CAPRi WORKING PAPER NO. 27

COOPERATION, COLLECTIVE ACTION AND NATURAL RESOURCES MANAGEMENT IN BURKINA FASO: A METHODOLOGICAL NOTE

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DECEMBER 2002

ACKNOWLEDGMENTS

Research was funded by the System-Wide Program on Collective Action and Property Rights (CAPRi), and team members would like to thank Ruth Meinzen-Dick and Monica Di Gregorio for intellectual as well as financial support. Additional funding was received from an ILRI Ford Foundation grant. The authors would also like to thank Hermann Grell for his generous support of the fieldwork, for critical insights and comments on the research. The authors would also like to thank participants for very helpful comments received at the CAPRi-sponsored workshop on Methodologies for the Study of Collective Action, held in Nyeri, Kenya, February, 2002. Finally, the authors would like to thank Frank Place and Samuel Benin for reviewing the paper and providing excellent commentary and suggested revisions.

This paper has also been released also as LPAPWP53 by the International Livestock Research Institute, Nairobi, Kenya.

ABSTRACT

This paper presents a detailed description of the applied methodology used to study collective action in natural resource management (NRM). Data were collected in 48 villages in northeastern Burkina Faso, at the community, institutional, household and market levels. The paper first discusses the analytical framework underlying the study of collective action, and then describes in detail the methods used to measure collective action and community-level cooperative capacity, and the determinants of cooperative capacity. We also describe data collection methods as well as potential problems in eliciting unbiased information. The impact of cooperative capacity on a variety of outcomes observed at both the community and household level is then presented in order to highlight practical applications.

Keywords: collective action; natural resource management; Burkina Faso; cooperation; social capital; rangelands

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1. INTRODUCTION

This paper provides a synthesis of a research project undertaken in northeastern Burkina Faso, which focused on collective action in natural resource management (NRM). Results presented below are based on a survey undertaken in 48 villages in two Sahelian Provinces: Oudalan and Séno (map shown in Appendix 2) during the end of the rainy season, 2000 (Drabo and Dutilly-Diane 2001).

While there has been much discussion of the factors affecting the success of collective action, little has been done to consider the practical application of these concepts in empirical settings. One difficulty is in defining certain terms such as "social capital", and after agreeing on a definition for the term, in determining what observable indicators actually measure social capital (Bardhan 1993 and 2001; Grootaert et al. 1999). Even when there is agreement on certain concepts and their measurement, the impact on cooperation is often disputed. Though competing arguments have been put forth by nearly everyone writing on "successful" cooperation and collective action at the local level, we can use the case studies collected in Berkes & Folke (1998) to illustrate the wide range of variables over which there is disagreement about the impact on

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cooperation: 1) Size of the Group: Groups should be small – to decrease transactions and communications costs and because small is generally associated with homogeneous groups (Gadgil et al. 1998; Sporrong 1998; Hanna 1998; Alcorn & Toledo 1998; Jodha 1998), but groups cannot be too small or they won't be able to cover the costs of cooperation (Hanna), 2) Profitability: Prices, or relative profitability, should be high enough to make collective action profitable (Chpts. Begossi 1998; Warren & Pinkston 1998; Hanna 1998), but not too high so as to induce over-exploitation of the resource (Gadgil et al.1998; Berkes 1998; Jodha 1998), 3) Isolation: Systems should be relatively isolated, so as to reduce outside pressure on traditional authorities and to enable the community to effectively exclude "outsiders" (Sporrong 1998; Hanna 1998; Alcorn & Toleda 1998; Jodha 1998), but not too isolated because this may mean very thin markets and returns may be too low to cover costs of cooperation (Hanna), because (regulated) contact with the outside may introduce valuable new technologies and/or practices (Warren & Pinkston), and because exposure to (but not domination by) outside cultures increases cultural capital and promotes flexible institutions (Begossi 1998); and 4) Strong Social Cohesion: Strong kinship-based relationships or belief in supernatural forces is essential for promoting and enforcing collective action and group cooperation in the management of resources (Sporrong 1998; Berkes 1998; Warren & Pinkston 1998; Alcorn & Toledo 1998); but too much reliance on community ties or the supernatural may lead to collapse of effective mechanisms for controlling resource use when these are challenged and where the explicit link between the social norm and sustainable practices is not clear (Gadgil et al. 1998), or may promote cultural and institutional inertia in the face of fluctuating circumstances (Begossi 1998).

Given the messy state of affairs in the broader literature, in this paper we consider a particular study of 48 villages located in northeastern Burkina Faso, and detail how we conceptualized, measured and applied different measures of cooperative capacity, how these measures relate to explanatory factors hypothesized to affect cooperation, and finally, the impact of these indicators on a variety of outcomes observed at both the community and household level. In the conclusion, we consider how results from this study can be used to more clearly identify the expected impacts of explanatory variables on NRM outcomes, and the indirect impact of these variables on NRM via an impact on cooperation itself.

The paper is organized as follows. In the next section, we provide a brief overview of the current situation in northeastern Burkina Faso. In section 3, we present an overview of the underlying theoretical framework motivating the development of indicators of cooperative capacity, the variables that affect this capacity, and in turn, how this capacity affects NRM outcomes. We then consider practical problems regarding the survey instruments and data collection in section 4. In section 5, we develop measures of cooperative capacity, and in section 6, we examine the determinants of cooperative capacity. Results of a number of analyses using cooperative capacity as an explanatory variable in community-level decisions on land use and management and conflicts, household income patterns, and household decisions to engage in collective action are presented in section 7. Concluding comments are given in section 8.

2. OVERVIEW OF THE SITUATION IN NORTHEASTERN BURKINA FASO

Burkina Faso is an agro-pastoral Sahelian country, where livestock production has always been an important component of agricultural activity. In the drier northern regions, livestock production is based on extensive and semi-extensive systems where access to common grazing lands and transhumance is heavily relied upon to provide forage resources. In such systems, there is wide scope for collective action and cooperation to influence land use and allocation patterns, resource management, investments and maintenance of community resources, and household income and well being. For instance, stock densities on community pastures determine the productivity of land in animal production, and to the extent that productivity falls due to over-stocking, there will be pressure to change land allocation in favor of private crop activities. The extent to which community members migrate to non-community pastures thereby relieving pressure on home resources also affects productivity of land in pasture, and will also have an indirect impact on land allocation decisions at the community level. Clearly, herd mobility and activities such as manure contracting between farmers with few animals and transhumant pastoralists require coordination at the supra-household level. Finally, decisions on community-level investments (e.g. water point construction and maintenance, agro-forestry investments, bush clearing, soil erosion control measures), and the effectiveness with which these decisions are implemented will have a direct impact on both short-term profitability and long-term sustainability of alternative production activities.

Within the household economy, undertaking a range of crop and livestock activities enables the household to exploit different agro-ecological niches and to

diversify food and cash income sources. Yet, despite the many benefits of integrated crop-livestock production in these environments and despite the fact that many households engage in both livestock and crop activities, there remain contentious issues over land use and land allocation patterns and the appropriate institutions for managing natural resources – sometimes leading to violent conflict. Furthermore, increased population pressure and sedentarization of the pastoral population are thought to contribute to increased pressure on the natural resource base. It is also hypothesized that current government land policy and the indeterminacy of the government's role in land tenure has made it difficult for community members to create new institutional forms for managing resources (Ouedraogo 1993 and 2001).

Nonetheless, households increasingly have greater incentives to actively manage their natural resources, even when this must be done in conjunction with all community members, or, in the case of mobility, with members from neighboring or far distant communities. In all communities in the study region, at least some part of community land is common pasture. Community waterpoints require maintenance, and sometimes use rules, in order to satisfy both human and livestock needs. Trees are often planted in common pastures to provide shade for animals and as a mean of soil erosion control. There are a number of other soil erosion control techniques observed in the communities (e.g. stone bunds). Though these are usually constructed on individual cropland, labor is collectively provided and there are also spillover benefits to the community as a whole in terms of reduced soil erosion.

We hypothesize that the success of collective action will be a function of individuals' incentives to contribute to maintenance and abide by rules and regulations,

the capacity of the community as a whole to cooperate and to manage these incentives, and the overall policy environment in which these institutions must operate. Our focus in this paper is on a community's capacity to cooperate, developing indicators of this capacity, identifying determinants of capacity, and then using these indicators to examine the impact of cooperative capacity on a variety of outcomes at both the household and community levels.

3. THEORETICAL OVERVIEW

Before starting, we define a few terms that we employ in the remainder of the paper: collective action in NRM, cooperation, externalities, capacity to cooperate, indicators of collective action, and determinants of collective action.

For the purpose of this paper, we define collective action in NRM as the act of internalizing negative externalities and/or the generation of positive externalities in the use and management of natural resources. Externalities occur whenever one person's decisions affect outcomes for another person. The traditional example is that of livestock on common pasture; the number of livestock one person puts on the pasture affects his/her own production and also affects livestock production of all others sharing the commons as well. In this case, use of the common pasture generates a negative externality. An example of a positive externality is given by soil erosion control measures, which improve soil productivity in the specific area in which such measures are employed but also generate positive externalities via improved erosion control over a much wider area. In this context, cooperation is identical to collective action and we use the terms synonymously in this paper.

The capacity of the community to cooperate is the underlying ability of the community to create formal and informal frameworks to achieve goals of collective action, no matter what those goals are. This is an important distinction, since many previous analyses have conflated the underlying capacity to undertake any activity with the particular characteristics and incentives to undertake a specific activity. Certain variables may affect both the capacity to cooperate in general, as well as the incentives to undertake a particular action. The number of members provides an example of a variable that is likely to affect both the capacity to cooperate in general and individual incentives to undertake many activities in particular. For instance, the number of members is hypothesized to have an inverted-U shaped impact on cooperative capacity. Starting with few members, fixed costs of cooperation per member are at their highest, and decrease as the number of members increases, which fosters cooperation. Eventually, however, these lower fixed costs per member will be offset by increasing variable costs of cooperation, which increase because of the time needed to coordinate activities, negotiate decisions, agree on procedures for implementation, and monitor and enforce rules. At the same time, consider the effect of an increase in members on the individual incentives to undertake specific natural resource management activities. Greater membership increases the individual incentives to overexploit a common-pool resource. Individual incentives to under-provide labor for maintaining water points may also increase as the number of members increases. On the other hand, more members may increase individual incentives to provide certain types of public goods, especially those subject to increasing returns to scale, those that require a lump-sum investment, or those that benefit from

network externalities. This is but one example; in this paper, we attempt to highlight the impact of various factors on cooperative capacity specifically.

The major focus of the empirical analysis below is to recover the underlying capacity to cooperate at the community level, which is not directly observable and is rather a latent variable. For this purpose, we use a factor analysis of variables thought to be associated with cooperative capacity, in order to recover our main latent variable (Penning and Leuthold, 2000). Given our particular dataset, indicators of collective action are drawn from two main categories: networks and organizational performance. Network indicators include the density of organizations and density of household participation; organizational performance indicators include number of rules, regulations, activities, and effective participation by members in activities and at meetings. Determinants of cooperative capacity are those variables hypothesized to directly affect the capacity of a community to make and enforce collective action decisions; we defer a discussion of the these specific determinants to section 6.

At this point, it may be useful to consider a term that we will not be using, social capital. The term "social capital" has recently become a popular term to describe a type of stock of goodwill amongst community members; trust is often considered one of the key aspects of social capital (Seabright 1994; Dasgupta & Serageldin 2001). To date, most analyses have considered the impact of "social capital" on private, or individual, welfare. For instance, social capital may facilitate reciprocal insurance arrangements thereby decreasing household or individual risk, or it may be used to facilitate access to credit or information leading to increased productivity and better marketing opportunities (Maluccio et al. 1999; Fafchamps 2000; Geran 2001). Fewer analyses attempt to

measure the impact of "social capital" on cooperation at the community level, though c.f. Krishna (2001).

Nonetheless, many scholars, particularly economists, find the term "social capital" confusing or simply misleading, since it seems natural to try and relate the concept of social capital to other forms of capital with which economists are intimately familiar (c.f. chapters by Arrow and Stiglitz in Dasgupta and Seregeldin 2000). In the final chapter of the Dasgupta and Seregeldin book, Dasgupta argues that "social capital" may in fact be better described as a factor that determines, in part, total factor productivity. In other words, "social capital" factors enable the more traditional capital variables to be combined more efficiently. Structures or processes that improve organizational efficiency have long been considered factors that improve total factor productivity, as distinct from the stocks of capital combined to produce an output – it is the "how" and not the "what" of production. Ford's production line is an example of "how"; more output could be produced from the same stock of labor and physical capital. The increase was due to the way in which factors were combined that lead to an increase in total factor productivity. In the same vein, if my neighbor and I were making individual decisions regarding how many animals to put on a piece of land that we both shared, and we were overstocking in the sense that both of us could be made better off if we decided on the optimal number for both of us together, then a change in the institutional framework as to "how" we arrived at a decision – from individual to joint maximization -- seems naturally to be a change in "how", which in turn increases the returns to the stocks of capital, land, and labor that we both own. Though this may seem

an overly pedantic concern, in the remainder of the paper, we eschew the use of the term "social capital" and instead use cooperative capacity.

4. SURVEY INSTRUMENTS AND DATA COLLECTION

This study is based on a survey administered in 48 communities of four administrative regions (Gorgadji, Dori, Gorom and Bani) of the provinces of Séno and Oudalan during the end of rainy season (August - October) of the year 2000. The study was undertaken in collaboration with the Programme Sahel Burkinabe (PSB) supported by GTZ, and one of the objectives of the research was to measure the impact of the various projects and programs on natural resource management and household livelihood strategies. Thus, communities were stratified into four categories on the basis of the length of participation in various PSB/GTZ programs, as follows: villages working with GTZ before 1996 (13), villages that entered the program between 1996 and 1999 (12), new GTZ's villages (9) and a group of control villages which have never worked with GTZ (14).

Table 1--Village sampling

	Gorgadji	Dori O.	Gorom	Bani	**Total**
Before 96	7	4	2	-	**13**
After 96	-	6	6	-	**12**
New	-	-	4	5	**9**
Control	-	-	7	7	**14**
Total	**7**	**10**	**19**	**12**	**48**

4.1. DATA

Data were collected in 48 communities located in northeastern Burkina Faso, in the two provinces of Ouadalan and Seno; a map of the region is found in Appendix 2. At the household level, information was gathered from the head of household with the primary aim of capturing individual incentives to access and use community-level

resources and households' participation in collective action. Data were also collected on the institutions and more formal organizations that dealt with NRM. Such organizations and institutions operated at various levels. Some were village-level, others pertained only to a sub-group of community members (i.e. operated at the level of quarters within a village, or included only members with a shared interest/economic objective), and others operated at the supra-village level (i.e. unions of various types of organizations). Very basic information was also collected on additional projects and organizations that did not deal with NRM issues. Extensive information was also collected on the community as a whole, including basic demographic information, structure and mobility of all livestock herds in the community, infrastructure, and detailed information on land allocation and resource mapping using aerial photographs as a base. Finally, data were collected at six markets identified as being important for livestock transactions for surveyed communities. A fuller description of the survey instruments and comments on some of the problems encountered during fieldwork are discussed in the remainder of this section.

4.2. SURVEY INSTRUMENTS

Household Surveys: The first task was to define the household. Because livestock is the primary income generating activity in this region and because we were interested particularly in the use and management of common pastures and herd mobility, we defined a household as comprised by all individuals whose livestock income depends on the same herd. A total of 401 household heads were interviewed; or, about 8.5 households per community on average, with a minimum of 7 households and a maximum of 19 per community. The main sections of the survey were: household demographic characteristics (composition, age, education), crop and animal production, annual income

by source (agriculture, off-farm local, migrant remittances), and household members' participation in community-based organizations and natural resource management activities.

Institutional Questionnaire: This questionnaire was administered collectively to the village leader, representatives of the major NRM institutions and other key informants. Three broad types of data were collected. First, a census was taken of all institutions (e.g. the chief) and organizations in charge of any aspect of NRM, and detailed information was recorded regarding the structure of management, how the organization was created and who/what group began the organization, the number of members, frequency of meetings and attendance at those meetings, etc. This section was followed by an enumeration of all activities related to NRM in the community with detailed information on the activities, the institution or organizations responsible, methods of monitoring and enforcing participation, and actual participation rates. This part of the survey was structured to gather information by resource: common pastures, water sources, soil, and tree resources. Information gathered by activity and resource could then be cross-referenced with the institutional data gathered in the first section, and by data collected at the household level. The final section of the survey gathered information on rules and regulations, following a similar format to that for the activities section.

Because the institutional questionnaire had many open-ended and quasi open-ended questions, some of the data recording suffered from enumerator bias. While certain "prompts" were used – enumerators asked about different rules by resource and sometimes by season, for instance – there still remained much leeway for the individual

enumerator to structure discussions with participants. Three enumerators, all with experience in both structured and open-ended survey techniques were trained, and they worked together with project members to refine the structure of the questionnaire through a series of pre-testing and refinement exercises. Nonetheless, it is a fact that more open-ended techniques are more likely to suffer from enumerator bias, and this problem should be directly addressed when structuring the questionnaire and training. Methods of triangulation have been employed by other researchers to limit the potential for collecting biased or skewed information introduced by interviewing a small number of non-randomly sampled key informants, but it should be emphasized that triangulation measures will not mitigate bias introduced by the enumerator him/herself. In general, then, we feel that enumerator bias in open-ended data gathering formats has been glossed over. As an example from our particular case, one enumerator had had recent experience working with an NGO on implementation of water point maintenance project. This enumerator tended to engage his interviewees in much more in-depth discussions of water and recordings of activities, participation, etc., and recorded information was significantly different from that collected by the other two enumerators. On the other hand, there was no statistical difference in any of the purely quantitative measures gathered by these same enumerators. Because the information on water management was so different between enumerators, much of these data were simply lost. In other cases where bias was less extreme, we constructed “inflation coefficients” based on the enumerator average vs. the sample average for biased variables, and constructed “corrected” variable estimates by multiplying actual recorded values by the inflation coefficient.

Community-Level Questionnaire and Resource Mapping Exercise: Data on the main characteristics of the community was collected, such as basic demographic data (number of households by ethnicity, number of female-headed households, number of quarters within the village, etc.), resources shared with other communities, herd demography and mobility, community infrastructure, and identification of major markets used by community members. Though difficult and somewhat time consuming, collection of data on large and small ruminants was largely accomplished by considering the number of cattle, goats and sheep of each individual household, usually counted by quarter in the larger villages. Information on herd mobility, following a 12-month calendar, was also elicited in this manner. In addition, aerial photographs were used to construct resource maps for each community, and to identify community boundaries – including identification of areas over which resources were shared with other communities. Boundary coordinates were also obtained with GPS units (Garmin). Resource maps included information on land use and soil types, key resources such as waterpoints and sand dunes, and the location of the village, hamlets and roads.

Market Questionnaire*:* Data on prices for 3-5 year old male bovines, cereals and dairy products were collected in six markets during three separate months during the year, August, 2000, November, 2000, and March, 2001. Of the six markets, three were major markets (Djibo, Gorom, Dori), and three were minor markets (Bombofa, Markoye, Gorgadji).

5. MEASURING THE CAPACITY TO COOPERATE

5.1 AGGREGATING INFORMATION AT THE VILLAGE LEVEL

As noted above, one of the primary reasons for collecting detailed data on NRM institutions and organizations was to be able to capture the underlying capacity of a community to cooperate. We hypothesize that certain communities will be able to organize more efficiently to achieve community-level goals – irrespective of what those goals might be – and we use a factor analysis of the characteristics of formal NRM organizations to recover this latent capacity to cooperate. For the factor analysis, information on the wide-rage of institutions and more formal organizations in each community is aggregated to create variables at the community level. A detailed description of the construction of aggregated variables and the results of the factor analysis are first presented, followed by an econometric analysis of the determinants of the constructed factors.

5.2 CHOICE OF VARIABLES

There are two sets of variables often considered to affect a group's capacity to cooperate; the degree of trust amongst members and network capacity. Unfortunately, no proxies of "trust" were obtained. The density of organizations and the participation rates by households in these organizations are used to proxy network capacity; these variables reflect the capacity to share information and facilitate the transformation of information into knowledge and action. We also consider a third set of characteristics, hereafter referred to as "organizational" achievements, which includes such variables as frequency of and attendance at meetings, the number of rules and regulations devised and activities

undertaken, and whether or not labor contributions are made. We recognize that the organizational achievements of any one organization will be influenced by other factors specific to the final goals of that organization. Nonetheless, we posit that the aggregation of these intermediate performance indicators across community-level institutions reflects community's latent, unobservable, capacity to cooperate.

More specifically, the variables used in the factor analysis to recover cooperative capacity are as follows:

- NRM Network: Number of NRM institutions/organizations per household
- NRM Membership: Percent of households that are members of NRM institution/organizations, averaged over all NRM institutions, multiplied by the number of these organizations
- Non-NRM Network: Number of non-NRM institutions/organizations per household (i.e.. women's groups)
- Non-NRM Membership: Average percent of household members of non-NRM organizations, multiplied by the number of these organizations.
- Meetings: Number of meetings held per year, averaged over all NRM organizations
- Rules: Total number of rules observed for all NRM organizations
- Activities: Total number of activities observed for all NRM organizations
- Average Meetings Participation Rate: We asked how many households "usually" attended meetings; this number was used to create the percent of households attending meetings for each institution, and a variable was constructed of the average of this percent across organizations.

- Average Activities Participation Rate: As with the meetings variable, the percent of households "usually" participating was constructed, and an average was taken across organizations.
- Average number of workdays allocated to collective activities, per member

5.3. AGGREGATING INDICATORS OF COLLECTIVE ACTION

As a first step, we note that if these variables do indeed give information on an underlying capacity to cooperate, they should be significantly correlated. Table 2 presents the correlation matrix and indicates whether the variables are correlated at the 85% level of significance.

Table 2--Correlation matrix between 10 indicators of CA.

	A	B	C	D	E	F	G	H	I	J
A										
B	+									
C	+	+								
D	+	+	+							
E										
F		+	+							
G		+		-						
H	+									
I	+	+			+		+			
J						+		+	+	

A – Network NRM
B – Membership in NRM
C – Network non-NRM
D – Membership non-NRM
E - # meetings
F - # rules
G - # activities
H – Participation rate in meetings
I – Participation rate in activities
J - # days worked

The correlation matrix shows that many of variables are positively and significantly correlated, with the exception of the number of activities and membership in non-NRM organizations. The relatively strong correlations among these variables is

captured in the factor analysis. Results of a principal component factor analysis for the first two factors, which had eigenvalues greater than one, are presented below.

	First Factor	Second Factor
Eigenvalue:	1.39	1.02
Cumulative:	.50	.79

Table 3--Scoring coefficients for first two factors

Variables	INC	ICC
Network NRM	**0.241**	-0.065
Membership NRM	**0.355**	0.087
Network others	**0.300**	**-0.291**
Membership others	**0.168**	**-0.175**
# Meetings	0.032	0.071
# Activities	0.058	**0.207**
# Rules	-0.013	**0.101**
Participation in meetings	0.028	0.091
Participation in work	**0.132**	**0.422**
# Days of work	0.087	**0.223**

To highlight scoring coefficients with strong loadings, we have put those with coefficients greater than |.1| in bold. Looking at the first factor in table 3, we note that the scoring coefficients are relatively high and positive for the network and membership variables and to a lesser extent on percent of members who actually contribute labor, but coefficients are relatively low for number and participation in meetings, activities, rules and the total number of days worked. Given these scoring coefficients, we hereafter refer to this factor as the indicator of network capacity (INC).

In contrast, scoring coefficients for the second factor are strong and positive for most of the variables measuring active participation – number of rules, number of activities, participation in activities and the number of days worked – with the exception of participation in meetings. The coefficients for density and number of meetings for non-NRM organizations are actually negative. Given the heavier weight on variables associated with making and implementing decisions, we hereafter refer to this factor as the indicator of implementation capacity (IIC).

6. ANALYSIS OF DETERMINANTS OF COOPERATIVE CAPACITY

In this section, we examine the determinants of the estimated indices of cooperative capacity. This is done to test whether the explanatory factors are consistent with theory, though as noted in the following discussion, there remains wide disagreement on the theoretical impact of many variables on cooperative capacity. Total number of households and the square of households are included to test the hypothesis that cooperation is more difficult both with few households, because of fixed costs, and with many households, because of increased variable costs of communication and monitoring (Olson 1965; Ostrom 1990; de Janvry et al. 1998). The impact of heterogeneity is still a source of contention in the wider literature. Here, we include two measures of heterogeneity: i) social heterogeneity, proxied by the number of quarters within a village and the number of ethnic groups, and ii) an indicator of cattle ownership heterogeneity[4]. Social heterogeneity is almost always hypothesized to have a negative affect on cooperation, because different social norms may make creating and enforcing

[4] Heterogeneity in cattle ownership is a simple variance measure of livestock holdings, using just three data points on the minimum, maximum and average herd sizes observed in the community.

decisions more costly. On the other hand, at least some researchers posit that socio-cultural homogeneity may lead to a stagnation of ideas and may foster institutional inertia, thereby leading to lower overall institutional capacity vis-à-vis communities with greater socio-cultural diversity (Begossi 1998). There is also wide disagreement on the impact of heterogeneity in wealth. On the one hand, wealth heterogeneity may make finding agreements that are mutually beneficial to all more difficult. On the other hand, a subset of members may now find it in their best interest to undertake certain activities (Olson 1965; Baland and Platteau 1997), or wealthier members may find it in their interest to assume leadership and benefactor roles within a community (Wade 1987). The theoretical impact of this variable is thus ambiguous. Exit options, proxied by the percentage of households with at least one member engaged in migration for wage work is expected to reduce cooperative capacity, since it weakens social cohesion and may make it more difficult to make and enforce collective decisions (Bhardan 1993). Income variability, i.e. fluctuations in both crop and animal yields due to rainfall variability, is hypothesized to increase cooperative capacity, since it is hypothesized to increase the relative value of cooperative agreements, particular where these can also serve as mutual insurance (Poteete 2001; McCarthy 1999). Alternatively, high variability may reduce cooperative capacity to the extent that it obscures the link between cooperation and improvements in natural resources and diminishes the capacity of a group to engage in learning by doing (Berkes 1998). To proxy for environmental variability, we collected information on both rainfall and natural divisible vegetation indices (NDVI) corresponding to each community. There is rather strong negative correlation between variability and average rainfall or NDVI; therefore it is difficult to separate out the impact

of rainfall vs. the impact of variability. We mainly use the coefficient of variation of rainfall, with the recognition that this variable is higher in areas with low rainfall but high rainfall variability.

The extent to which community resources are shared with either neighboring communities or with transhumant herders may also reduce cooperative capacity by making communication and enforcement more costly. Education in general is hypothesized to favor cooperative capacity by increasing individuals' capacity to acquire information and transform such information into knowledge. Distance to the regional capital may also have an ambiguous impact on the capacity to cooperate. On the one hand, the greater the distance, the less likely that the activities of non-community government officials will interfere with the authority and activities of local organizations. On the other hand, distance to the capital may reflect higher costs of learning about other instances of collective action in the region and reduced spillover benefits from examples of other successful interventions, thereby leading to lower cooperative capacity.

We also consider a set of variables capturing the structure of the organizations in the community. Roughly following the structure, conduct and performance literature, we are hypothesizing that the structure of organizations can either enhance or diminish cooperative capacity. We are proposing that more participatory forms of decision making mean that more decisions will be made, monitored and enforced. Using information on the proportion of organizations in which the chief has the sole responsibility for making rules, for monitoring members' abidance by the rules, and for enforcing the rules, we created a variable called "chief dominant", which is a sum of average of these three proportions. We also include the proportion of

organizations/institutions where the chief plus others, e.g. members of an executive committee, make the rules together (collective rule-making), and finally the proportion of organizations where the rules are made by an executive committee or elected (or nominated) president, but without any involvement of the chief (members-only rule-making).

Finally, we take into account the presence of external programs/projects (mainly international NGO's) and the duration of these programs, to test the effect on cooperative capacity. We have divided the number of programs in existence since before 1986 with those beginning sometime during 1987-1993, and those beginning after 1993. As noted above, the study was undertaken in conjunction with PSB/GTZ, and the coordinator of PSB/GTZ delineated three distinct conceptual frameworks guiding project implementation, and noted that the change in frameworks leading to a change in development paradigms affected many projects in the region (Grell, personal communication). In general, most programs/projects beginning before 1986 had an overwhelming focus on technical solutions to crop production and NRM, whereas those beginning during the period 1987-1993 largely adopted the "terroir" approach, with a focus on specific resources within given boundaries. Many projects/programs beginning after 1993 expanded on the "terroir" approach to consider the system as a whole, including community members' use of non-community resources and vice-versa.

Regression results are summarized in Table 4 below, full statistical results are presented in Appendix 1 Table A1.

Table 4--The determinants of collective action

	INC	IIC
Demographic/Agro-Ecological		
Size community	---	
Size community sq.	++	
# Quarters	++	
Heterogeneity in cattle holding	++	
# Ethnic groups		+
% Adults migrating	++	--
% Households with public education	+	++
Rainfall variability	++	--
Institutions structure		
% Making, monitoring and enforcement undertaken by chief only		
% Rules made in collaboration	++	
% Rules made without the chief		--
# Projects		
Before 1988	++	
1986-1993 (Terroir approach)		++
1993-2001 (NRM approach)		+
Distance to regional capital	--	
External pressure		
# village max. sharing pasture		
Transhumants using pasture		+

+, (-) = positive (negative) and significant at the 10% level
++, (--) = positive (negative) and significant at the 5% level

The estimated equation for network capacity has fairly good explanatory power, but many of the significant coefficients are opposite in sign to those predicted by theory. Instead of corroborating the inverted-U shaped hypothesis regarding the impact of the number of households, the relationship is U-shaped and significant. The coefficient of variation of rainfall is positively related to network capacity, indicating that low rainfall and high climatic variability increases the value of developing network capacity, which may itself reflect a mechanism to improve mutual insurance mechanisms within the community. Distance to the regional capital is negative. Interestingly, the number of quarters, heterogeneity in livestock holdings, and the percent of households where at least one adult migrates all lead to greater network capacity. While it makes a good deal of

sense that having many distinct neighborhoods and heterogeneity income-generation patterns increase the value of networks, this result highlights why network capacity in and of itself may not improve the capacity of community members to undertake collective action. Education however, is positively related to network capacity, as we expect and the number of rules made in collaboration with the chief is also positive. In summary, it appears that population dense, heterogeneous communities that are close to the regional capital and where many households rely on migration for wage work, there is a greater density of networks in both NRM and non-NRM related organizations and thus high network capacity. Collaboration between the institution of the chief and household members, and the number of programs which begun in the earliest period (before 1986) also lead to higher network capacity.

At this point, it is worth comparing the estimation results for the network capacity index to previous work on "social capital", which focused on the ability of individuals to rely on social relationships to accrue *private* benefits – e.g. to increase a households' access to insurance, credit and labor sharing arrangements. The network capacity index constructed here appears to reflect the capacity of individuals to exploit social relationships to improve individual or household well-being, and in that sense, could be considered to proxy "social capital" as the term has been previously employed.

Significant variables for the second equation are mostly different from those in the first equation. Here, migration for wage work has a negative impact on implementation capacity, whereas the proportion of households with public schooling positively affects active capacity, as hypothesized. The number of different ethnic groups represented in the community increases implementation capacity, indicating that

diverse ethnic and social backgrounds increases the knowledge base and thus the possibilities for collective action. The number of projects undertaken during the latter two periods also led to greater implementation capacity, indicating that the change in project focus may favor community level implementation over individual household adoption of specific techniques. Neither collaborative rule-making nor whether the chief plays a dominant role have a statistically significant impact on implementation capacity, but interestingly, such capacity is lower in communities where a relatively large percentage of different organizations do not include the chief in the rule making process. This may arise because of friction between the institution of the chief and other organizations, or, it may be due to the fact that in communities where the role of the chief is diminishing rapidly, substitute organizations have not yet been able to substitute for roles previously undertaken by the chief. It would certainly be worthwhile to collect further information on institutional change with the explicit aim of separating out permanent versus transitory effects; however, this type of analysis, which would require a long time series, is not possible with our dataset. Finally, we note that the coefficient of variation in rainfall has a negative impact on implementation capacity. This indicates that collective action may be less valuable in such areas, which is an interesting contrast with the network capacity variable, which is higher precisely in these areas.

Overall, the estimated equations provide evidence that these indices capture different aspects of cooperative capacity. In the next sections, we examine how these capacity indices impact land use and allocation patterns observed at the community level, conflicts observed in the communities, and household-level variables such as total income and pattern of income sources.

7. THE IMPACT OF COOPERATIVE CAPACITY

7.1 COMMUNITY-LEVEL IMPACTS

7.1.1 *Land Allocation and Land Use*

McCarthy, and Dutilly-Diane (2002) developed a model of land allocated to crops vs. pastures, stock densities, and herd mobility; here we simply report part of the results to highlight the impact of the cooperative capacity indices. All three dependent variables are hypothesized to be affected by cooperative capacity. The land allocation decision – between public pastures versus private crops – is characterized by positive externalities, so we hypothesize that cooperative capacity increases land allocated to public pastures, all else equal (McCarthy et al. 1998). The stock density decision is characterized by the traditional, negative crowding externality; therefore, cooperative capacity is hypothesized to have a negative effect on stock densities. Finally, we hypothesize that effective herd mobility requires communication and coordination amongst community members, and thus that cooperative capacity should increase herd mobility[5]. Controlling for agro-ecological, market, and demographic variables (as reported in Appendix 1 Table A2), the estimated equations give the following results:

[5] Clearly, as with all the dependent variables discussed in the following sections, variables other than cooperative capacity will impact the herd mobility decision. Relative rainfall realizations across the relevant region will obviously be a key factor; the theoretical model on which the empirical estimations are based assumes that for at least some rainfall realizations, only a fraction of herders will be mobile. Cooperative capacity may simply make the decision more efficient by acting as a "clearing house" of information, or it may increase herd mobility directly in the case where there is a tendency for a larger fraction to remain on the home pastures for a longer period of time thereby over-exploiting home resources in the absence of a cooperative mechanism to promote herd mobility.

Table 5--Cooperative capacity and land use/management (summary of results)

	Stock densities	% Common Pasture	Mobility
Network Capacity	++	--	+
Implementation Capacity	--	+	

The different capacity indices have strikingly different impacts on land use and allocation variables. Network capacity actually leads to higher stock densities and less land in common pastures; two effects that we would expect to be associated with less successful collective action. On the other hand, higher network capacity leads to greater herd mobility, as we would expect. With regard to the implementation capacity index, a higher index leads to lower stock densities and a larger share of community land allocated to common pastures. This index seems to better capture the ability of the community as a whole to internalize externalities in the use and management of community resources.

7.1.2 Impact of cooperative capacity on conflicts

Another important issue in the region is conflict resolution (Barry 1996; Kambou 1997; Banzhaf et al. 2000; Drabo et al.2001; PSB/GTZ 1999). Conflicts can be internal to the village; the vast majority of which stem from crop damage by cattle (80% of 183 registered conflicts). External conflicts (with neighboring villages and, rarely, with transhumants) often result from crop damage too, though conflicts surrounding encroachment also occur. The impact of cooperative capacity on conflicts is difficult to capture when looking at a cross-section of data. While potential endogeneity problems beset many analyses, it is particularly difficult to determine the impact of cooperative capacity on conflicts, without considering the likely impact of conflicts on cooperative capacity. We expect the relationship between conflicts and cooperative capacity to be

negative and reinforcing; that is, we expect that lower cooperative capacity will lead to more conflicts, and that more conflicts will reduce cooperative capacity. Given data constraints, we cannot separately estimate conflicts and cooperative capacity, and instead simply examine the correlation coefficients between conflicts, cooperative capacity and the land use and management variables from above (stock densities, common pasture land, herd mobility), which are presented in Table 6 below.

Table 6--Matrix of Correlation coefficients*

	Total	External	Internal	Crop damage
Network Capacity	-.01	**-.15**	.07	.02
Implementation Capacity	.03	-.01	.04	.08
Stock density	-0.15	**-0.29**	0.12	-0.02
Land in pasture	**0.32**	0.12	**0.32**	**0.27**
Mobility	**0.24**	-0.01	0.19	**0.28**

* Coefficients significant at the 10% level are reported in bold.

First, we note that only one of the correlation coefficients among the conflicts and cooperative capacity variables is statistically significant. The relationship between network capacity and external conflicts is negative, indicating that either network capacity reduces external conflicts, or that few external conflicts engender greater networks, or a combination of both effects.

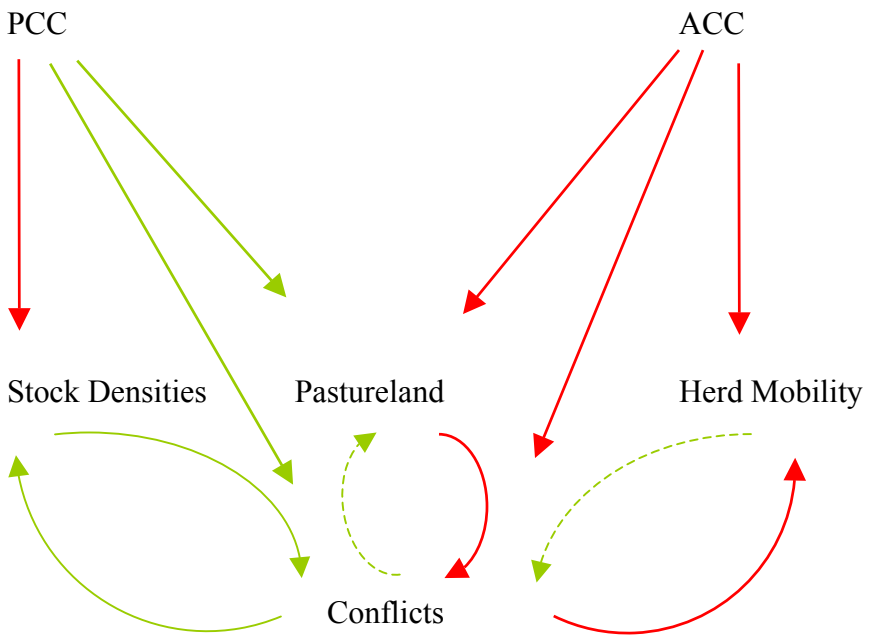
Regarding the land use and management variables, we see that stock densities are negatively correlated with external conflicts, while land in pasture and greater herd mobility are positively correlated with crop damage and total conflicts. The inter-relationship between land use and management variables and conflicts is not necessarily reinforcing and somewhat more complicated than the case for cooperative capacity and

conflicts. For instance, higher stock densities may deter non-community members from using community pastures[6] with the consequent effect of reducing external conflicts. At the same time, in areas with few external conflicts, livestock production may be considered less risky, thereby leading to increased stock densities. Here, we expect the inter-relationship to be reinforcing; high densities reduce external conflicts, low external conflicts lead to higher stock densities. In fact, the correlation coefficients are negative for 3 of the 4 conflict variables; but only the coefficient between stock densities and external conflicts is negative and significant. Alternatively, a high percentage of land allocated to pastures may increase the potential for livestock to damage crops thereby leading to more conflicts, especially internal. On the other hand, it seems reasonable to argue that the presence of many conflicts would increase privatization of resources and thus reduce land allocated to pasture. So, we expect more pastureland to lead to higher conflicts, but higher conflicts to lead to less pastureland. From the simple correlation coefficients, it appears that the first effect is stronger; more land in pasture, greater opportunities for conflict, and thus more conflicts. Finally, *a priori*, we expect that mobility would be greater in areas with many conflicts, but that lower mobility itself would increase conflicts, especially those due to crop damage. So, we expect conflicts to cause more mobility, but more mobility to reduce conflicts. The correlation coefficient is consistent with the first hypothesis, that more conflicts increase the proportion of households engaging in mobility.

[6] Note how this explanation is very similar to predatory pricing models in oligopoly theory.

While fully recognizing data limitations, we draw on the above analysis to propose the following schematic representation of the relationships between cooperative capacity, land management and conflicts.

Figure 1--Synthesis of relations between cooperative capacity, land management and conflicts



Positive impact

Negative Impact

Dashed lines indicate the hypothesized impact, even where that impact is not detected in the data.

7.1.3 Community versus sub-group collective action

Another question often of interest is how sub-groups within a community arise and how well they perform (Dutilly-Diané 2001). It is often hypothesized that sub-groups form when total number of households or economic, social or cultural heterogeneity make cooperation at the level of the community too costly. In our study

communities, we can only look at the sub-group vs. community-wide institutions for water sources, since there are only a few instances of sub-group formation for other types of NRM. Since we are looking at a specific institution, we cannot use the cooperative capacity indices directly. Instead, we simply examine the means on performance, structure, and certain demographic variables, to determine whether there are significant differences between community-wide vs. sub-group water institutions. Results are presented in Table 7 below.

Table 7--Comparison in mean for performance, structure indicators of water institutions, and community characteristics of water institutions: community vs. sub-village level

	One (27 Communities)	Multiple (48 organizations in 16 Communities)	T-test†
Performance			
# Meetings	6.6	3.4	**
Participation in Meetings	0.84	0.75	
# Days Worked	4.6	4.4	
Proportion of households that participated in work	0.69	0.71	
Monetary Contributions	1328	1080	
Proportion of households that paid contribution	0.91	.80	*
Structure			
Elected bureau	0.14	0.17	
Chief Dominant	2.7	2.2	
Collective Rule-Making	.07	.08	
Rules made without Chief	.09	.20	**
Community characteristics			
Size village			
# households	70	138	***
Ethnic Majority	0.75	0.62	**
Heterogeneity			
In cattle holding	65	22	
% Households with cattle	0.78	0.66	**
# Quarters	4.1	6.5	***
# Ethnic groups	3.1	3.9	(*)
# Spoken languages	2.6	3.5	**
External influence			
# Programs	2.1	2.5	

† T-test significant at: (*) 85%; * 90% ; ** 95%; *** 99% level.

Communities where there is one water organization score higher on number of meetings and participation by members in terms of monetary contributions, but communities with multiple water organizations are more likely to have broader

participation by the population in rule making, particularly in communities where community members are more likely to make rules without the participation of the chief. There is no difference on other structure and performance indicators, however. The number of household belonging to water sub-groups is roughly the same as for community-wide water organizations, indicating that sub-groups are indeed forming to offset potential negative impacts on collective action when the total number of members becomes too large. Various heterogeneity indicators are also strongly and positively correlated with sub-group formation. Thus, statistical results confirm the hypothesis that sub-groups form in large and heterogeneous villages.

7.2 ANALYSIS AT THE HOUSEHOLD-LEVEL

In this next section, we use household survey data to investigate the impact of the cooperative capacity on household incomes and composition of income. We also consider the impact of cooperative capacity on individual households participation in various collective activities, including soil erosion control, reforestation and water point maintenance.

7.2.1 Capacity, and household income level and diversification

In this section, we present a summary of results found in Dutilly-Diane et al. (2002). In that paper, the authors develop and estimate a household model of total income and income shares from crops, livestock, local off-farm activities (petty trading, handicrafts, etc.) and migration activities. In the first stage, the authors determine that the household sample should be divided according to whether households are net buyers of grain or whether they are self-sufficient. In Table 8 below, we present results of the

impact of cooperative capacity on total income and income shares by these categories, full results are presented in Appendix 1, Tables A3 and A4.

Table 8--Income and income shares

	Total	Crops	Livestock	Off-local	Migration
	Buyers of grain (355)				
Network Capacity		+			
Implementation Capacity	+		+		
	Self-Sufficient in grain (46)				
Network Capacity			**-**	+	
Implementation Capacity			+	**-**	

There is a distinctive effect of network vs. implementation capacity on the type of activities undertaken. First, consider the households that are net purchasers of grain – who make up a large share of total households. For this group, network capacity favors crops vs. livestock; that is, network capacity favors the activity relying almost completely on private inputs (cropping) vs. the activity relying significantly on common resources (livestock). On the other hand, active cooperation leads to both higher livestock incomes and greater total income. For the much smaller subset of households self-sufficient in grain, network capacity reduces the level of income from livestock, but leads to increased local off-farm income. Implementation capacity has exactly the opposite effect; it leads to greater level of income from livestock. Altogether, these effects tend to offset each other, since there is no impact on total income. Neither index has a significant impact on the proportion of income generated from non-local income.

The differential impact of the two cooperative capacity indices is really rather interesting. The network density relationships that form the basis of much of the social capital literature indeed seem to increase household capacity to increase incomes from private activities – either cropping or off-farm local incomes in our study. Nonetheless,

the region is relatively favorable for livestock production, and greater livestock production leads to higher total incomes for the large majority of households that are net grain purchasers. Because of the reliance on common pool resources, livestock production requires active resource management. A relatively high degree of network capacity does not enable community members to actively manage their resources, and indeed may best be seen as a second-best substitute in these environments.

7.2.2 Community capacity to cooperate and household participation

In this section, we ask "how does the capacity of a community to cooperate influence individual decisions to contribute to collective action?" Controlling for household characteristics as well as community-level variables in a standard probit model of the participation decision, we find that implementation capacity has a positive and significant impact on reforestation and erosion control activities but no effect on water activities and, because of the overwhelming importance of water activities in total activities at the household level, no effect on the decision to participate in any collective activity. Network capacity has no impact on the participation decision for any of the activities[7]. To some extent, this partially reflects the construction of the two indices – number of activities has a higher coefficient score on the implementation versus network capacity indicator, for instance. Still, it is worth emphasizing that the indices were constructed from community-level data aggregated over a wide-range of community-level organizations with the intent of capturing underlying cooperative capacity and is comprised of ten separate factors, whereas the participation decision discussed here is a household-level decision.

[7] Results for the probit equations are given in the Appendix 1, Table A5.

Looking at household participation statistics in Table 9, we note that nearly 2/3rds of households participate in at least one activity, which is most likely to be a water maintenance activity. Only between 20-25% of households participated in erosion control and reforestation activities; activities which are influenced by cooperative capacity. These results hint at different "need" for cooperative capacity, perhaps depending on the historical importance of various activities, with water source management/maintenance activities largely having a very long history compared to many of the reforestation and erosion control activities.

Table 9--Household participation in NRM activities.

	All	Water	Reforestation	Erosion
# Households concerned in activity*	360	310	225	268
# Households undertaking activity	243	67	44	67
% Households undertaking activity	0.67	0.61	0.20	0.25

* Households whose village undertake the activity

8. CONCLUSION

The aim of the paper is to highlight the methodological issues surrounding the use of community-level data on cooperation, both in terms of constructing indicators of cooperative capacity, and using these indicators to explain various aspects of natural resource management and household livelihood strategies. The rich collection of data in this northeastern region of Burkina Faso allowed for multiple levels of analysis: community, groups within communities, and household.

We believe there are a number of key lessons learned through the process of data collection and analyses. First, we believe that the issue of enumerator bias when relying on open-ended interviewing techniques to elicit information from key informants or individuals is a problem that has received far too little serious attention. At the very least, acknowledgement of the likely bias, along with developing measures to reduce the bias beforehand and manage it afterward, should be considered a crucial aspect of data collection.

Secondly, a review of previous research shows that there is still a great deal of debate over the factors that determine "successful" collective action. Equally important but less discussed is the fact that there remains a great deal of debate over what observable characteristics actually comprise "social capital", or, in our case, cooperative capacity, or indeed "cooperation". We created indicators of cooperative capacity based on more than one characteristic precisely because we hypothesize that no single characteristic of any one organization is likely to reflect underlying cooperative capacity. Still, we must acknowledge that this is an ad hoc specification. Because the specification is ad hoc, we went further to check if the indicators could be explained by

variables hypothesized to affect cooperation, but again, we had to acknowledge that the impact of many variables is ambiguous in the general literature. Finally, we used the indicators as explanatory variables or examined their correlation with other outcome variables that are hypothesized to be related to cooperative capacity.

Looking at the evidence in its entirety, we believe that there is strong reason to believe that cooperative capacity may not be a "unique underlying factor", but rather capacity may itself have different components. Individuals may access networks and sustain membership in organizations primarily for private benefit in terms of increased production, improved marketing, or insurance. Individuals may also participate in organizations to undertake collective action and generate gains that accrue to the group as a whole, via the provision of public goods or mitigation of negative externalities. What is good for the individual may not benefit the group; characteristics previously associated with "social capital" may not improve the capacity of a community to engage in collective action. The determinants of network capacity – heterogeneity, proximity to the regional center – indicated that this variable may capture the capacity to use networks for individual gain. This interpretation fits quite well with the results from land use and allocation patterns observed at the community level and in terms of individual income patterns. Network capacity is also negatively correlated with conflicts. Implementation capacity, on the other hand, behaves more in accord with the literature on determinants of "successful collective action"; again, particularly with respect to land use and allocation, and household income. This capacity is also positively related to the probability that households engage in certain public goods provision activities, but it is also positively correlated with conflicts.

To summarize, because the theoretical framework to understand – let alone measure – collective action and cooperative capacity is still rudimentary at best, we feel that our results highlight the need to consider the issues from multiple angles. Corroborating "evidence" is simply necessary, since the nature of the empirical analysis is ad hoc. Results also need to feed back into the construction and development of more realistic and rigorous theoretical models.

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APPENDIX 1

Table A1--The determinants of collective action

	INC		IIC	
	Coef.	t-stat	Coef.	t-stat
Demographic				
Size community	-.005	-3.89 **	0.002	0.78
Size community sq.	1.3E-05	2.78 **	-1.61E-06	-0.22
# Quarters	0.034	3.84 **	0.005	0.35
# Ethnic groups	-0.008	0.01	0.031	1.63 *
Heterogeneity in cattle holding	0.018	2.31 **	-0.016	-1.26
% Adults migrating	0.515	2.09 **	-1.205	-3.07 **
% Households w/ public education	0.454	2.09 **	0.460	1.84 *
Institutions structure				
Chief dominant chief	-0.001	-0.04	-0.051	-1.54
% rules made in collaboration	0.328	3.12 **	-0.058	-0.35
% rules made without chief	-0.052	-0.56	-0.260	-1.76 *
# Projects				
Before 1986	0.030	2.06 **	-0.020	-0.87
1986-1993 (Terroir approach)	0.019	1.21	0.083	3.36 **
1993-2001 (NRM approach)	0.027	1.07	0.079	1.96 *
Distance to regional capital	-0.075	-3.22 **	-0.050	-1.16
External pressure				
# Village sharing pasture	-0.010	0.35	-0.044	-0.52
Transhumants using pasture	0.008	0.17	0.200	2.64 **
Coefficient of Variation, Rainfall	.653	3.35 **	-.783	-2.52 **
Constant	1.457	4.56 **	-.620	-1.22
Number of observations		48		48
R2		0.66		0.56

Table A2--Impact of Cooperative Capacity on Land Allocation, Grazing Pressure and Herd Mobility

	% Land cropped		Grazing pressure		% Cattle remaining home	
	Coef.	z	Coef.	z	Coef.	z
COOPERATION INDEXES						
INC*total households	0.10	2.21 **	0.40	2.02 **	0.06	1.66 *
IIC*total households	-0.06	-1.87 *	-0.26	-1.99 **	-0.003	-.12
Demographic						
Population Density	0.16	3.84 **	0.76	4.25 **	-0.04	-1.22
Dominant ethnic group, crop farmers +	0.07	1.01	-0.47	-1.63 *	0.08	1.33
Heterogeneity in cattle ownership	0.02	1.41	0.10	2.01 **	0.01	1.23
Proportion of Households with Public Schooling	-.35	-1.54	-.63	-.64	-.37	-1.85 *
Agro-ecological						
Seeno soil, dominant +	0.13	2.55 **	0.60	2.63 **	0.05	.99
Bolaare soil, dominant +	0.01	0.15	-0.26	-0.85	-0.11	-1.93 **
Pond +	0.04	0.85	-0.06	-0.28	0.08	1.73 *
Rainfall coef. Variation (ln)	-0.12	-0.33	-2.86	-1.91 *		
Diff. 1999-mean					4.97	4.17 **
External pressure						
# Villages sharing pasture	0.01	0.22	-0.03	-0.18	0.10	3.01 **
Transhumants +	0.08	.96	1.11	3.21 **	-0.09	-1.31
Market & Infrastructures						
Livestock/grain price (ln)	0.69	1.35	1.79	0.81	2.44	4.03 **
Distance to cattle market (ln)	0.03	1.72 *	0.18	2.20 **	-0.01	-0.03
Infrastructures	0.01	.36	0.43	2.79 **	-0.02	-.79
Constant	-.02	-0.03	-5.51	-1.82 *	-7.58	-3.94 **
# observations	48		48		48	
R2	0.60		0.66		0.57	

+ : Dummy variables

Table A3--Income by source, food buyer households - partial results

(endogenous variables: income by source)

	Marginal effect on income (1000 CFAF)				
	Total	Crop	Livestock	Non-ag.[1]	Migration[1]
Shifters in crop production					
Potential Yield (10 kg/ha) - instrumented	8.0*	1.8**	-1.9*	-0.2	8.5*
Agriculturalist ethnic group +	-9.9	24.1**	-49.2**	-6.7	118.5**
Shifters in livestock production					
Land availability (10 ha per household)	5.0	-1.0	10.9**	-16.2**	2.3
Network Capacity	19.7	66.9*	-9.1	77.2	-38.3
Implementation Capacity	169.0**	23.7	123.8**	-22.4	10.8
Education					
Public education +	112.6**	58.1**	-14.4	84.1**	26.5
Adult Literacy +	24.0	–	–	–	-68.7
Average value of income (1000 CFAF)	459.6	156.3	184.2	43.2	75.8

Estimation with robust IV for total, crop, and livestock income, and with IV Tobit for off-farm and migration income. In addition to the reported variables, explanatory variables include distance to market, age of household head, number of men and women 16-60 years old, and an Oudalan dummy. Number of observations: 325 buyers of food.

* (**) indicates coefficient significant at more than 90% (95%).

– indicates that public education stands for "public education or literacy"

[1] Marginal effect among participants to the activity

+ : Dummy variables

Table A4--Income by source, food self-sufficient households - partial results

(endogenous variables: income by source)

	Marginal effect on income (1000 CFAF)				
	Total	Crop	Livestock	Non-ag.[1]	Migration[1]
Shifters in crop production					
Potential Yield (10 kg/ha) - instrumented	11.4*	0.6	3.3*	3.6	-21.5**
Agriculturalist ethnic group +	-48.8	11.2	-44.6	-118.5	-21.7
Shifters in livestock production					
Land availability (10 ha per household)	2.0	1.0	5.4	-18.4	-42*
Network Capacity	-511.6	59.1	-369**	1193*	1812*
Implementation Capacity	338.3	-123.1	523**	-963**	-410.5
Education					
Public education +	128.7	-0.1	-54.2	315**	405**
Adult Literacy +	-48.8	–	–	-161.6	-946**
Average value of income (1000 CFAF)	497.4	254.3	151.0	61.9	30.2

Estimation with robust IV for total, crop, and livestock income, and with IV Tobit for off-farm and migration income. In addition to the reported variables, explanatory variables include number of dependents, transfer dummy, age of household head, and number of men and women 16-60 years old. Number of observations: 48 self-sufficent households in food.

* (**) indicates coefficient significative at more than 90% (95%).

– indicates that public education stands for "public education or literacy"

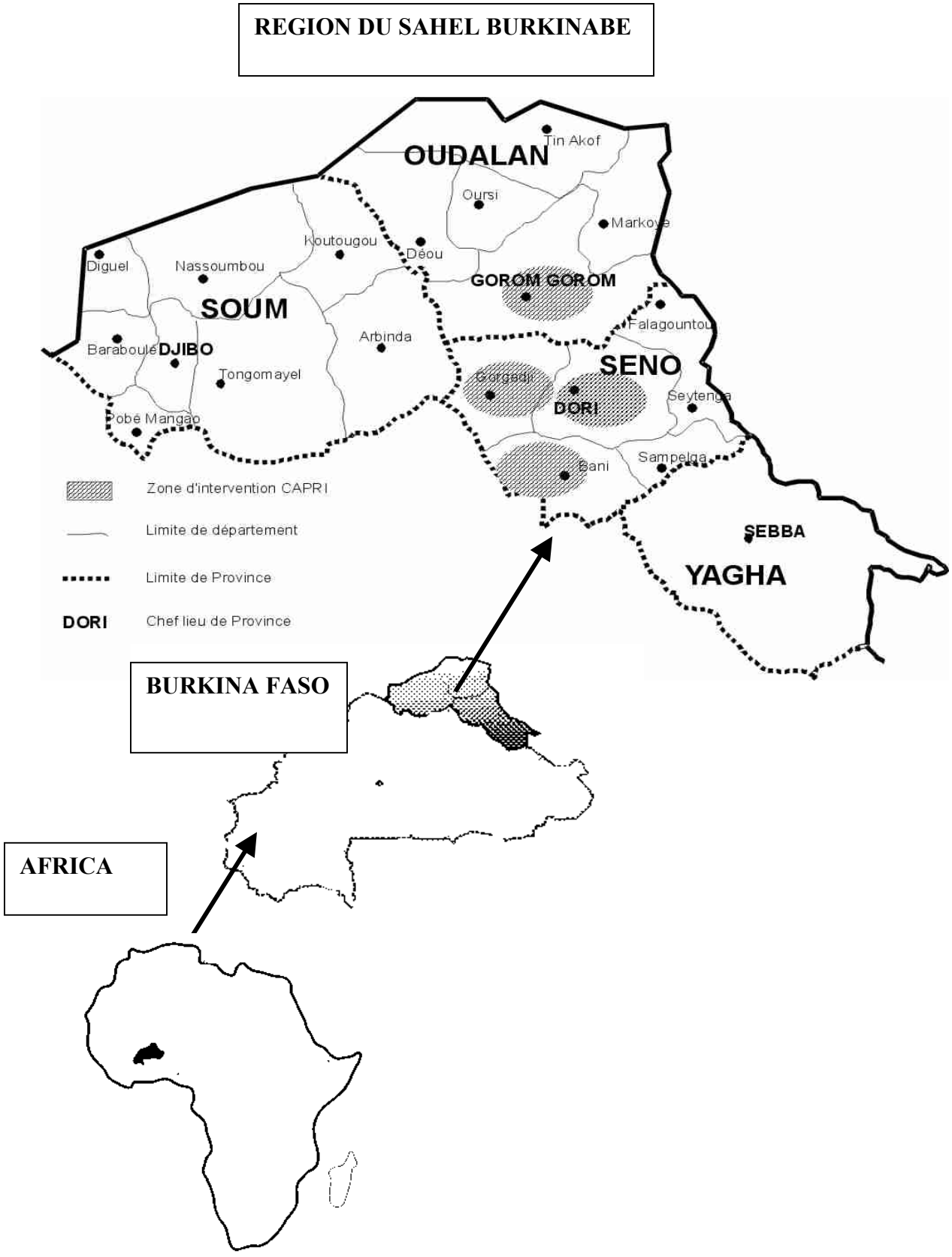
[1] Marginal effect among participants to the activity

+ : Dummy variables

Table A5--Determinants of household participation (Probit)

	All activity		Water maintenance		Deforestation		Erosion control	
	Coef.	z	Coef.	z	Coef.	z	Coef.	z
INC	-0.1152	-0.15	-0.5211	-0.59	3.0364	1.84 *	2.3746	2.28 **
IIC	1.0194	1.28	0.6492	0.75	0.6075	0.61	0.491	0.64
Size household (AE)	0.0138	0.53	0.0248	1.00	0.0085	0.42	-0.0085	-0.31
Age head household	-0.1192	-0.47	-0.4549	-1.87 *	-0.1925	-0.64	0.2737	0.80
No off-farm income	-0.2491	-1.27	-0.2367	-1.37	-0.9366	-2.52 **	-0.5761	-2.55 **
No education	-0.015	-0.11	0.1442	0.96	-0.1584	-0.81	-0.1581	-0.81
Ethnicity of household head	0.1296	0.61	-0.2221	-0.91	0.1672	0.48	0.5007	2.07 **
Size of cropland holdings	0.2609	1.83 *	0.2459	1.58	0.5118	2.42 **	0.3453	2.00 **
Proportion of income from off-farm work	-0.1152	-0.26	0.2174	0.43	-1.0013	-1.49	-1.3368	-2.34 **
One water organization			0.3213	1.05				
Nb obs.		358		301		224		266
Prob>Chi2		0.009		0.025		0.000		0.000
Correctly predicticted obs. (%)		67		66		82		81

Appendix 2--Maps of the survey region



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