

# War Induced Covariate Shocks and Natural Resource Degradation in Burkina Faso:

## Evidence from the Ivorian Crisis

Takeshi Sakurai\* and Kimseyinga Savadogo\*\*

February 2007

### 1. Introduction

It is often pointed out that there is a vicious cycle between poverty and environmental degradation in developing countries (for example, a review by Duraiappah (1998)). However, it is usually difficult to provide empirical evidence of the nexus due to the lack of data, and even if otherwise, most of the empirical studies show only static relationship between the two (e.g. Cavendish (2000)). The difficulty may arise from two characteristics of the nexus. First, resource degradation induced by chronic poverty is slow and gradual, and hence is hardly observable. Second, chronic poverty itself may not cause resource degradation if the nexus is at a stable equilibrium point. Transient poverty, on the other hand, could have a direct impact on the environment, but its magnitude would be quite small if it takes place only occasionally or affects a limited number of households in a community. In the latter case, the robustness of environmental resources in fact provides households with an insurance against the transient poverty. Moreover, in situations where only part of a community is adversely affected, it is known that informal insurance

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Seminar presentation, Department of Applied Economics, University of Minnesota (Saint Paul, March 9, 2007). This paper is one of the outputs of the research project titled "Fragility of the Sahelian Farmers and Soil Degradation: A Consideration of Policy Intervention" funded by Global Environment Research Fund, Ministry of the Environment, Government of Japan (FY 2003 – 2005).

\* Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries (PRIMAFF)  
2-2-1 Nishigahara, Kita-ku, Tokyo 114-0024, JAPAN, email: sakurai4@affrc.go.jp

\*\* University of Ouagadougou, Ouagadougou, Burkina Faso, and currently on a sabbatical leave at the University of Minnesota, Minneapolis- Saint Paul.

mechanisms may help households who suffer negative shocks<sup>1</sup>. However, in the case of covariate shocks induced by drought, war, economic crisis, and so on, many households in a wide area fall in transient poverty at the same time and the informal insurance mechanisms such as local risk sharing will not work effectively. Then, if households' coping with shocks relies on environmental resources, as is often the case in developing countries, their behavior could have a significant, negative impact on the environment<sup>2</sup>. As such, in order to investigate empirically the dynamic relationship between poverty and environmental degradation, we should focus on transient poverty due to covariate shocks. Furthermore, since covariate shocks could be the onset of the vicious cycle, it is necessary to know how to prevent the onset from the viewpoint of policymakers. With this regard, the analysis of the consequences of covariate shocks will be critically important. Hence, this paper, taking covariate shocks induced by a war as an example, investigates their impact on soil degradation in Burkina Faso<sup>3</sup>.

Burkina Faso, a landlocked country in West Africa, is located in the semi-arid zone in the Sahelian region on the southern edge of the Sahara desert (Figure 1). Most of the country's territory belongs to the Savanna zone whose annual precipitation varies from 400 mm in the north-east to 1200 mm in the south-west. Agriculture in this country is generally rain-fed, and erratic rainfall contributes to keeping its productivity low and unstable. Because

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<sup>1</sup> A detailed review of research on informal insurance mechanisms in developing countries is available in Chapter 8 of Bardhan and Udry (1999). It is shown that rural communities have mechanisms to pool idiosyncratic risks incurred at individual households level, although they are not perfect.

<sup>2</sup> Households could cope with covariate shocks by receiving remittance from other regions that are not affected by the same shocks and/or out-migrating to such regions (e.g., forest zone in the case of drought). Moreover, to complement the imperfect risk-sharing within a region, households usually accumulate livestock and other assets as precautionary savings. Therefore, the impacts of a covariate shock depend on individual household's characteristics, implying that not all the households will exploit environmental resources to cope with such shocks.

<sup>3</sup> This paper focuses on covariate shocks due to a war, rather than drought or other covariate shocks. Since droughts are very frequent in Burkina Faso, rural households are known to diversify away from the risky agricultural income source (e.g., Reardon, Matlon, and Delgado (1988)). Therefore, drought shock may not cause a new process of resource degradation. Another major economy-wide shock was the 50 percent devaluation of the currency (the CFA franc) in January 1994, but its impact on resource management is little known.

of the stagnation of agricultural productivity, the country remains one of the poorest in the world. In 2003, 46.4 percent of people nationwide and 52.3 percent of the rural population lived below the national poverty (Burkina Faso, 2004). External migration, either sub-regional or intercontinental, has emerged as one effective way for households to overcome the weak (or lack of) local income earning opportunities (Wouterse and Taylor, 2006). Income is derived either from seasonal migration by household members, or through remittances sent by relatives installed in the destination country. The most common destination of migrants and source of remittances is neighboring Côte d'Ivoire, where an estimated 2 to 3 million Burkinabe (i.e. one fifth of the population) lived by the year 2000 (Kress, 2006). It was estimated that in the 1990s, remittances made up about 6 percent of Burkina's GDP and amounted to some \$140 million (about CFAF 70 billion) , almost at parity with export revenues estimated at \$216 million (Savadogo et al. 2006, Kress 2006). At the household level, Reardon et al. (1988) estimated that transfers constituted 10 to 20 percent of household income. Hence, migration and remittances have traditionally provided rural households in Burkina Faso some partial insurance mechanism against climatic fluctuations. In addition, the regional migration has been contributing to the mitigation of population pressure on the land in Burkina Faso.

However, in September 2002, a military rebellion took place in Côte d'Ivoire. As a result, a considerable number of Burkinabè living in Côte d'Ivoire were forced to return to their home country, the total number being officially estimated at 350,000 as of July 2003. That is, the crisis in the neighboring country has imposed unexpected income reduction as the sources of remittances and migration income have been lost. In addition, the returnees from Côte d'Ivoire have caused unexpected population pressure on rural Burkina Faso. Due to this shock (i.e. unanticipated, transitory worsening of economic welfare), agricultural households

that are living near subsistence level will try to increase income from agriculture and may accelerate fertility-depriving cultivation, and hence the risk for soil degradation. This research investigates empirically the effect of the Ivorian crisis on soil degradation in Burkina Faso by looking at its impact on area farmed and the use of fertility management inputs. Specifically, the study uses an econometric model to first assess the impact of the crisis on welfare indicators for rural households in Burkina Faso, then to assess the impacts of the change in these welfare indicators on the area of land cropped by households and their use of soil fertility inputs, including chemical and organic fertilizers.

A specificity of the present work is that it is based on hard data available both before and after a break point, a usually rare commodity. A household panel data set starting in 1999 (two years before the crisis) and ending in 2005 provides the backbone for the analysis. In addition, we conducted an extensive village level survey in 2003-2004 to assess the extent of the crisis and its impact on key village economic and demographic variables. To our knowledge, this is the first study to use a panel data set to assess the impact of the Ivorian crisis on rural households in Burkina Faso.

The remainder of the paper is organized in four sections. In section 2, the data collection process is discussed. Section 3 contains the analytical framework and the econometric model used. Section 4 presents the empirical findings and section 5 summarizes and concludes the paper.

## **2. Study Site and Data**

The data used in this paper come from two sources. The first is a longitudinal study of eight villages from 1998 to 2004, and the second is an extensive cross section survey of 208

villages in 2003. Both data were collected as part of a collaborative research project by Japan International Research Center for Agricultural Sciences (JIRCAS) and University of Ouagadougou (UO).

The eight sites<sup>4</sup> of the longitudinal study are shown in Figure 2. They spread over the four major agro-ecological zones in Burkina Faso: the northern Sudanian zone, the southern Sudanian zone, the northern Guinean zone, and the southern Guinean zone. They differ significantly in the level of annual precipitation, and accordingly households' technological choice and risk management are different.

Thirty-two households were selected in each village in the following way. First, a village census was carried out in 1998, and households were stratified based on the ownership/adoption of animal traction technology. Then, the number of sample households of each stratum is determined proportionally to the total number of households in each stratum so that the sample size of each village is fixed at thirty-two households. As a result, the number of sample households amounts to 256 spread over the eight villages in the four agro-ecological zones.

Then, from 1999 households were surveyed repeatedly for five years so as to construct a panel dataset. The interview was conducted three times a year; after harvest in February, at the end of the dry season in May, and prior to harvesting in September. In the middle of the survey period, the civil war broke out in Côte d'Ivoire in September 2002. This paper uses two years of the panel data to explore the immediate impact of the crisis, specifically by comparing households' behavior in 2002 before the crisis and that in 2003 after the crisis.

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<sup>4</sup> Among these eight villages, six villages (villages 1 and 2 in the northern Sudanian zone, villages 3 and 4 in the southern Sudanian zone, and villages 5 and 6 in the northern Guinean zone) are those where ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) conducted a household survey from 1980 to 1985. JIRCAS/UO chose them as the study sites to measure household level changes in twenty years.

There are several studies that analyze households' micro-level behavior to cope with macro-level covariate shocks: for example, the impact of the currency crisis on fertility in Mexico (Mckenzie (1999)), households' coping with flood in Peru Amazon (Takasaki et al. (2004)), the impact of the Great Hanshin-Awaji earthquake on households' expenditure (Sawada and Shimizutani (2004)). Mckenzie (1999) uses several sets of cross-section data including one collected before the crisis, but others use one set of cross-section data collected only after the shock. Unlike the previous studies, the advantage of this paper is that it uses panel data that span the pre- and post crisis years.

In order to confirm that the changes observed in the sample households can be attributed to the country-wide shock caused by the Ivorian crisis, the extensive village survey was implemented. The 208 villages were randomly selected from 13 provinces out of 45 provinces in Burkina Faso. The 13 provinces were purposefully selected to include those where migration was shown to be prevalent according to the 1996 national demographic census. The eight villages of the longitudinal study were included in this wider sample. The survey was carried out from December 2003 to January 2004 in each village using a group interview approach (groups usually included the village chief, council members, and the leaders of village organizations).

### **3. Analytical Framework**

Rural households in Burkina Faso are considered to face two kinds of covariate shock as a result of the Ivorian crisis. The first is the increase in household size due to the reflux of migrants

from Côte d'Ivoire<sup>5</sup>. The second type of shock is the decrease in household income due to the suspension of remittances and/or seasonal migration. Moreover, region-wide shocks may occur if the shocks at the household level affect the market prices of goods and services. While prices could be pushed upward by a rise in demand stemming from the increase in population, the slackening incomes could act to decrease demand. The net effect on prices will depend on the relative strengths of these opposing forces. This study focuses on livestock holdings and non-agricultural income since they are significant income sources in the West Africa semi-arid tropics. Livestock in West Africa is known to be an asset for self-insurance against unexpected decline of income (Sakurai and Reardon (1997)) or a buffer stock to smooth consumption (Fafchamps et al. (1998)). If many households sell livestock at the same time due to a covariate shock, livestock prices will collapse and the fall of asset value will have a negative impact for livestock holders. Similarly, if many households seek non-agricultural income to compensate for the loss of remittances and migration income, the wage rate will decline and the target additional income may not be achieved. As such, the household level impacts of the war-induced shocks are likely to be of various types and different magnitudes, depending on household characteristics, regional characteristics, and market characteristics. Hence, even though the shock induced by the Ivorian crisis may be common to all households, its impact on a particular household will depend on its intrinsic capacity to absorb this exogenous shock.

Notwithstanding the household level mechanisms put in place to mitigate the shock, we expect per capita income at the household level to decline as a result of the simultaneous increase in household size and decrease in remittances and migration income. In other words, the shock will

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<sup>5</sup> A village may experience an increase in population due to returnees without a significant change in the size of existing households. The number of returnees of a village includes individuals who are not indigenous to the village, but have received permission to settle by the village chief.

cause transient poverty. To cope with this kind of transient poverty, rural households can choose all or some of the following strategies: sell livestock, increase non-agricultural income, and/or increase agricultural production in the short-run. Therefore, instead of focusing on the decline of income, i.e., transient poverty, this paper is going to examine households' behavior to cope with the event of transient poverty. In particular, we look at the possible linkage between the occurrence of transient poverty and households' choices of natural resource management. We posit that transient poverty may cause soil degradation on already fragile lands, by inducing the expansion of cropping area without investing in soil fertility management inputs. In Burkina Faso, population pressure has eliminated the feasibility of traditional resource conservation methods, such as fallowing (Sanders et al., 1996). With the current practice of very short fallow periods, an uncontrolled expansion of cropping area will cause soil degradation and desertification.

The analytical framework presented above can be expressed in a simple reduced form econometric model. The variables of interest are the total cropping area per household ( $A$ ), the amount of chemical fertilizer per hectare ( $C$ ), and the amount of organic fertilizer—manure and compost—per hectare ( $M$ ). The three equations of the model are

$$\Delta A_i = F(\Delta S_i, \Delta T_i, \Delta N_i, \Delta L_i, \mathbf{W}_i, \mathbf{X}_i, \mathbf{V}) \quad (1)$$

$$\Delta C_i = G(\Delta S_i, \Delta T_i, \Delta N_i, \Delta L_i, \mathbf{W}_i, \mathbf{X}_i, \mathbf{V}) \quad (2)$$

$$\Delta M_i = H(\Delta S_i, \Delta T_i, \Delta N_i, \Delta L_i, \mathbf{W}_i, \mathbf{X}_i, \mathbf{V}) \quad (3)$$

where  $\Delta$  is the difference operator applied to the year after the crisis (dry season 2003) and the year before (dry season 2002). The subscript  $i$  stands for household. The three equations use the same explanatory variables. Among these explanatory variables, household level shocks are captured by four variables: The change in household size (number of persons),  $\Delta S_i$ ; the change in the amount of

remittances received,  $\Delta T_i$ ; the change in the amount of non-agricultural income,  $\Delta N_i$ , and the change in the value of livestock holdings,  $\Delta L_i$ . The other explanatory variables are the vector of household's asset as of the dry season of the year 2002 ( $\mathbf{W}$ ), the vector of time-invariant household characteristics that are fixed in 2002 and 2003 ( $\mathbf{X}$ ), and the vector of village/agro-ecological zone dummies ( $\mathbf{V}$ ).

Several econometric techniques dealing with three types of problems/properties are applied to estimate equations (1), (2) and (3). The first problem is that household-level shocks are likely to be endogenous, and thus each equation contains possible endogenous variables ( $\Delta S_i$ ,  $\Delta T_i$ ,  $\Delta N_i$ , and  $\Delta L_i$ ). The second problem is that the three equations form a system of seemingly unrelated equations, as the error terms of these equations are likely to be correlated. The third problem to deal with is the panel nature of the data and the eventuality of household level fixed effects. It is known that in the presence of fixed effects, any estimation technique that ignores them leads to inconsistent estimators. This includes the use of a pooled regression or the specification of the error structure as a random effects model. We deal with each of the three possible problems in the following way. First, a two-stage regression is used to estimate each equation separately where the shock variables are instrumented by exogenous variables in the vectors of  $\mathbf{W}$ ,  $\mathbf{X}$ , and  $\mathbf{V}$ . Second, we take into account the covariance structure of the error terms in order to increase the efficiency of the estimation. Third, we test for the presence of fixed effects using the Hausman test. To allow this test, the dependent and explanatory variables are considered in levels for each year, 2002 and 2003.

## **4. Results**

### **4.1 Country-Wide Shock**

Based on the extensive survey of the 208 villages, it is confirmed that the Ivorian crisis has caused shocks in rural Burkina Faso (Table 1). The number of returnees is 129 per village on

average, which is almost 10% of the mean village population. Such an increase cannot be solely attributed to natural growth. If the figure is disaggregated to zone level, the rate of increase in village population is the highest in the southern Guinean zone, and is the second highest in the southern Sudanian zone. The former is on the border with Côte d'Ivoire and hence a village may accept returnees who do not originate from this village. The southern Sudanian zone is the zone that has traditionally been prone to migration to Côte d'Ivoire. The table also shows that households' dependence on external remittances and that on seasonal migration to abroad have declined significantly after the crisis. The external dependence is obviously the lowest in the northern Guinean zone, the most agriculturally-favorable zone among the four. In sum, the extensive village survey reveals that there are significant and widespread impacts of the Ivorian crisis on some demographic and economic aspects at the village level in Burkina Faso. The magnitudes of these shocks depend on the agro-ecological zone that conditions households' subsistence strategies.

#### **4.2 Household-Level Shock**

In this section, we confirm that the countrywide shocks are experienced by households in our longitudinal data set, and try to uncover which characteristics predispose households to experiencing or not these shocks. We do this by comparing descriptive statistics before and after the crisis, and by regressing the shock variables on household characteristics.

First, the means of the shock variables before and after the crisis for the four study zones are presented in Table 2. For the overall sample, one notes a decrease in the average amount of remittances received per head, and an increase in the average household size. These changes are statistically significant at the 5 percent level. The data suggest that the value of livestock holdings and the amount of non-agricultural income do not differ significantly between the two periods on

average. Although the mean values are smaller after the crisis, the large standard errors eliminate any statistical significance. In the case of remittances and household size, although the differences are significant, they are not as large as implied by the extensive survey results. Concerning the remittances received, the change due to the Ivorian crisis was directly asked in the extensive survey, while in the household survey household's coping, for example a shift of remittance sources from Côte d'Ivoire to other countries, may be included and as a result shocks are mitigated. As for household size, the extensive survey counts all the returnees in the village including non-household members, but the household survey concerns only individuals residing in the household<sup>6</sup>.

Zone-wise comparisons in Table 2 show that the significant increase in household size is observed in the two Sudanian zones, while the significant decrease in remittances received is observed in the two Guinean zones. In all the agro-ecological zones except in the northern Sudanian zone, the mean values of remittances, livestock holdings, and non-agricultural income after the crisis are smaller than those before the crisis although some are not statistically significant. In the northern Sudanian zone, on the other hand, their mean values have become significantly greater after the crisis. Again, the analysis implies that the shocks due to the Ivorian crisis are observable in all agro-ecological zones, but the impacts differ across zones.

Second, we show what types of households are prone to the shocks. Indeed, beyond agro-ecology, we expect household and village characteristics to be causes of the differentiation between households. We specify four equations, one for each of the household-endogenous shock variables ( $\Delta S_i$ ,  $\Delta T_i$ ,  $\Delta N_i$  and  $\Delta L_i$ ). Each regression contains the set of exogenous variables ( $\mathbf{W}_i$ ,  $\mathbf{X}_i$ , and  $\mathbf{V}$ ). The error terms of these four equations are likely to be correlated contemporaneously, and

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<sup>6</sup> The increase in household size includes natural growth, and hence it is not necessarily due to the civil war. But in the survey we asked about the reason of the presence of new adult members. Frequency analysis shows that in most cases, the new members had returned from Côte d'Ivoire.

the usual efficient estimation technique in this case is Seemingly Unrelated Regressions (SUR). However, in our case the regressors are the same in each equations, and in such a case it is known that the parameter estimates are identical whether single equation OLS or system estimation by SUR is used. Since SUR takes into account the covariance structure of the four error terms (which we believe is not spherical), this method provides more exact standard errors than single equation OLS and this is the method we use. The results are presented in Table 3 and provide interesting insights into what causes households to experience the common shock of the war differently. We summarize the main points below.

*Variation of remittances ( $\Delta T_i$ ).* Four points are salient: (i) The reduction in remittances received is greater among households with smaller asset holdings such as land and livestock, implying that poorer households are the most adversely affected; (ii) The reduction in remittances received is greater among households with fewer members. This reinforces (i), as in rural areas production is mostly labor based, and household members provide most of the labor inputs; (iii) The reduction in remittances received is greater if the household head is illiterate, and (iv) Concerning agro-ecological zone, the reduction of remittance received is significantly large in the southern Guinean zone as captured by the constant. The second and third points imply that households' ability to diversify the sources of remittance contributes to the stability of the amount of remittances received.

*Variation of household size ( $\Delta S_i$ ).* The change in household size is explained essentially by two variables in the regression. First, being consistent with Table 2, household size significantly increases in the southern Sudanian zone. Second, households with animal traction technology receive more household members than those without it. This finding, and also the previous result on the relation between the reduction in remittances and household size,

presents a theoretical interest. The ownership of animal traction equipment reflects the capacity of households to invest, and capacity is positively related to the external transfers of income, such as remittances, to the household. The finding can be interpreted within the framework of the New Economics of Migration Labor (Stark and Bloom, 1985; Rozelle, Taylor and de Brauw, 1999; and Taylor, Rozelle and de Brauw, 2003), which views migration as an effort by rural households to shield themselves from market failures (such as credit) constraining local production. In this context, households with animal traction are more likely to be those with relatives living elsewhere, such as Côte d'Ivoire, and sending remittances. The larger increase in the number of returnees for these households indicate the reflux of these providers of income to the household in the aftermath of the crisis.

*Variation of livestock holdings ( $\Delta L_i$ ).* The change in livestock holdings is largely determined by the agro-ecological zone: a significant reduction is observed in the southern Sudanian zone and the southern Guinean zone, which is consistent with Table 2. Moreover, livestock holdings significantly decrease after the crisis in the case of households with smaller agricultural production or with larger livestock holdings before the crisis, probably because such households rely more on livestock to smooth income.

*Variation of non-agricultural income ( $\Delta N_i$ ).* A larger decrease in non-agricultural income is observed among households that have higher non-agricultural income before the crisis. Since a significant part of non-agricultural income is earned through seasonal migration, the result suggests the existence of the shock.

#### **4.3 Coping with Shock and Soil Fertility Management**

This section explores the consequences of the shocks, particularly focusing on the expansion

of cropping area and the management of soil fertility because, as argued previously, households' coping behavior against the shocks could be the onset of soil degradation and desertification. As shown in Table 4, sample households significantly increased cropping area after the crisis on average. In Burkina Faso, the traditional practice to maintain soil fertility is fallowing and shifting cultivation. Land allocation is governed by an informal, communal land tenure system. Hence, if necessary, a household can expand its cropping area by reducing the fallow period and/or bringing into cultivation marginal land that is not usually cultivated. Thus, the question is if such expansions are associated with soil fertility management. According to Table 4, the total amount of chemical fertilizer and that of manure/compost increased on average after the crisis, but their amounts per hectare did not change significantly because of the concomitant increase in cropped area. Therefore, one could be tempted to infer that the area expansion induced by the Ivorian crisis is not fertility-depriving from this simple comparison of the means. However, not all households and zones are affected in the same way as shown in the previous section. The model specified in equations 1-3 is now implemented to examine the joint impacts of the shock variables and other household characteristics on land use and soil fertility management.

Following our argument of the likely correlation among the error terms, equations (1), (2) and (3) are simultaneously estimated using an instrumental variable technique. The exogenous, explanatory variables shown in Table 3 are used as instruments for the four endogenous, shock variables<sup>7</sup>. Practically, we used a three stage estimation, where the first two stages (applying OLS to each equation representing each of the four endogenous shock variables and obtaining the fitted values) are given by the regression results presented in Table 3. Generally, it is hypothesized that a

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<sup>7</sup> The Hausman tests for endogeneity did not necessarily support the endogeneity of the four shock variables in the system, but since they are theoretically considered endogenous, a three-stage estimation technique is applied.

shock that decreases household non-agricultural income will stimulate agricultural production (either an area expansion or an increase in input use). On the other hand, household assets holdings before the crisis are hypothesized to mitigate the shock. The results are shown in Table 5, and the key points are summarized below.

*Area equation.* Four points emerge from the parameter estimates. (i) The reduction in remittances received increases cropping area by 1.91 hectares per 100,000 FCFA (about 200 US dollars). (ii) The increase in household size increases cropping area by 0.32 hectares per person. (iii) The reduction in the value of livestock holdings increases cropping area by 0.31 hectares per 100,000 FCFA (about 200 US dollars). (iv) Household initial assets holdings have no significant effect on the change in cropping area. In sum, sample households cope with the shocks by extending area under cultivation regardless of their asset level, which is indicative of the use of extensification of agricultural production as a fall-back position for farmers faced with the shocks.

*Chemical fertilizer equation.* The reduction of remittances was found to have no effect on the use of chemical fertilizer. In contrast, the increase in household size was found to significantly reduce fertilizer use per hectare. As shown in Tables 2 and 3, the reduction of remittances is observed in the two Guinean zones, while the increase of household size is observed in the two Sudanian zones, particularly in the southern Sudanian zone. Hence, the result implies that households cannot increase the amount of fertilizer proportionally to the increase in cropping area in the southern Sudanian zone. Unlike the two Guinean zones where farmers producing cotton have access to credit for fertilizer acquisition<sup>8</sup>, households in the two Sudanian zones are likely to face cash constraint.

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<sup>8</sup> Farmers receive a group based credit through the cotton parastatal, SOFITEX. Credit is targeted toward cotton and maize production, and to short term consumption smoothing.

*Manure/compost equation.* The results of the manure/compost equation show that the initial livestock holdings as well as their variation (increase) have a significant and positive effect on the use of organic fertilizer per hectare. Thus, livestock appears as the constraint to the increased use of organic fertilizer. Unlike the change in cropping area, the change in the use of organic fertilizer is affected by household assets: households that have more agricultural production before the crisis and/or households with more members before the crisis, do not reduce their use of organic fertilizer as much as those with lower production.

The regression results presented in Table 5 generally support our hypotheses, and can be interpreted in a consistent manner. The extremely low  $R^2$  values for the chemical fertilizer and the organic fertilizer equations however raise some concerns, as they suggest that the regressors fail to explain the observed variations in these dependent variables. This signals that important variables may have been omitted in the regression (even though low R-squared values are not unusual in cross section data, and our data set is a very short panel). We exploit the panel nature of the data to test for the presence of household fixed effects not accounted for by the regressors. To implement the new model, the model represented by equations 1 through 3 is modified so that the variables are now measured in their levels of 2002 and 2003. We introduce interaction terms between zone and year to capture any covariate shock that is not captured by household-level shocks (a dummy variable is created for the interaction between the year 2003 and each of the four zones--the northern and southern Sudanian, and the northern and southern Guinean zones).

Table 6 presents the regression results. The null hypothesis of a random effect model was rejected for the area and chemical fertilizer equations, but not for the organic fertilizer equation. Note that the R-squared have significantly improved for the two fixed effects models, but not for the

random effects equation<sup>9</sup>. A quick diagnostic shows that the explanatory power of the models has thus improved.

The results of the modified models give some additional insights. In the area equation, the coefficient of the southern Sudanian zone suggests that area in 2003 was expanded by about 1.51 hectares per household due to reasons other than the four household-level shocks. Unlike the three-stage regression results shown in Table 5, household size does not have a significant effect on the cropping area, probably because it is captured by the dummy for the southern Sudanian zone where household size increased the most after the crisis. Other than this, both the reduction of remittances received and the reduction of livestock value increased cropping area significantly, which is consistent with the results shown in Table 5. Moreover, the reduction of non-agricultural income is also found to have a significant and positive impact on the cropping area expansion. As for chemical fertilizer, no household-level shock variable has a significant effect in the fixed effect regression. But it is revealed that the input rate increased in 2003 by 24 kg per hectare in the northern Guinean zone and it decreased in 2003 by 16 kg per hectare in the southern Guinean zone. We note that the northern Guinean zone is a major cotton production zone, more so than the southern Guinean zone. The difference of results for the two zones again points to the role of an effective credit market in household investment in conservation technology. In the case of the two Sudanian zones, these are known to be agro-ecologically unfavorable, and farmers use only very little amounts of chemical fertilizer per hectare regardless of the situation. In these zones it is expected that shocks will not have any significant effect on the use of chemical fertilizer. The results of the manure/compost equation (estimated as a random effects model) are similar to those of the chemical

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<sup>9</sup> The fixed effects regression for the manure/compost equation gave a high  $R^2$  value (0.93) but the Hausman test could not reject the null hypothesis of random effects.

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fertilizer equation: no shock variable has a significant impact on the use of organic fertilizer. But according to the coefficients for the zone-level shocks, the input rate of organic fertilizer increased by 0.87 cart/hectare in the northern Sudanian zone and by 1.44 cart/hectare in the northern Guinean zone. These results are consistent with Table 2, which indicates that the value of livestock holdings has either increased or did not change significantly in these two zones.

## **5. Conclusions**

The main objective of this paper was to test the hypothesis that the internal crisis that overtook Côte d'Ivoire in September 2002 has had a detrimental incidence on land management in Burkina Faso and is likely to lead to soil degradation. The channel of transmission of this external shock was hypothesized to be through reduced remittances and an increase in household size in rural Burkina Faso. We used a two-year household level panel data set covering the pre- and post-war years and an extensive post-war village level survey to understand first to what extents the crisis rippled down in the form of shocks to rural villages and households, and second how the shocks experienced by households affected their land management strategies. Our findings can be summarized in two main points.

First, our extensive village survey confirmed that the civil war had a widespread impact in rural Burkina Faso via a surge in village population and a sharp reduction in the reliance on remittances from Côte d'Ivoire. These findings were also materialized within our panel of sample households: in particular, small size and low asset households were found to be affected most in terms of reduced remittances. Animal traction households were found to house the greatest number of returnees, lending support to the New Economics of Migration Labor that hypothesizes that migration is a means to overcome local financial market failures and spur

technology adoption.

Second, our analysis found that households faced with shocks resorted to mechanisms that were conducive to soil degradation. Households both increased cropped area and reduced the rate of application of fertilizer (chemical and organic) in their fields as a joint consequence of reduced incomes and increased number of members. Since the more vulnerable households in the more degraded zones were found to be the most prone to the shocks, it follows that they are also those most prone to the soil degradation practices, further compromising their livelihood systems. In particular, the transient poverty induced by the crisis is likely to lead to long term, welfare reducing resource degradation. These findings agree with the general belief that a vicious cycle exists between poverty and environmental degradation.

Three major implications can be drawn from the results of the study.

First, the study points to the fragility of natural resource management in Burkina Faso. Because of population pressure, this country has been experiencing a breakdown of the traditional system of shifting cultivation and long fallow-periods which was effective in maintaining soil fertility. The response to the recent shock from the Ivorian crisis is contributing to the acceleration of this trend and suggests that the 'natural' fall back position of farmers in the advent of widespread shocks appears to be a greater exploitation of natural resources.

Second, the results of the analysis underscore the role of a well functioning capital markets as a shield against fertility-depriving cultivation. The northern Guinean zone, where cotton producers evolve in a situation of a state supported credit market, has been less prone to extensification in cultivation than the other zones analyzed.

Third, the findings remind us of the role of sub-regional peace in the search for

economic progress in the fragile economies of West Africa. The crisis emerged as a major shock that has disturbed long established economic choices made by individual households. These choices had resulted in a long run equilibrium position in many areas, in particular in land resource management in Burkina Faso. Was disrupts this equilibrium, and regional peace appears as a key condition of mutual growth in the very interdependent national economies in West Africa.

This analysis looks only at the first year following the crisis. After this initial year, area expansion and the ensuing resource degradation is likely to continue and accelerate in the absence of alternative choices for farmers. The major policy implication is that public intervention in the form of assisted credit or the facilitation of households' involvement in non farm income generating activities would be indicated in order to prevent the downward spiral of resource degradation as farmers attempt to adjust to the new situation.

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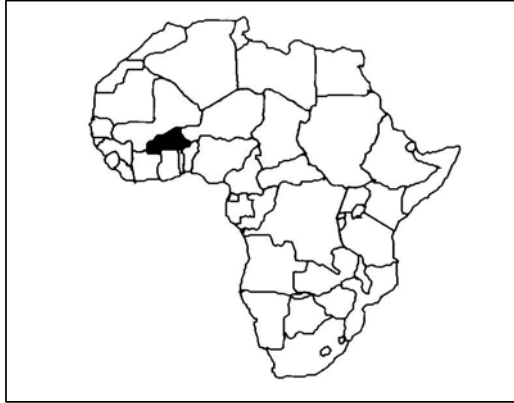
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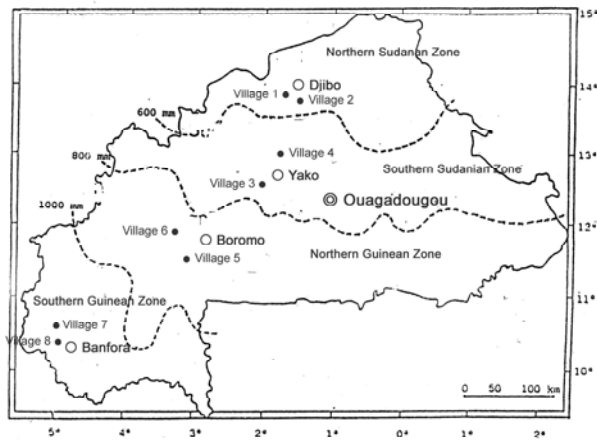
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**Figure 1** Location of Burkina Faso



**Figure 2 Study Site**

Table 1 Impacts of the Ivorian Crisis at Village Level in Burkina Faso <sup>1)</sup>

Impacts	Before the Crisis	After the Crisis (change)
<b>Village Population</b>		
Whole Sample	1362	1491 (+129)
Sudanian Zone (north)	1222	1302 (+80)
Sudanian Zone (south)	1604	1763 (+159)
Guinean Zone (north)	1146	1189 (+43)
Guinean Zone (south)	1383	1607 (+224)
<b>Percentage of Households Depending on Remittance Receiving</b>		
Whole Sample	42.9	8.0 (-34.9)
Sudanian Zone (north)	54.1	10.9 (-30.3)
Sudanian Zone (south)	44.5	14.2 (-30.3)
Guinean Zone (north)	26.3	0.8 (-25.5)
Guinean Zone (south)	43.8	3.4 (-40.4)
<b>Percentage of Households Depending on Seasonal Migration to Abroad</b>		
Whole Sample	35.7	7.0 (-28.7)
Sudanian Zone (north)	43.2	2.1 (-41.1)
Sudanian Zone (south)	26.8	5.0 (-21.8)
Guinean Zone (north)	26.5	8.6 (-17.9)
Guinean Zone (south)	48.6	13.3 (-35.3)

<sup>1)</sup> Average of 208 villages surveyed

Table 2 Impacts of the Ivorian Crisis at Household Level in Burkina Faso <sup>1)</sup>

Impacts	Year 2002	Year 2003	Difference <sup>2)</sup>
Amount of Remittance Received (10 <sup>3</sup> FCFA) <sup>3)</sup>			
Whole Sample	67.6 (85.2)	53.7 (69.2)	- **
Sudanian Zone (north)	22.9 (21.4)	49.3 (83.3)	+ **
Sudanian Zone (south)	70.3 (103)	50.5 (65.3)	0
Guinean Zone (north)	98.9 (90.7)	70.4 (66.5)	- ***
Guinean Zone (south)	73.2 (83.6)	42.7 (58.7)	- ***
Number of Household Members			
Whole Sample	10.9 (8.39)	11.3 (8.74)	+ **
Sudanian Zone (north)	8.32 (5.27)	8.35 (5.74)	+ **
Sudanian Zone (south)	12.1 (9.67)	13.8 (10.9)	+ ***
Guinean Zone (north)	12.6 (10.3)	12.5 (9.72)	0
Guinean Zone (south)	10.2 (6.49)	10.1 (6.41)	0
Value of Livestock Holdings (10 <sup>3</sup> FCFA)			
Whole Sample	242 (377)	228 (342)	0
Sudanian Zone (north)	179 (252)	280 (535)	+ **
Sudanian Zone (south)	242 (512)	157 (184)	0
Guinean Zone (north)	328 (386)	300 (292)	0
Guinean Zone (south)	231 (318)	171 (176)	- **
Amount of Non-Agricultural Income (10 <sup>3</sup> FCFA)			
Whole Sample	38.3 (78.1)	36.5 (105)	0
Sudanian Zone (north)	13.7 (13.7)	30.9 (43.9)	+ ***
Sudanian Zone (south)	34.5 (69.9)	30.9 (17.5)	0
Guinean Zone (north)	72.8 (125)	51.8 (110)	0
Guinean Zone (south)	37.0 (58.5)	34.0 (31.7)	0

<sup>1)</sup> The numbers are sample mean values in the dry season of year 2002 (before the crisis) and in the dry season of year 2003 (after the crisis) respectively. Standard deviations are in the parentheses.

<sup>2)</sup> Results of paired-sample T-tests are shown. The two means are different at the significance level of 1% (\*\*\*), 5% (\*\*), and 10% (\*) respectively.

<sup>3)</sup> The amount of remittance includes transfer from household members out-migrated and transfer from non-household members such as relatives and independent children. They are from not only Côte d'Ivoire, but also other foreign countries as well as other regions in Burkina Faso. Note that in-kind transfers are converted into monetary values.

Table 3 Determinants of Household-Level Shocks <sup>1)</sup>

Dependent Variables Explanatory Variables	Change in Remittance (10 <sup>5</sup> FCFA)	Change in Household Size (person)	Change in Livestock Value (10 <sup>5</sup> FCFA)	Change in Non-Ag. Income (10 <sup>5</sup> FCFA)
Household Assets in 2002 Dry Season				
Cropping area*rainfall (10 <sup>3</sup> ha*mm)	0.05 (0.02) ***	-0.05 (0.09)	0.34 (0.08) ***	-0.05 (0.03)
Value of livestock (10 <sup>5</sup> FCFA)	0.04 (0.01) ***	0.02 (0.07)	-0.66 (0.07) ***	0.00 (0.02)
Remittance received (10 <sup>5</sup> FCFA)	-0.84 (0.06) ***	-0.39 (0.28)	-0.30 (0.26)	-0.38 (0.10) ***
Non-ag. income (10 <sup>5</sup> FCFA)	-0.12 (0.06) **	0.22 (0.28)	-0.22 (0.27)	-0.50 (0.10) ***
Household size (person)	0.01 (0.01) *	-0.04 (0.04)	0.04 (0.04)	0.07 (0.01) ***
Household Characteristics				
Fulani ethnic group (dummy)	-0.19 (0.17)	-0.86 (0.85)	0.34 (0.80)	-0.22 (0.30)
Mossi ethnic group (dummy)	0.04 (0.22)	-0.14 (1.10)	-0.16 (0.10)	-0.11 (0.39)
Literate household head (dummy)	0.31 (0.12) ***	0.80 (0.57)	0.60 (0.54)	0.24 (0.20)
Age of household head	0.27 (0.28)	1.93 (1.39)	-0.70 (1.31)	-0.51 (0.49)
Use of animal traction (dummy)	-0.10 (0.10)	1.08 (0.49) **	0.89 (0.46) *	-0.11 (0.17)
Village Characteristics				
Northern Sudanian zone (dummy)	0.67 (0.17) ***	0.09 (0.83)	1.72 (0.78) **	-0.11 (0.29)
Village 1 in NS zone (dummy)	-0.05 (0.16)	0.74 (0.79)	2.81 (0.74) ***	-0.05 (0.28)
Southern Sudanian zone (dummy)	0.58 (0.26) **	2.77 (1.31) **	1.44 (1.23)	0.12 (0.46)
Village 3 in SS zone (dummy)	-0.00 (0.16)	-0.46 (0.82)	-0.42 (0.77)	-0.47 (0.29) *
Northern Guinean zone (dummy)	0.51 (0.14) ***	0.75 (0.70)	1.63 (0.66) **	-0.02 (0.25)
Village 5 in NG zone (dummy)	0.26 (0.17)	-0.80 (0.82)	-0.22 (0.77)	-0.18 (0.29)
Village 7 in SG zone (dummy)	0.56 (0.15) ***	1.01 (0.77)	0.67 (0.72)	-0.04 (0.27)
Constant	-0.67 (0.18) ***	-1.26 (0.91)	-1.69 (0.86) **	0.25 (0.32)
R <sup>2</sup>	0.62	0.16	0.43	0.25

<sup>1)</sup> Four equations are simultaneously estimated by SUR model. Standard errors are in parentheses. \*, \*\*, and \*\*\* indicate that the coefficient is estimated at significance level 10%, 5%, and 1% respectively.

Table 4 Impacts of the Ivorian Crisis on Soil Fertility Management in Burkina Faso <sup>1)</sup>

Impacts	Year 2002	Year 2003	Difference <sup>2)</sup>
Total cropping area (ha)	6.56 (5.50)	6.95 (5.88)	+ **
Input rate of chemical fertilizer (kg/ha)	27.8 (45.6)	30.3 (44.8)	0
Total amount of chemical fertilizer (kg)	200 (363)	241 (417)	+ *
Input rate of organic fertilizer (cart/ha) <sup>3)</sup>	2.21 (7.95)	2.36 (6.97)	0
Total amount of organic fertilizer (cart)	9.86 (16.7)	15.0 (32.2)	+ ***

<sup>1)</sup>The numbers are sample mean values in the cropping season of year 2002 (before the crisis) and in the cropping season of year 2003 (after the crisis) respectively. Standard deviations are in the parentheses.

<sup>2)</sup> Results of paired-sample T-tests are shown. The two means are different at the significance level of 1% (\*\*\*) and 5% (\*\*) respectively.

<sup>3)</sup>Organic fertilizer includes manure and compost. The unit of measurement is cart that carries the organic fertilizer to the field. One cart normally weights about 400 kg.

Table 5 Households' Coping with the Ivorian Shocks <sup>1)</sup>

Explanatory Variables	Change in Total Cropping Area (ha)	Change in Input Rate of Chemical Fertilizer (kg/ha)	Change in Input Rate of Organic Fertilizer (kg/ha)
Shocks at Household Level (endogenous)			
Change in remittance received (10 <sup>5</sup> FCFA)	-1.89 (0.94) **	22.9 (20.8)	-2.26 (1.69)
Change in household size (person)	0.32 (0.19) *	-9.62 (4.15) **	-0.79 (0.34) **
Change in Non-ag. Income (10 <sup>5</sup> FCFA)	0.13 (1.12)	-46.7 (24.7) *	-3.25 (2.00)
Change in livestock value (10 <sup>5</sup> FCFA)	-0.31 (0.18) *	1.35 (3.90)	0.60 (0.32) *
Household Assets in 2002 Dry Season			
Cropping area*rainfall (10 <sup>3</sup> ha*mm)	-0.16 (0.10)	-4.27 (2.19) *	-0.40 (0.18) **
Value of livestock (10 <sup>5</sup> FCFA)	-0.08 (0.13)	0.14 (2.85)	0.44 (0.23) *
Remittance received (10 <sup>5</sup> FCFA)	-0.87 (0.93)	2.45 (20.5)	-3.23 (1.66) *
Non-ag. income (10 <sup>5</sup> FCFA)	0.69 (0.60)	-16.6 (13.3)	-1.54 (1.08)
Household size (person)	0.09 (0.08)	3.01 (1.75) *	0.29 (0.14) **
Constant	0.31 (0.39)	-1.61 (8.64)	0.87 (0.70)
R <sup>2</sup>	0.21	0.004	0.008

<sup>1)</sup> Three equations are simultaneously estimated by three-stage least squares model. Shock variables at household level are assumed to be endogenous, and are instrumented by exogenous explanatory variables shown in Table 3. Standard errors are in parentheses. \*, \*\*, and \*\*\* indicate that the coefficient is estimated at significance level 10%, 5%, and 1% respectively.

Table 6 Households' Coping with the Ivorian Shocks <sup>1)</sup>

Explanatory Variables	Dependent Variables	Total Cropping Area (ha)	Input Rate of Chemical Fertilizer (kg/ha)	Input Rate of Organic Fertilizer (kg/ha)
Shocks at Household Level				
Remittance received (10 <sup>5</sup> FCFA)		-0.71 (0.25) **	0.52 (3.16)	0.01 (0.29)
Household size (person)		-0.04 (0.06)	-0.06 (0.79)	0.04 (0.04)
Livestock value (10 <sup>5</sup> FCFA)		-0.28 (0.06) **	-0.56 (0.80)	0.01 (0.07)
Non-ag. Income (10 <sup>5</sup> FCFA)		-0.34 (0.20) *	-1.91 (2.37)	-0.09 (0.21)
Shocks at Zone Level (dummy for year 2003)				
	Sudanian Zone (north)	0.05 (0.43)	0.31 (5.33)	0.87 (0.51) *
	Sudanian Zone (south)	1.51 (0.45) **	-2.83 (5.64)	-0.35 (0.53)
	Guinean Zone (north)	0.04 (0.38)	23.6 (4.83) ***	1.44 (0.46) ***
	Guinean Zone (south)	0.10 (0.39)	-15.6 (4.90) ***	0.37 (0.47)
Constant		NA	NA	1.61 (0.63) **
P-value of Hausman test (H <sub>0</sub> : random effect)		0.00	0.00	0.92
Model used		fixed effects	fixed effects	random effects
R <sup>2</sup>		0.95	0.85	0.004

<sup>1)</sup> Three equations are separately estimated by either fixed effect model or random effect model depending on the result of Hausman test shown in the table. Zone-level shock variables are made interacted with agro-ecological zone dummies. Standard errors are in parentheses. \*, \*\*, and \*\*\* indicate that the coefficient is estimated at significance level 10%, 5%, and 1% respectively.