A Natural Experiment of Demographic Pressure on Soil Fertility Management: The Case of Rural Burkina Faso

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Objectives

- What will happen when a rapid increase in population takes place in rural areas of developing countries?
- Questions:
  - Can the ecosystem provide people with enough food?
  - Will people have capacity to manage such a situation?
  - In particular, will population pressure induce intensification of agricultural production?
- Empirical data are rarely available.
- A natural experiment:
  - An unexpected civil war in neighboring country caused a massive population inflow in rural area due to returnees.
  - A panel dataset in which this event took place is available.

Study Site

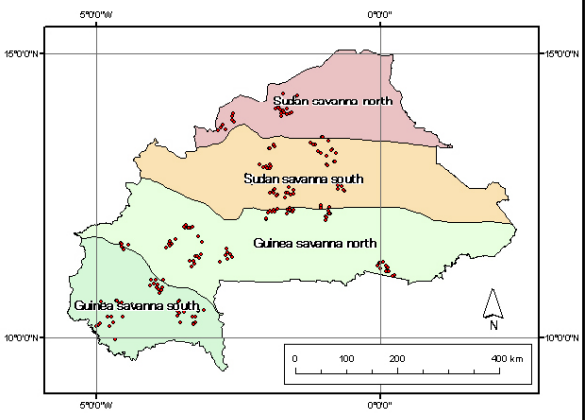
- Burkina Faso
  - Landlocked country on the southern edge of the Sahara desert
  - Soil degradation and desertification are significant
  - Low and unstable agricultural production due to erratic rainfall
  - Migration, either, permanent, long-term, or seasonal, to neighboring Côte d'Ivoire

The Experiment

- **Civil war took place in Côte d'Ivoire in September 2002**
- **Burkinabés living in Côte d'Ivoire were obliged to go back to Burkina Faso**
  - **The number of returnees amounts to 350,000 as of July 2003 according to the Government of Burkina Faso**
- **Due to the war, seasonal migration was suspended**
- **The Ivorian crisis caused shocks in rural Burkina Faso:**
  - **Unexpected increase in population pressure**
  - **Unexpected decrease in income**

Extensive Village Survey

- 13 provinces out of 45 provinces
- Two districts were randomly drawn in each province, and 8 villages were randomly selected in each province
- 208 villages in total
- Survey was conducted by means of group interview in each village
- Satellite image analysis to see the change of area under cultivation



Impact of the Ivorian Crisis Village Level

Impact of the Ivorian Crisis on the Villages in Burkina Faso

	Village Population		% of Households Depending on Remittance		% of Households Depending on Seasonal Migration	
	Before	After (change)	Before	After (change)	Before	After (change)
Whole Sample	1359	1488 (+129)	42.6	5.2 (-37.5)	35.7	6.7 (-28.9)
North Sudaninan	1222	1303 (+81)	54.1	10.9 (-43.2)	43.2	2.1 (-41.1)
South Sudanian	1604	1764 (+160)	44.5	5.3 (-39.2)	26.8	4.0 (-22.8)
North Guinean	1146	1189 (+43)	26.3	0.8 (-25.6)	26.5	8.6 (-17.9)
South Guinean	1383	1607 (+224)	43.8	3.3 (-40.6)	48.6	13.3 (-35.3)

Source: Extensive Village Survey over 208 Villages

Impact of Ivorian Crisis Village Level

Impact of Ivorian Crisis on the Area under Cultivation

	Change of Cultivated Area	
	Average 2001/2002	Average 2003/2004
Whole Sample (N=148)	3.32 (1.24)	3.50 (1.31)
North Sudanian (N=49)	2.74 (0.80)	3.31 (1.11)***
South Sudanian (N=57)	2.92 (0.79)	3.43 (1.24)**
North Guinean (N=35)	4.36 (1.13)	3.80 (1.61)
South Guinean (N=7)	5.43 (2.01)	3.86 (1.49)**

Source: SPOT/VEGETATION. Area under cultivated is indexed from 1 (minimum) to 10 (maximum).

Regression analysis confirms that the returnees and the reduction of remittance received cause the increase of cultivated area.

Detailed Household Survey

- Two villages each from the four agro-ecological zones
- 32 households are randomly selected
- Interviews were carried out three times a year from 1999 to 2004 to construct a panel dataset
- This study uses data in 2002 (before the crisis) and in 2003 (after the crisis) to see the impact of the crisis

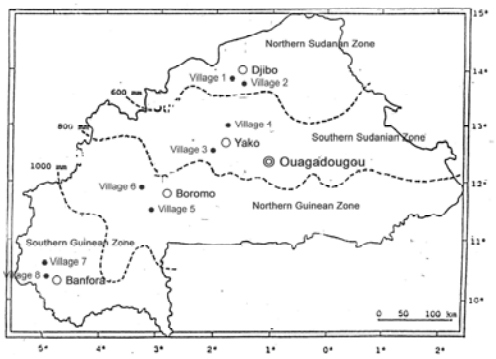


Figure 2 Study Site

Analytical Framework

- Ivorian crisis
  - Exogenous to all
  - Covariate shock
- Household level shock
  - Depending on household, village, regional characteristics
  - Covariate, but its impact is endogenous
- First, determinants of the endogenous shocks at household level
- Second, effect of the endogenous shocks on household farming practice that may cause soil degradation and desertification

Econometric Specification

$\Delta Ai = F(\Delta Si, \Delta Ti, \Delta Ni, \Delta Li, \mathbf{W}i, \mathbf{X}i, \mathbf{V})$ (1)

$\Delta Ci = G(\Delta Si, \Delta Ti, \Delta Ni, \Delta Li, \mathbf{W}i, \mathbf{X}i, \mathbf{V})$ (2)

$\Delta Mi = H(\Delta Si, \Delta Ti, \Delta Ni, \Delta Li, \mathbf{W}i, \mathbf{X}i, \mathbf{V})$ (3)

Δ: difference between 2002 and 2003
i : household

Variables about soil fertility management

A: total cropping area per household
C: amount of chemical fertilizer per hectare
M: amount of organic fertilizer per hectare

Household level shocks

S: household size
T: amount of remittance received
N: amount of non-agricultural income
L: value of livestock holdings

Exogenous variables

W: household assets in 2002
X : time-invariant household characteristics
V : village and regional characteristics

Estimation

Three-stage least squares (endogenous variables are instrumented)

Shocks at Household Level

Table 1-1

	Transfer Received (10^3 FCFA)			Household Size		
Year	2002	2003	t-test	2002	2003	t-test
Mean[1)]	67.6	53.7	**	10.9	11.3	**
(SD)	(85.2)	(69.2)		(8.39)	(8.74)	

Table 1-2

	Livestock Value (10^3 FCFA)			Non-ag. Income (10^3 FCFA)		
Year	2002	2003	t-test	2002	2003	t-test
Mean[1)]	242	228		38.3	36.5	
(SD)	(377)	(342)		(78.1)	(105)	

1. Transfer receiving reduced significantly

2. Household size increased significantly

Household level shocks are confirmed

Determinants of Household Level Shocks

Determinants of household level shocks

Dependent / Explanatory Variables	Δ HH Size	Δ Transfer Received
Household Assets before the Crisis		
Agri Production (10^3 ha*mm)[2)]	-0.05 (0.09)	0.05 (0.02) ***
Household Size	-0.04 (0.04)	0.01 (0.01)
Transfer Received (10^5 FCFA)	-0.39 (0.29)	-0.84 (0.06) ***
Livestock Value (10^5 FCFA)	0.02 (0.07)	0.04 (0.02) **
Non-agri Income (10^5 FCFA)	0.22 (0.30)	-0.12 (0.06) *
Household Characteristics		
Fulani Ethnic (dummy)	-0.86 (0.89)	-0.19 (0.18)
Mosi Ethnic (dummy)	-0.14 (1.15)	0.04 (0.23)
Litaracy of HH Head (dummy)	0.81 (0.60)	0.31 (0.12) **
Age of HH Head (10^2)	1.93 (1.46)	0.27 (0.29)
Use of Animal Traction (dummy)	1.08 (0.51) **	-0.10 (0.10)
Village Characteristics		
North Sudanian (dummy)	0.09 (0.87)	0.67 (0.17) ***
Village 1 (dummy)	0.74 (0.83)	-0.05 (0.17)
South Sudanian (dummy)	2.77 (1.38) **	0.58 (0.28) **
Village 3 (dummy)	-0.46 (0.85)	-0.00 (0.17)
North Guinean (dummy)	0.75 (0.73)	0.51 (0.15) ***
Village 5 (dummy)	-0.80 (0.86)	0.26 (0.17)
South Guinean V7 (dummy)	1.01 (0.80)	0.56 (0.16) ***
Constant	-1.26 (0.96)	-0.67 (0.19) ***
R^2	0.16	0.62

1) OLS is used for each equation. Standard errors are in parentheses. ***, **, and * mean significance levels 1%, 5%, and 10% respectively.

Determinants of Household Level Shocks

- Household Size
  - –Significant increase in South Sudanian zone
  - –Few other variables explain the change of household size

Impact of the Shock on Agricultural Technologies

Table 3-1

	Cultivated Area (ha)			Application Rate of Chemical Fertilizer (kg/ha)			Total Amount of Chemical Fertilizer (kg)		
Year	2002	2003		2002	2003		2002	2003	
Mean (SD)	6.56 (5.50)	6.95 (5.88)	**	27.8 (45.6)	30.3 (44.8)	0	200 (363)	241 (417)	*

Table 3-2

	Application Rate of Manure/Compost (cart/ha)			Total Amount of Manure/Compost (cart)		
Year	2002	2003		2002	2003	
Mean (SD)	2.21 (7.95)	2.36 (6.97)	0	9.86 (16.7)	15.0 (32.2)	***

1. Household increased area under cultivation
2. Total amount of chemical fertilizer increased
3. Total amount of manure increased

Household Coping with Shock

Household's Coping with Shocks Induced by the Ivorian Crisis (3SLS Model)

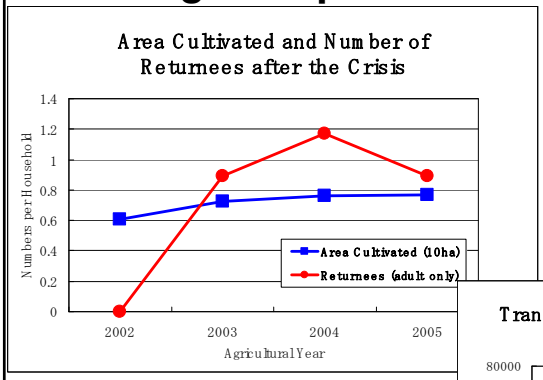
Dependent / Explanatory Variables	Δ Area Cultivated (ha)	Δ Chemical Fertilizer (kg/ha)	Δ Manure/Compost (cart/ha)
Household-Level Shock (Endo.)			
Δ Household Size	0.32 (0.19) *	-9.62 (4.15) **	-0.79 (0.34) **
Δ Transfer Rreceived (10^5 FCFA)	-1.89 (0.94) **	22.9 (20.8)	-2.26 (1.69)
Δ Livestock Value (10^5 FCFA)	-0.31 (0.18) *	1.35 (3.90)	0.60 (0.32) *
Δ Non-agri. Income (10^5 FCFA)	0.13 (1.12)	-46.7 (24.7) *	-3.25 (2.00)
Household's Asset before the Crisis			
Agri Production (10^3 ha*mm)	-0.16 (0.10)	-4.27 (2.19) *	-0.40 (0.18) **
Household Size	0.09 (0.08)	3.01 (1.75) *	0.29 (0.14) **
Transfer Received (10^5 FCFA)	-0.87 (0.93)	2.45 (20.5)	-3.23 (1.66) *
Livestock Value (10^5 FCFA)	-0.08 (0.13)	0.15 (2.85)	0.44 (0.23) *
Non-agri. Income (10^5 FCFA)	0.59 (0.60)	-16.6 (13.3)	-1.54 (1.08)
Constant	0.31 (0.39)	-1.61 (8.64)	0.87 (0.70)
R^2	0.21	0.004	0.008

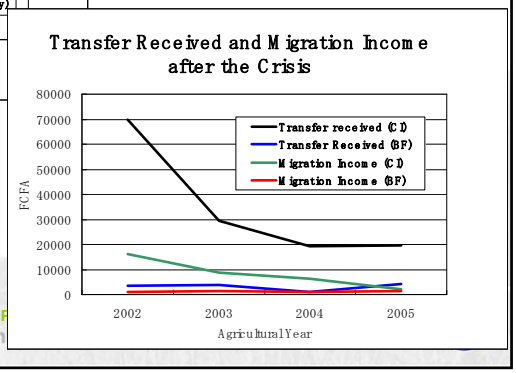
3SLS is used for estimation. Standard errors are in parentheses.

Household's Coping with the Ivorian Shock

- Increase of household size
  - Area cultivated: + 0.32 ha / one person
  - Chemical fertilizer: - 9.62 kg/ha / one person
  - Manure/compost: - 0.79 cart/ha /one person
- Reduction of transfer received
  - Area cultivated: + 1.91 ha / 100,000 FCFA

Prolonged Impact in South Sudanian Zone





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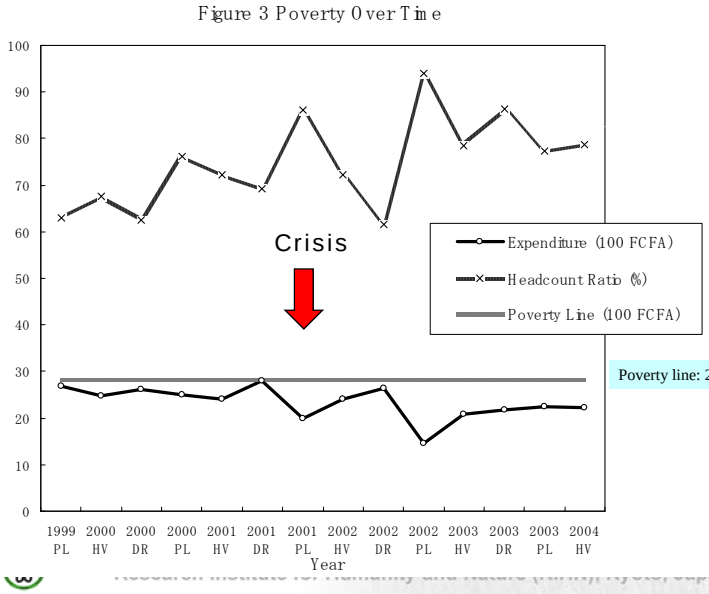
Prolonged Impact in South Sudanian Zone



Poverty line: 2832 FCFA

Conclusions

- Agricultural households in Burkina Faso cope with a population shock by expanding area cultivated and reducing the rate of fertilizer application.
- Income shock has also a significant impact on area expansion, rather than inducing intensification.
- Informal household coping mechanisms seem to be insufficient, and may cause soil degradation/desertification.
- External shock relief is required in such cases.

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Thank you