size is measured categorically and it now appears that comparatively large plots are less productive than plots belonging to the lowest end (quartile) of the distribution. Provided that land quality is properly measured, the latter result supports the view that the inverse relationship between land size and productivity, well-known in the agricultural economics and development literature, stems from input market imperfections rather than from differences in quality (Bhalla, 1988). The greater productivity of plots benefiting from higher land tenure security is consonant with our expectation based on the existing literature (Besley, 1995; Brasselle et al., 2002).

*Table 4: Plot yield estimation using an OLS model*

Dependant variable: Plot yield in value terms (FCFA/ha)				
<i>Explanatory variables</i>	(1) Equation 1	(2) Equation 1a	(3) Equation 2	(4) Equation 2a
<i>Female private plot</i>	-237255.0** (116552.3)	-256867.0** (117754.1)	-86083.8 (86783.4)	-93564.8 (82476.6)
<i>Common plot</i>	-354995.2*** (89245.8)	-272062.9*** (97923.3)	-186778.0** (76691.7)	-144038.0* (79782.8)
<i>Area</i>	1906.5 (8022.5)		-10066.6 (12036.8)	
<i>Squared area</i>	349.5 (330.9)		460.3 (365.3)	
<i>2<sup>nd</sup> quartile</i>		-191509.4*** (64842.2)		-64243.1 (85967.8)
<i>3<sup>rd</sup> quartile</i>		-190763.6*** (56280.1)		-120048.2* (68755.3)
<i>4<sup>th</sup> quartile</i>		-135876.9*** (63031.6)		-155129.8* (83802.5)
<i>Bottom land</i>	327463.9*** (85726.6)	301578.1*** (87676.3)	49168.0 (110952.8)	29531.3 (106268.4)
<i>Fallow_5years</i>	-41229.7 (47520.0)	-59447.1 (42303.2)	-4152.3 (51360.6)	-11002.6 (52817.2)
<i>Location</i>	-969.9 (657.3)	-758.4 (677.7)	-219.9 (566.6)	-176.0 (589.2)
<i>land right</i>	152019.5** (74020.9)	152101.4** (73459.1)	129222.5** (63754.3)	131119.1** (64578.5)
<i>Chemical inputs</i>			4.6* (2.5)	4.6* (2.5)
<i>Hiring labour</i>			4916.3 (45680.8)	13336.3 (45268.5)
<i>Renting equipment</i>			93937.2 (180916.6)	105736.5 (174316.2)
<i>Age of farmer</i>	-2476.8 (2482.5)	-1582.2 (2465.7)	-2187.3 (1829.2)	-1810.6 (1879.4)
<i>Education of farmer</i>	30495.7 (71742.0)	28539.9 (80552.4)	23985.9 (81063.1)	26187.0 (82768.2)
<i>Constant</i>	116372.3 (93300.9)	217581.8** (99848.5)	63010.6 (145210.8)	89611.7 (149776.9)
<i>Crop FE</i>	<i>No</i>	<i>No</i>	<i>Yes</i>	<i>Yes</i>
<i>Household FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
Nr of observations	895	895	895	895
Nr of clusters	202	202	202	202
R-squared	30.7	31.4	48.8	48.9

Significant at \*\*\*1%, \*\*5% \*10%; robust standard errors clustered at household level in parenthesis

The relatively low productivity of the common fields is confirmed when taking into account of the non-labour inputs used in the production and when crop fixed effects are introduced (see columns 3 and 4 of Table 4). In other words, for plots owned by the same household, with similar characteristics, and planted to the same crop(s), those which are farmed individually prove to be more productive than those farmed collectively. Bear in mind that, given the rule followed by the head awarding private plots, these plots are not suspect of having been attributed to more dynamic members within the household (see supra). It is worth pointing out that the coefficient of *common plot* in estimation (2.a) remains quite large<sup>12</sup> even after having added all the necessary controls. On the other hand, the advantage of men over women with respect to their private plots vanishes. The fact that coefficient of *female private plot* remains insignificant whether we drop crop fixed effects while keeping the material inputs as explanatory variables or, conversely, we keep the crop fixed effects while removing the material inputs from the regression tends to indicate that the above two factors are at play. These latter results tend to suggest that women have less recourse to material inputs and do not make optimal crop choices, which is not surprising to the extent that they are expected to provide ingredients for collective meals (see supra). Note incidentally that if we remove the land security variable, the coefficient of *female private plot* becomes nearly significant.<sup>13</sup>

It could be objected that the relationship between the type of plot and land productivity is spurious owing to rough measurement of our land quality variable: the type of plot would be a proxy for a sort of land quality that we do not measure and, if private plots are of a better quality than the common fields, they give rise to higher yields. Fortunately, we are able to surmount the problem of rough measurement of land quality through the use of crop fixed effects. The underlying idea is that there exists a strong relationship between the type of crop grown and land quality, so that controlling for the former is about equivalent to controlling for the latter. It is thus revealing that in his study of Burkina Faso, a country very similar to Mali (both are Sahelian, neighbouring countries), Udry (1996) has shown that “the primary impact of the soil type and location variables runs through the choice of which crop to plant on a given plot. Much of the effect of these characteristics, therefore, is picked up by the

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<sup>12</sup> The productivity (per ha) premium of a male private plot compared to a common plot with similar characteristics is, on average, 144,038 FCFA (219.6 €). Bearing in mind that in Mali the PPP annual income per capita is 778.6€ (WDR, 2010), the advantage of farming a private plot is non negligible.

<sup>13</sup> If we re-estimate the regression presented in Table 4, column (4), using *female private plot* as the reference category for the type of plot variable, we find that neither the coefficient of *common plot*, nor the coefficient of *male private plot* are significantly different from zero.

household-year-crop effects in the regressions. There is a very strong correlation between both the location and the soil type of a plot and the crop planted on that plot” (p. 1025).

In order to test the robustness of our results when we control for land quality through the crop effect, we have re-estimated equation (2) for two specific crops. These crops are groundnuts and sorghum which present the nice features of being simultaneously grown on the three types of plots in a sufficiently large number of cases, and of being mostly grown on dry lands. The dependent variable is now a physical measure of land productivity. And the sample is now reduced to mixed structure only. Since the number of households in which there are both collective and individual (male) plots allotted to groundnut cultivation is limited, we do not control for household fixed effects but for village fixed effects instead. This means that we compare yields on private and collective plots across households within a particular village.<sup>14</sup>

As can be seen from the first column of Table 5, the estimation for groundnuts cultivation, the central results reported above continue to hold when we control for quality in the aforementioned way (dry versus bottom lands). However, the difference in physical harvest is no more observed between male private and common plots when sorghum cultivation is considered (Table 5, column (2)). When we restrict the sample to low-quality plots (dry lands) where groundnuts and sorghum are mostly grown, we find similar results (not shown). Along the same line, we have clubbed together all the care-intensive crops –groundnuts, cotton, rice, maize, and onions–, which also happen to be cash crops, and re-constructed our dependent variable defined in value terms. When we re-estimate equation (2), we find again that our results stand whether we control or not for crop fixed effects and whether we measure land area in total or with a discrete variable (see Table 5, columns (3), (4) and (5)): common fields tend to be less productive than male private plots. Interestingly, comparing results in the same columns shows that the coefficients of the *bottom land* dummy stop being statistically significant once we add crop fixed effects and the land area measured in quartiles. This suggests that with such controls we are relatively successful in picking up variations in land quality.

When we club together the other main crops, sorghum and millet (both subsistence crops), we see that our result does not hold anymore (see Table 5, column (6)). The latter, non-

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<sup>14</sup> When attention is restricted only to households in which groundnuts are grown on both types of plots (male individual and common plots), the sample size is reduced to 26 households, which is obviously a too small sample to apply inference tests. The average yield for groundnuts grown on (male) private plots in these 26 households is 743.45 kg/ha which is significantly (5%) larger than the yield of 383.33 kg/ha obtained on the common fields.

conclusive finding actually suggests that the kind of incentive problems mentioned by Guirkinger/Platteau (2011a) exist only when crops require efforts of a minimum quality. Upon second thoughts, this is not a surprising result: efficiency losses caused by incentive problems are not likely to be severe when effort quality is low and monitoring is, therefore, relatively easy. To verify the intuition behind the argument made by Guirkinger/Platteau, we ideally want to have a stronger test that would enable us to directly check the existence of the precise type of incentive problem assumed to plague collective production. This will be attempted in the next section.

Table 5: Crop-specific plot yield estimations

Dependant variable	Plot physical yield (kg/ha)		Plot yield in value terms (FCFA/ha)			
	(1) Equation 2 Groundnuts	(2) Equation 2 Sorghum	(3) Equation 2 Care-intensive crops <sup>a</sup>	(4) Equation 2a Care-intensive crops <sup>a</sup>	(5) Equation 2b Care-intensive crops <sup>a</sup>	(6) Equation 2 Subsistence crops <sup>b</sup>
<i>Explanatory variables</i>						
<i>Female private plot</i>	-29.6 (142.3)	-328.8 (331.6)	-253210.6 (208867.3)	-262906.0 (205463.1)	-264470.4 (220457.0)	-16096.2 (40795.0)
<i>Common plot</i>	-245.2* (131.8)	24.8 (281.2)	-288435.2** (129728.7)	-314521.6** (144799.6)	-229136.0* (128427.9)	-6429.5 (28615.8)
<i>Area</i>	-135.5* (80.5)	-72.7*** (26.4)	-9062.3 (9127.9)	-11578.0 (11254.9)		-3415.8* (2004.3)
<i>2<sup>nd</sup> quartile</i>					-295572.3** (133091.5)	
<i>3<sup>rd</sup> quartile</i>					-279106.2*** (93607.9)	
<i>4<sup>th</sup> quartile</i>					-299251.9** (119540.6)	
<i>Bottom land</i>	620.1** (291.2)	-149.2 (107.9)	-308.0 (153469.5)	167309.3** (67546.8)	26723.3 (128740.7)	36500.2 (56115.5)
<i>Fallow_5years</i>	-52.0 (139.7)	-290.8** (111.3)	-84636.3 (92767.2)	-70763.2 (98026.1)	-67313.8 (92455.7)	-9571.0 (6973.5)
<i>Location</i>	0.2 (0.9)	-2.6 (2.4)	-403.9 (562.8)	-624.8 (472.0)	-75.5 (558.1)	211.8 (374.9)
<i>Land right</i>	186.2* (98.5)	130.6 (276.5)	33513.2 (77240.1)	47228.5 (77775.4)	60446.7 (79514.4)	20790.6 (44687.4)
<i>Chemical inputs</i>	0.0 (0.0)	0.0 (0.0)	8.5 (5.4)	8.7* (5.3)	8.2 (5.3)	0.7 (0.5)
<i>Hiring labour</i>	-23.3 (85.9)	-166.9 (114.5)	24547.5 (70000.0)	-14806.4 (79646.9)	26637.3 (66574.3)	-1313.7 (7970.1)
<i>Renting equipment</i>	-292.2*** (81.9)	-266.8** (125.8)	64358.4 (147326.5)	64414.1 (140647.9)	114520.2 (159078.2)	-41248.9 (24819.5)
<i>Age of farmer</i>	0.7 (3.0)	-0.9 (5.6)	-2373.3 (2986.5)	-1906.3 (2827.6)	-2092.2 (3000.9)	-773.6 (977.1)
<i>Education of farmer</i>	-47.8 (131.7)	-275.9 (173.2)	65010.7 (70490.2)	56737.5 (70813.2)	31732.5 (73783.1)	4344.9 (45364.1)
<i>constant</i>	255.9 (187.4)	860.9 (427.4)	311567.2 (208733.5)	251091.4 (181000.8)	463484.9* (266517.3)	65746.4 (47368.0)
<i>Crop FE</i>	No	No	Yes	No	Yes	Yes
<i>Household FE</i>	No	No	Yes	Yes	Yes	Yes
<i>Village FE</i>	Yes	Yes	No	No	No	No
<i>Nr of observation</i>	195	271	620	620	620	429
<i>Nr of clusters</i>	89	129	198	198	198	196
<i>R-squared</i>	26.1	9.1	49.2	48.7	50.2	52.8

Significant at \*\*\*1%, \*\*5%, \*10%; robust standard errors clustered at household level in parenthesis

<sup>a</sup> Cotton, maize, rice, onion, groundnuts; <sup>b</sup> Sorghum and millet



Before embarking on this task, however, we need to mention a few robustness checks carried out on the basis of equation (2). First, we re-estimate the model on the basis of a restricted sample (of 830 plots) from which we have removed all the purely collective farms (farms in which there are collective plots only). This is because we want to avoid mixing collective plots that are subject to competition caused by the presence of private plots and collective plots that are immune to such a competitive effect (in the use of labour). Second, and essentially for the same reason, attention is restricted to households in which the three types of plots coexist (sample size is then reduced to 302 plots). Whether the former or the latter procedure is followed, we find that plots with similar characteristics, planted to the same crop by the same household exhibit higher productivity when cultivated individually (by male members) than when cultivated collectively (results not shown).

Third, it is possible that the superiority of private plots exists only for certain values of the plot area. To check this possibility, we add to the list of explanatory variables an interaction term between the area and the type of plot, a dummy with value one for collective plots and zero for male private plots. We find that the coefficient of this interaction term is positive and statistically significant (at 10 percent), yet is considerably smaller than the (significantly at 5 percent) negative coefficient of the type-of-plot variable (results not shown). In other words, increasing plot size has the effect of mitigating the productivity advantage of private over common plots. Fourth, if alternatively we directly deduct the chemical inputs expenses from the gross output value, and estimate this new dependant variable defined as the net output per ha in value term, results remain unchanged.

Fifth, in order to check for the possibility that our results are driven by extreme values, we have used estimation models robust to outliers. We thus re-estimated equations (1) and (2) with a technique which identifies and downweights observations associated to large residuals<sup>15</sup> (Verardi and Dehon, 2010; Verardi and Croux, 2009; Dehon, Gassner and Verardi, 2009). Thereafter, we have run our initial regressions (equation (1) and (2)) on a sample from which these identified outliers have been removed. Not only do our results stand, but they also turn out to be even more significant in explaining yield differentials between common and (male) individual plots (results not shown). Precisely the same conclusion is reached when, instead of controlling for household fixed effects, we control for village fixed effects. This is especially true in regard to the results presented in Table 4: the coefficients of *common plot* become significant at 1 percent. Yield differentials between

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<sup>15</sup> The Stata commands are “mmregress”; “qregress” and “rregress”.

different types of plots (common and male private plots) with similar characteristics, planted to the same crop are more important across households in a same village than within household.

## **5. Econometric results: testing for the moral-hazard-in-team problem**

So far, we have shown that male private plots are more productive than common fields when we control for plot's and farmer's characteristics as well as crop choice and material inputs. This could suggest that the productivity advantage of private plots stems from the application of more intensive labour effort conceived as the residual factor explaining productivity differentials (since we do not measure labour effort). In this section, we move one step further by trying to see whether the lower yields obtained on the common fields are caused by the moral-hazard-in-team (MHT) problem. This hypothesis has been suggested by our interviews during which many household heads explicitly refer to the incentive problems plaguing collective production. On the one hand, according to many patriarchs the household members do not do their best while working on the collective plots, thereby causing yields to fall.<sup>16</sup> On the other hand, it does not appear feasible to differentiate payments according to individual effort contributions to collective production. The main reason put forward by family heads is that serious intra-family conflicts would inevitably result.

Testing the presence of MHT problem is a priori difficult because a higher number of workers presumably has two simultaneous effects: (i) an additional worker gives rise to a greater dilution of incentives due to the MHT problem; and (ii) for given amounts of complementary production factors, he (she) causes the marginal productivity of labour to decrease. As we show below, this ambiguity cannot be completely surmounted, as theory allows us only potentially to discriminate between situations of first-best efficiency and situations plagued by the MHT problem.

Let us assume that the production technology is described by a Cobb-Douglas (CD) function subject to constant, decreasing or increasing returns to scale.<sup>17</sup> Denoting by  $A$  the land amount allotted to collective farming in the household, by  $L$  the aggregate labour input

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<sup>16</sup> For example, one of them said that "more effort is applied to the individual plots and when members work on the collective plot, they are tired". Another one complained that when they work on the collective field, his sons "are prone to keep energy in reserve for their individual plots" ("*ils se réservevent*"). (Guirkinger and Platteau, 2011a: 12) A lot of interviewed household heads also mentioned that a better quality of labour would increase the collective output.

<sup>17</sup> Note that the results would hold with a general form of the production function, but we use a CD function to derive explicit expressions for the variables of interest.

applied to this land, by  $n$  the number of workers assumed to be identical, and by  $l$  the individual amount of effort (in efficiency terms), we can write:  $Y_1 = A^\beta L^{1-\beta} \Rightarrow Y_1 = A^\beta (nl)^{1-\beta}$  if returns to scale are constant, and  $Y_2 = A^\alpha L^\beta \Rightarrow Y_2 = A^\alpha (nl)^\beta$  with  $\alpha + \beta > or < 1$  depending on whether returns to scale are increasing or decreasing. The marginal productivity of aggregate labour input is then:  $\frac{\partial Y_1}{\partial L} = (1-\beta) \left(\frac{A}{nl}\right)^\beta$  and  $\frac{\partial Y_2}{\partial L} = \beta A^\alpha \left(\frac{1}{nl}\right)^{1-\beta}$ , respectively.

As for the effort cost function, it is assumed to be convex (standard assumption). Two alternative specifications are considered, depending on whether the marginal cost of effort is increasing linearly or non-linearly with the amount of effort. We write:

$$(i) \quad CT(l) = \gamma l^2 \rightarrow Cm(l) = 2\gamma l$$

$$(ii) \quad CT(l) = \gamma l^3 \rightarrow Cm(l) = 3\gamma l^2$$

We then derive the equilibrium amounts of individual effort obtained under the two regimes, –the first-best efficiency situation and the situation characterized by the MHT problem–, and under the different combinations of assumptions regarding the shape of the effort cost function and the type of returns to scale. In the corresponding equilibrium condition, the MHT problem is captured by the fact that the worker receives only a share (equal to  $1/n$ ) of his (her) marginal productivity with the consequence that he (she) under-applies effort. After plugging the equilibrium values of effort into the production function, we compute the first derivatives of total output with respect to  $n$ , the only labour-related data that are available to us. Table 6 shows the equilibrium amounts of effort for all considered cases and Table 7 the values of the first derivatives of total output with respect to  $n$ .

*Table 6: Equilibrium levels of labour effort under the two regimes and for different labour cost functions*

Cost of labour effort function		1 <sup>st</sup> best-efficiency	With MHT problem
		Equilibrium $C^0$ : $Y'_L = Cm(l)$	Equilibrium $C^0$ : $\frac{1}{n}Y'_L = Cm(l)$
<b>CONSTANT RETURNS TO SCALE</b>	(i) $CT(l) = \gamma l^2 \rightarrow Cm(l) = 2\gamma l$	$l^* = \left( \left( \frac{A}{n} \right)^\beta \frac{1-\beta}{2\gamma} \right)^{1/(1+\beta)}$	$l^* = \left( \frac{A^\beta}{n} \frac{1-\beta}{2\gamma} \right)^{1/(1+\beta)}$
	(ii) $CT(l) = \gamma l^3 \rightarrow Cm(l) = 3\gamma l^2$	$l^* = \left( \left( \frac{A}{n} \right)^\beta \frac{1-\beta}{3\gamma} \right)^{1/(2+\beta)}$	$l^* = \left( \frac{A^\beta}{n^{1+\beta}} \frac{1-\beta}{3\gamma} \right)^{1/(2+\beta)}$
<b>INCREASING DECREASING RETURNS TO SCALE</b>	(i) $CT(l) = \gamma l^2 \rightarrow Cm(l) = 2\gamma l$	$l^* = \left( \frac{A^\alpha}{n^{1-\beta}} \frac{\beta}{2\gamma} \right)^{1/(2-\beta)}$	$l^* = \frac{1}{n} \left( \frac{A^\alpha \beta}{2\gamma} \right)^{1/(2-\beta)}$
	(ii) $CT(l) = \gamma l^3 \rightarrow Cm(l) = 3\gamma l^2$	$l^* = \left( \frac{A^\alpha}{n^{1-\beta}} \frac{\beta}{3\gamma} \right)^{1/(3-\beta)}$	$l^* = \left( \frac{A^\alpha}{n^{2-\beta}} \frac{\beta}{3\gamma} \right)^{1/(3-\beta)}$

*Table 7: Responses of total production to a marginal increase in the number of workers ( $n$ ) under the two regimes and for different labour cost functions*

	Marginal cost of labour effort	1 <sup>st</sup> best-efficiency	With MHT problem
<b>CONSTANT RETURNS TO SCALE</b>	(i) $Cm(l) = 2\gamma l$	$\frac{\partial Y}{\partial n} = \left( \frac{1-\beta}{1+\beta} \right) n^{-2\beta/(1+\beta)} A^{2\beta/(1+\beta)} \left( \frac{1-\beta}{2\gamma} \right)^{1-\beta/(1+\beta)}$	$\frac{\partial Y}{\partial n} = 0$
	(ii) $Cm(l) = 3\gamma l^2$	$\frac{\partial Y}{\partial n} = 2 \left( \frac{1-\beta}{2+\beta} \right) n^{-3\beta/(2+\beta)} A^{3\beta/(2+\beta)} \left( \frac{1-\beta}{3\gamma} \right)^{1-\beta/(2+\beta)}$	$\frac{\partial Y}{\partial n} = \left( \frac{1-\beta}{2+\beta} \right) n^{-(1+2\beta)/(2+\beta)} A^{3\beta/(2+\beta)} \left( \frac{1-\beta}{2\gamma} \right)^{1-\beta/(2+\beta)}$
<b>INCREASING DECREASING RETURNS TO SCALE</b>	(i) $Cm(l) = 2\gamma l$	$\frac{\partial Y}{\partial n} = \left( \frac{\beta}{2-\beta} \right) n^{-2(1-\beta)/(2-\beta)} A^{2\alpha/(2-\beta)} \left( \frac{\beta}{2\gamma} \right)^{\beta/(2-\beta)}$	$\frac{\partial Y}{\partial n} = 0$
	(ii) $Cm(l) = 3\gamma l^2$	$\frac{\partial Y}{\partial n} = \left( \frac{2\beta}{3-\beta} \right) n^{-3(1-\beta)/(3-\beta)} A^{3\alpha/(3-\beta)} \left( \frac{\beta}{3\gamma} \right)^{\beta/(3-\beta)}$	$\frac{\partial Y}{\partial n} = \left( \frac{\beta}{3-\beta} \right) n^{-(3-2\beta)/(3-\beta)} A^{3\alpha/(3-\beta)} \left( \frac{\beta}{3\gamma} \right)^{\beta/(3-\beta)}$

It is evident that all the expressions for the first derivatives can be signed unambiguously. Just note that when increasing (or decreasing) returns to scale are posited, a realistic

condition limiting the possible value of parameter  $\beta$  needs to be satisfied. The signs corresponding to each case are reported in Table 8.<sup>18</sup> In the same table, we also report the signs that are obtained when the output variable is the productivity per worker per land unit ( $Y/nA$ ) instead of the aggregate output (the corresponding first derivatives are not shown).

*Table 8: Comparative signs of the effects of a marginal increase in the number of workers on total production and on productivity per person per hectare, distinguishing between first-best situation and situation characterized by the MHT problem*

	Marginal cost of labour effort	1 <sup>st</sup> best-efficiency		With MHT problem	
		Y	Y/nA	Y	Y/nA
<b>CONSTANT RETURNS TO SCALE</b>	(i) $Cm(l) = 2\gamma l$	$\frac{\partial Y}{\partial n} > 0$	$\frac{\partial Y/nA}{\partial n} < 0$	$\frac{\partial Y}{\partial n} = 0$	$\frac{\partial Y/nA}{\partial n} < 0$
	(ii) $Cm(l) = 3\gamma l^2$	$\frac{\partial Y}{\partial n} > 0$	$\frac{\partial Y/nA}{\partial n} < 0$	$\frac{\partial Y}{\partial n} > 0$	$\frac{\partial Y/nA}{\partial n} < 0$
<b>INCREASING/ DECREASING RETURNS TO SCALE</b>	(i) $Cm(l) = 2\gamma l$	$\frac{\partial Y}{\partial n} > 0$ if $\beta < 2$	$\frac{\partial Y/nA}{\partial n} < 0$	$\frac{\partial Y}{\partial n} = 0$	$\frac{\partial Y/nA}{\partial n} < 0$
	(ii) $Cm(l) = 3\gamma l^2$	$\frac{\partial Y}{\partial n} > 0$ if $\beta < 3$	$\frac{\partial Y/nA}{\partial n} < 0$	$\frac{\partial Y}{\partial n} > 0$ if $\beta < 3$	$\frac{\partial Y/nA}{\partial n} < 0$

A glance at Table 8 reveals that the response of aggregate output to a change in the size of the workforce is always positive in the first-best situations yet can be nil in the presence of the MHT problem if the marginal cost of effort increases linearly in  $l$  (cases (i) in Table ). Whether returns to scale are decreasing, constant, or increasing does not modify this contrast. Moreover, when we look at the last column, we note that the signs of the derivative of the productivity per person per hectare with respect to  $n$  is consistently negative in all the cases examined: with such a measure of productivity, it is therefore impossible to detect empirically the possible presence of a MHT problem.

The results shown in the above table enable us to derive two predictions to empirically test the presence of MHT problem on collective fields. First, if total output (or output per hectare) can be shown to be unresponsive to a marginal increase in the number of workers, we could safely conclude that the MHT problem exists. Second, remember the finding

<sup>18</sup> When productivity per unit of land is considered, the results are obviously identical to those reported for total output (since  $A$  is constant).

obtained in Section 4 according to which land productivity is not significantly different between male private plots, on the one hand, and collective plots devoted to cultivation of traditional (subsistence) crops, on the other hand. In other words, the case of subsistence crops provides us with a ready counterfactual to the case of care-intensive crops for which we expect the MHT problem to exist. Since such a counterfactual is available, a second possible test of the MHT hypothesis would consist of showing that, the coefficient of the workforce size in the regression for care-intensive crops is significantly positive (cases (ii) in Table 8) but nevertheless smaller than the same coefficient in the regression for subsistence crops, which are easy to monitor.<sup>19</sup>

We first estimate a simple OLS model in which the dependent variable is the total monetary output obtained on a collective plot  $j$  of a household  $h$ ,  $Y_{ih}$  :

$$Y_{ih} = \alpha + \beta nr\_workers_h + \gamma plot\_character_{ih} + \rho head\_character_h + \delta CROP_{ih} + \lambda VILLAGE_h + \varepsilon_{ih}$$

We control for plot characteristics, complementary inputs, household head characteristics, crop and village fixed effects in the same way as we have done in the previous section. The critical differences between the present and the previous econometric exercises are that the sample is now restricted to collective fields and that a labour variable, the  $nr\_workers$  engaged in collective family production is included in the list of the explanatory variables. Moreover, in the vector of the plot characteristics, we have available a proxy for the use of organic fertilizers (labeled *manure*), which is measured by the total number of cattle heads owned by the household, and a dummy indicating whether the household owns a *plough*. The results are presented in column (1) of Table 9 where no distinction is made between care-intensive (rice, groundnuts, maize, cotton and onions) and traditional subsistence crops (millet and sorghum). In columns (2) and (3), the model is re-estimated successively for the former and the latter crops considered separately.

The findings strongly suggest the presence of a MHT problem on the collective fields. As a matter of fact, the coefficient of the workforce variable is not significantly different from zero, and is quite small, in the first two regressions while it is significantly positive in the third regression where subsistence crops are isolated. Note that when the model is re-estimated using output per person per hectare as the dependent variable, we find that, as

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<sup>19</sup> We can easily show that  $\frac{\partial Y}{\partial n}$  under the 1<sup>st</sup> best efficiency is higher than  $\frac{\partial Y}{\partial n}$  obtained with the MHT problem (see Table 7, cases (ii)).

expected, the coefficient of the workforce variable is negative and significant (at 1 percent level) in the three cases examined (results shown in Appendix B).

It could be objected that the effect of the number of workers is spurious in so far as the size of the workforce is positively correlated with the number of women working on the field who are usually shown to be less productive than men (results usually obtained in the literature but not supported by our data analysis, see Table 4 and 5, supra). In order to check for this possibility, we have re-estimated the model taking the number of male and female workers instead of the total number of workers. Our results stand: the number of workers, whether male or female, does not significantly influence monetary output. As an additional check, we re-estimated the model by introducing a variable measuring the ratio of men to women. The results continue to hold and the coefficient of the gender ratio is negative and significant whereas it should have been positive if men were more productive than women.

Since our measurement of workforce is the number of members working on the collective plots in general, we implicitly assumed, in the former regressions, that the head does not allocate the available workforce between the various collective fields<sup>20</sup>. In order to take that possibility into account, we have re-estimated the model at the farm level instead of the plot level. This change does not seem to affect our results which are identical whether the effect of the workforce size is estimated at the farm or plot level.<sup>21</sup>

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<sup>20</sup> We have the information on the number of workers per plot in our questionnaire but did not exploit this information. As a matter of fact, in almost all sample households it turns out that all the male members work on all the common plots.

<sup>21</sup> Estimations at the farm level are less relevant since we need to aggregate plot characteristics.

*Table 9: Estimating the effects of the number of workers on total output value for all type of crops and distinguishing between care-intensive and subsistence crops*

Dependant Variable: Plot output in value terms (FCFA)			
<i>Explanatory variables</i>	(1) All crops	(2) Care-intensive crops <sup>a</sup>	(3) Subsistence crops <sup>b</sup>
<i>Nr of workers</i>	-366.9 (3536.5)	-3634.2 (2245.8)	4189.8* (2322.5)
<i>Land area</i>	79166.3*** (8407.3)	110593.4*** (10768.2)	31450.2*** (5916.3)
<i>Bottom land</i>	108168.4** (46825.5)	-24395.4 (34464.4)	-695.9 (14810.9)
<i>Fallow_5years</i>	-45882.2 (35883.0)	13228.9 (24058.7)	-41365.4*** (14222.9)
<i>Location</i>	-368.4 (480.8)	183.4 (290.5)	-376.8 (270.5)
<i>Land rights</i>	-54402.3 (41167.9)	-19473.3 (26262.6)	-23734.6 (30824.6)
<i>Chemical inputs</i>	1.5*** (0.4)	0.5 (0.3)	0.2 (0.1)
<i>Hiring labour</i>	18368.8 (33818.3)	29804.1 (19960.6)	-16684.9 (21029.5)
<i>Renting material</i>	-69279.9 (44023.4)	-70581.0** (31042.9)	-15804.2 (22331.4)
<i>Plough dummy</i>	15121.7 (33147.2)	37859.3 (23847.1)	15607.9 (16244.9)
<i>Manure</i>	8401.1** (4275.9)	7902.2** (3704.5)	351.9 (1393.9)
<i>Age of the farmer</i>	904.4 (1149.5)	818.9 (815.4)	-391.3 (672.6)
<i>Education of the farmer</i>	38755.5 (46423.3)	19644.1 (36851.0)	-2488.4 (26807.3)
<i>Constant</i>	-19201.7 (97379.6)	30313.9 (54419.9)	126853.8 (103463.7)
<i>Crop FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Village FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Nr of observations</i>	455	455	455
<i>Nr of clusters</i>	201	201	201
<i>R-squared</i>	77.2	86.6	34.2

Significant at \*\*\*1%, \*\*5%, \*10%; robust standard errors clustered at household level in parenthesis

<sup>a</sup> Cotton, maize, rice, onion, groundnuts

<sup>b</sup> Sorghum and millet



It might seem strange that household heads would allow such a large workforce to operate on the collective fields that their marginal productivity comes down to zero. The oddity vanishes, however, once we realize that the logic of traditional subsistence economies differs from the logic of so-called ‘commercialized’ economies. As argued by Lewis (1954), Cohen and Weitzman (1975), and Platteau (1991), the former type is characterized by specific employment and remuneration rules: each member of the social unit (typically a family) enjoys a guaranteed access to employment on the collective farm, and receives the average product as reward for participation in productive activities. Since the number of claimants is thus fixed, optimal production corresponds to its maximum level (marginal productivity is zero). The same conclusion obviously obtains if members receive an institutional, customary wage and the family head appropriates a rent that he seeks to maximize.

In support of the MHT hypothesis, we are actually able to complement the quantitative tests presented above with suggestive evidence derived from simple correlation analysis of more qualitative information available to us. We know that cultivation of individual plots is constrained by specific timing rules imposed by the household head. If the MHT problem exists and the head is aware of it, we expect him to impose relatively strict rules when the problem is rather severe owing to the participation of numerous people in collective farming operations. Along this line, we construct a variable which describes the prevailing work rule on male individual plots.<sup>22</sup> Three possibilities are considered, which we rank by decreasing order of severity: (1) male members are allowed to work only one day a week; (2) they may work before sunrise and after sunset (that is, during the coolest hours of the day), and sometimes also one day a week, or two days a week; and (3) they may work five or six days a week, or whenever they want. The result, reported in Table 10, is according to expectation: the number of workers participating in collective production is greater in households where the most constraining rule is in force (see column (1)).

Guirkinger and Platteau (2010b) have argued that “the temptation to free ride on other members’ efforts on the collective fields appears to be perceptible when several married men work together”. The idea is that, since the families of married men are very likely to be of unequal size, the way of distributing the collective output might look arbitrary to a category of parents: whether the head decides to distribute output equally among all sons, or to give shares proportionate to their family size, the rule will distort incentives (for members with larger family size in the former case, and for members with smaller family size in the latter).

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<sup>22</sup> In some households, we observe that the household head imposes different rules to his male members, for these cases, we take the stricter rule imposed as the rule in force for the household.

In addition, it is plausible that once they get married male members tend to identify with their new family more than with their family of origin. As a result, they may not feel as strongly tied as before to the large household unit, thereby causing a weakening of solidarity links and an activation of feelings of competition and rivalry. In order to test that idea, we correlate the degree of severity of the time allocation rule with the number of married men, rather than the total number of workers on the collective field (see column (2)). We again find that the rule is comparatively strict when the number of married men is higher, and the statistical significance of the difference of means is even more conclusive than in column (1).<sup>23</sup>

*Table 10: Correlation analysis of the relationship between the time allocation rule and the number of workers, the number of married men or the type of family*

Time allocation rules for work on private (male) plots (by decreasing order of severity)	(1) Nr of workers (std.dev.)	(2) Nr of married men (std.dev.)	(3) Nr of extended families (%)	(4) Nr of simple families (%)	(5) Nr of hholds with male private plots
(1) One day a week	12.1 (6.2)	4.2 (2.0)	22 (59.5)	8 (27.6)	30
(2) Coolest hours of the day + sometimes one day / two days a week	10.0 (5.0)	3.0 (1.5)	8 (21.6)	11 (37.9)	19
(3) Five or six days a week / free choice	9.8 (5.7)	3.2 (1.9)	7 (18.9)	10 (34.5)	17
(1) ≠ (2) t-test: P-value	0.112	0.022**			
(1) ≠ (3) t-test: P-value	0.109	0.076*			
Number of household			37	29	66

In the same line, we check whether a relationship exists between the type of rule used by the head and the type of household. The hypothesis is that a more severe rule should prevail when families are extended in the sense of comprising brothers and nephews. In other words, a greater discipline is expected to be imposed by the head when there are more distant intra-family links and, therefore, greater temptation to free ride on other members' efforts. Column (3) appears to bear out this last hypothesis: in extended families, the most severe time allocation rule is applied in about 60 percent of the cases, as against hardly 28 percent for the other families.

<sup>23</sup> When, following the same logic, we measure the size of the workforce by the number of married male members instead of the number of workers in our regression estimate of the MHT problem, we again find that this variable has no significant impact on the value of collective output for care-intensive crops whereas the influence is significantly positive for subsistence crops.

Finally, under the assumption that the household head monitors effort if he is himself present on the collective field, we expect his presence to be more frequently observed when there is a higher risk of labour shirking, that is, when there are numerous workers or married men, or when the family is of the extended type. Our data, however, do not confirm this hypothesis. On the contrary, we find that the household head participates in collective production when there are fewer workers available to farm the collective fields. This suggests that the presence of the head on these fields arises more from the need to complement a rather scarce workforce than from the need to supervise the efforts applied by the participating members.

## **6. Conclusion**

This paper has clearly established, on the basis of first-hand data collected in Mali, that significant productivity differentials exist between collective fields managed by the household head for the sake of the family as a whole, on the one hand, and private plots managed by individual male members for their own benefit, on the other hand. Moreover, there is strong evidence that these differentials can be attributed to substantial variations in the labour effort applied to cultivation, which we do not measure directly. This conclusion is inferred from the fact that productivity differences subsist after controlling for plots' and farmers' characteristics, the use of complementary inputs, and for crop and household fixed effects. By using crop fixed effects, we do not only control for the possible differences in crop choices between (male) members and the household head, but we also mitigate the effect of possible quality variations that are not well captured by our rather rough distinction between dry and bottom lands.

The cropwise distinction has yielded an interesting finding: the productivity advantage of private (male) farming exists for care-intensive crops yet not for the two traditional, subsistence crops (millet and sorghum). A plausible explanation for the observed superiority of private plots in terms of effort intensity is the presence of the moral-hazard-in-team problem which distorts labour incentives on collective fields devoted to the cultivation of care-intensive crops. This hypothesis has been confirmed by an empirical test of the effect on land productivity of the number of individuals engaged in collective production. Our results are therefore in support of the theory of the family farm proposed by Guirkinger and Platteau (2011a). According to them, indeed, collective farming in the context of extended family farms is vulnerable to efficiency losses precisely because of the above incentive problem.

From an efficiency point of view, purely collective family farms are thus at disadvantage compared with mixed farms (in which private plots coexist with common ones). Why do household heads accept such inefficiency losses of which they seem to be quite aware? The answer provided by Guirkinger and Platteau (2011a) is rent capture by the heads. Since their own incomes are essentially obtained from collective farming, there exists an obvious trade-off between efficiency and rent capture considerations. When land becomes sufficiently scarce, the head's income is maximized by awarding private plots to members. Another plausible explanation refers to risk considerations. To the extent that common fields act as a risk-pooling mechanism, their lower productivity is at the root of an efficiency-insurance trade-off. At equilibrium, therefore, risk-averse members are expected to choose a mix of collective and private plots -in the way sometimes followed in agricultural producer cooperatives- (Carter, 1987; Delpierre, Guirkinger, and Platteau, 2011). To the extent that agricultural production remains plagued by risk, such an explanation can explain the persistence of mixed farms, but not its emergence since collective farms dominated in the initial situation.

A third explanation is based on the idea that optimal institutional adjustments are not instantaneous. Thus, recent adoption of care-intensive, commercialized crops which are more efficiently grown on private (male) plots, has not yet given rise to the required change in the farm structure. This latter explanation is not entirely convincing, however. When private plots coexist with collective fields, indeed, there is no complete crop specialization between the former and the latter.

## Appendix A

*Table A.1 : Crop's allocation (frequencies and average cultivated area) during the rainy season*

Crop	All plots		All collective plots		All individual plots		Male individual plots		Female individual plots	
	Nr. of plots	Average area of the plot	Nr. of plots	Average area of the plot	Nr. of plots	Average area of the plot	Nr. of plots	Average area of the plot	Nr. of plots	Average area of the plot
Cotton	122	3.67 (3.63)	114	3.79 (3.72)	8	2.03 (1.26)	7	1.89 (1.29)	1	3.00
Millet	221	2.19 (1.75)	205	2.33 (1.74)	16	0.46 (0.29)	5	0.57 (0.42)	11	0.41 (0.22)
Sorghum	351	2.23 (2.29)	264	2.79 (2.35)	87	0.55 (0.89)	21	1.31 (1.35)	66	0.31 (0.49)
Maize	205	1.79 (1.71)	182	1.94 (1.74)	23	0.60 (0.50)	15	0.69 (0.55)	8	0.43 (0.37)
Rice	171	0.54 (0.75)	29	1.01 (1.61)	142	0.44 (0.32)	14	0.54 (0.58)	128	0.43 (0.28)
Groundnuts	254	0.57 (0.83)	97	0.97 (1.06)	157	0.32 (0.51)	39	0.58 (0.95)	118	0.24 (0.18)
Niebe	68	2.00 (2.94)	47	2.75 (3.26)	21	0.32 (0.42)	8	0.42 (0.65)	13	0.26 (0.18)
Gombo	47	0.14 (0.13)	2	0.50 (0.35)	45	0.12 (0.10)	2	0.15 (0.00)	43	0.12 (0.10)
Beens	41	0.41 (0.30)	29	0.48 (0.32)	12	0.23 (0.15)	0	0	12	0.23 (0.15)
Chili	103	0.18 (0.19)	3	0.50 (0.00)	100	0.17 (0.18)	36	0.17 (0.16)	64	0.16 (0.19)
Ginger	37	0.29 (0.31)	11	0.63 (0.38)	26	0.15 (0.10)	9	0.19 (0.10)	17	0.12 (0.09)
Other crops <sup>a</sup>	122	0.68 (1.02)	72	1.03 (1.21)	50	0.18 (0.24)	21	0.29 (0.33)	29	0.10 (0.07)

<sup>a</sup> onion, potato, sweet potato, fonio, tomato, bissam, salad, cabbage, cashewnuts, sesam

*Table A.2: Crop's allocation (frequencies and average cultivated area) during the dry season (on bottom land only)*

Crop	All plots		All collective plots		All individual plots		<i>Male individual plots</i>		<i>Female individual plots</i>	
	Nr. of plots	Average area of the plot	Nr. of plots	Average area of the plot	Nr. of plots	Average area of the plots	<i>Nr. of plots</i>	<i>Average area of the plot</i>	<i>Nr. of plots</i>	<i>Average area of the plot</i>
Onion	109	0.14 (0.13)	8	0.23 (0.15)	101	0.13 (0.13)	35	0.13 (0.11)	66	0.13 (0.14)
groundnuts	26	0.19 (0.16)	2	0.29	24	0.18 (0.17)	3	0.15 (0.04)	21	0.18 (0.18)
Sweet potato	35	0.23 (0.17)	4	0.33 (0.12)	31	0.22 (0.17)	9	0.29 (0.20)	22	0.19 (0.16)
Other crops <sup>a</sup>	48	0.31 (0.32)	15	0.53 (0.43)	33	0.21 (0.19)	18	0.25 (0.20)	15	0.16 (0.16)

<sup>a</sup> potato, chili, tomato, salad, cabbage

*Table A.3: Crop's allocation between dry and bottom land during the rainy season.*

Type of Crop	Dry land		Bottom land	
	Nr. of plots	Average area of the plot	Nr. of plots	Average area of the plot
Cotton	122	3.67 (3.63)	0	0
Millet	219	2.21 (1.75)	2	0.4 (0.00)
Sorghum	351	2.23 (2.29)	0	0
Maize	194	1.86 (1.72)	11	0.66 (0.84)
Rice	25	0.64 (0.57)	146	0.52 (0.77)
Groundnuts	244	0.59 (0.84)	10	0.21 (0.37)
Niebe	65	2.08 (2.98)	3	0.21 (0.25)
Gombo	29	0.17 (0.14)	18	0.08 (0.10)
Beans	41	0.41 (0.30)	0	0
Fonio	36	0.79 (0.50)	0	0
Chili	62	0.21 (0.20)	41	0.13 (0.15)
Ginger	37	0.29 (0.31)	0	0
Other crops <sup>a</sup>	100	0.78 (1.10)	22	0.23 (0.32)

<sup>a</sup> onion, potato, sweet potato, fonio, tomato, bissam, salad, cabbage, cashewnuts, sesam

Table A.4: Descriptive statistics of the main variables.

	Total		Collective Plot (CP)		Individual Plot (IP)		P-Val CP><IP	Male individual Plot (MIP)		Female individual Plot (FIP)		P-Val MIP><FIP	P-Val CP><MIP
	Average (std. dev)	Nr obs	Average (std dev)	Nr obs	Average (std. dev)	Nr obs		Average (std. dev)	Nr obs	Average (std. dev)	Nr obs		
<b>(1) Monetary Yields (FCFA/ha)</b>													
Total yield	243 110.4 (21 654.4)	979	85 564.1 (6 511.0)	459	382 175.3 (39 383.8)	520	0.000	520 687 (91 134.1)	149	326 546.3 (41 061)	371	0.013	0.000
Yield net of fertilizer cost	218 284.2 (20 839.8)	979	67 366.0 (5 823.2)	459	351 498.4 (37 966.1)	520	0.000	474 883.1 (87 333.9)	149	301 945.0 (39 816.4)	371	0.020	0.000
Yield for dry land	94 636.6 (5 572.7)	672	65 559.3 (2 657.3)	414	136 527.2 (13 211.1)	258	0.000	183 926.5 (27 923.4)	79	115 607.7 (14 296.3)	179	0.008	0.000
Yield for bottom land	572 115.8 (64 181.7)	307	269 608.2 (55 176.1)	45	624 073.2 (74 165.3)	262	0.025	900 745.3 (181 594.3)	70	523 203.1 (75 591.4)	192	0.012	0.000
Yield for care intensive crops <sup>a</sup>	218 762.2 (23979.9)	680	100 691.9 (6 289.9)	287	304 986.6 (40 711.6)	393	0.000	499 738.1 (144 465.2)	94	243 760.4 (27 666.9)	299	0.004	0.000
Yield for subsistence crops <sup>b</sup>	47 879.7 (2 989.3)	447	47 959.2 (2 927.7)	348	47 600.2 (8 770.9)	99	0.480	57 518.5 (12 236.0)	23	44 598.6 (10 822.9)	76	0.268	0.209
<b>(2) Physical Yields (kg/ha)</b>													
Cotton	896.87 (44.13)	122	887.55 (46.55)	114	1029.76 (79.78)	8	0.214	1057.82 (85.98)	7	833.33 (0)	1	/	0.187
Millet	691.91 (50.82)	221	692.75 (53.31)	205	681.74 (169.95)	16	0.477	746.66	5	654.69	12	0.407	0.438
Sorghum	586.09 (42.73)	351	593.73 (46.14)	264	563.16 (100.72)	87	0.379	755.17 (176.23)	21	502.97 (119.94)	67	0.144	0.173
Maize	1100.41 (56.78)	205	1080.20 (59.58)	182	1260.33 (184.46)	23	0.159	1437.78 (255.86)	15	927.60 (194.15)	8	0.097	0.053
Rice	2 243.27 (279.91)	171	1 280.38 (430.13)	29	2 439.92 (323.48)	142	0.060	2369.05 (873.23)	14	2447.67 (346.90)	128	0.471	0.107
Onion	3115.50 (481.42)	109	1912.88 (70.61)	8	3210.76 (515.88)	101	0.243	4150.44 (1155.16)	35	2712.45 (495.36)	66	0.093	0.184
Groundnuts (kg/ha)	507.3 (36.6)	254	384.2 (31.8)	97	583.4 (54.2)	157	0.004	729.52 (126.88)	39	530.47 (58.56)	119	0.057	0.000



<b>(3) farming areas (ha)</b>													
Cultivated area	2.35 (0.12)	1023	4.43 (0.23)	488	0.44 (0.03)	535	0.000	0.66 (0.10)	154	0.35 (0.02)	381	0.000	0.000
Dry land cultivated area	3.38 (0.18)	672	5.11 (0.26)	414	0.60 (0.07)	258	0.000	1.03 (0.18)	79	0.41 (0.05)	179	0.000	0.000
Bottom land cultivated area	0.42 (0.04)	307	1.06 (0.26)	45	0.31 (0.02)	262	0.000	0.30 (0.04)	70	0.32 (0.02)	192	0.316	0.001
Care intensive crops <sup>a</sup> area	1.57 (0.12)	680	3.17 (0.24)	287	0.40 (0.12)	393	0.000	0.62 (0.12)	94	0.33 (0.02)	299	0.000	0.000
Subsistence crops <sup>b</sup> area	2.83 (0.13)	447	3.45 (0.15)	348	0.57 (0.09)	99	0.000	1.32 (0.27)	23	0.34 (0.05)	76	0.000	0.000
<b>(4) Inputs</b>													
Fertilizer from CMDT (kg/ha)	15.78 (1.42)	979	29.85 (2.63)	459	3.36 (1.09)	520	0.000	9.76 (3.64)	149	0.79 (0.37)	371	0.000	0.000
Fertilizer from traders (kg/ha)	63.73 (8.51)	979	29.63 (4.54)	459	93.83 (14.40)	520	0.000	149.53 (30.60)	149	71.46 (17.64)	371	0.011	0.000
Total Fertilizer (FCFA/ha)	20 617.6 (2 257.7)	979	14 803.5 (1232.17)	459	25 749.8 (4 097.9)	520	0.007	42 470.5 (8 308.4)	149	19 034.4 (4 637.01)	371	0.005	0.000
Herbicide (FCFA/ha)	4 208.5 (523.3)	979	3 394.5 (406.0)	459	4 927.1 (917.1)	520	0.072	3 333.3 (1 520.5)	149	5 567.1 (1 130.6)	371	0.135	0.478
Total chemical inputs (FCFA/ha)	24 826.2 (2 445.1)	979	18 198.0 (1 376.2)	459	30 676.8 (4 426.6)	520	0.005	45 803.9 (9 020.8)	149	24 601.6 (5 010.3)	371	0.015	0.000
Hiring labour (%)	27.8	1016	28.4	486	27.4	530	0.713	19.1	152	30.7	378	0.007	0.023
Rent in equipment (%)	10.2	/	6.0	/	14.1	/	0.000	6.6	/	17.2	/	0.002	0.783
Right to plant a tree (%)	65.3	/	84.3	/	47.9	/	0.000	69.7	/	39.1	/	0.000	0.000
Localization of the plot (min)	23.6 (0.9)	1001	22.9 (1.3)	487	24.2 (1.2)	514	0.440	16.78 (1.71)	154	27.42 (1.59)	360	0.000	0.007
Farmer's age (years)	48.5 (0.5)	985	56.2 (0.6)	487	41.04 (0.7)	498	0.000	38.66 (1.23)	117	41.77 (0.88)	381	0.036	0.000

<sup>a</sup> Cotton, maize, rice, onion, groundnuts; <sup>b</sup> Millet, sorghum

*Table A.5: distinction between plots which were lying fallow at least one year over the last five years and those which have been cultivated every year.*

<i>Fallow_5years</i>	Nr of plots (%)	Nr of Collective Plots (%)	Nr of Individual Plots (%)	Monetary yields for CP (FCFA)
Plots cultivated every year over the last 5 years	931 (91.6)	401 (82.5)	530 (100.0)	89210.7
Plots which were lying fallow at least one year over the last 5 years	85 (8.4)	85* (17.5)	0 (0)	66799.1
P-value				0.107

\*86% of them belong to the household head

## Appendix B

*Table B.1: Estimating the effects of the number of workers on yield per worker in value term for all type of crops and distinguishing between care-intensive and subsistence crops*

Dependant Variable: Plot output per person per ha in value terms			
<i>Explanatory variables</i>	(1) All crops	(2) Care-intensive crops <sup>a</sup>	(3) Subsistence crops <sup>b</sup>
<i>Nr of workers</i>	-1620.2*** (327.2)	-2058.9*** (419.3)	-655.1*** (181.5)
<i>Land area</i>	104.9 (218.2)	41.2 (286.7)	-524.9*** (195.1)
<i>Bottom land</i>	34928.9*** (9859.4)	14425.7** (6692.0)	4136.6 (4242.3)
<i>Fallow_5years</i>	-765.9 (4099.4)	-2759.6 (3339.1)	-2998.2** (1188.8)
<i>Location</i>	1.1 (32.3)	34.3 (44.5)	-13.5 (21.3)
<i>Land rights</i>	1618.6 (2943.2)	-472.4 (4181.9)	2464.1** (1266.9)
<i>Chemical inputs</i>	0.5*** (0.2)	0.3** (0.1)	0.1 (0.1)
<i>Hiring labour</i>	-4466.2* (2603.4)	899.7 (2727.1)	-644.9 (1345.1)
<i>Renting material</i>	-8132.7** (3326.1)	-1046.9 (3802.9)	-2406.6 (2222.3)
<i>Plough dummy</i>	9082.6** (3524.1)	-2874.1 (4143.6)	-54.7 (1270.2)
<i>Manure</i>	-25.7 (98.9)	-40.0 (115.4)	11.8 (47.5)
<i>Age of the farmer</i>	-50.5 (124.6)	51.5 (126.6)	-81.7 (57.5)
<i>Education of the farmer</i>	-2838.7 (4043.5)	-4424.7 (5140.5)	-2936.6 (2192.9)
<i>Constant</i>	25939.9*** (8231.5)	31049.9*** (10258.7)	19868.8*** (5642.2)
<i>Crop FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Village FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Nr of observations</i>	455	286	345
<i>Nr of clusters</i>	201	190	195
<i>R-squared</i>	45.6	35.8	23.6

Significant at \*\*\*1%, \*\*5%, \*10%; robust standard errors clustered at household level in parenthesis

<sup>a</sup> Cotton, maize, rice, onion, groundnuts

<sup>b</sup> Sorghum and millet

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