

1 Climate Variability and population vulnerability in the Sahel:
2 Farmers' evaluation of mitigation strategies and policies

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4 Authors

5 Malick Zoromé¹, Bruno Barbier^{2*}, Hamma Yacouba¹, Harouna Karambiri¹,

6 ¹ 2ie (Institut International d'Ingénierie de l'Eau et de l'Environnement 2iE), 01 BP 594
7 Ouagadougou 01, Burkina Faso

8 ² CIRAD UMR G-Eau (International Cooperation Center for Agronomic Research and
9 Development) en poste au 2ie.

10 * Corresponding author Email: BBarbier@cirad.fr

11 Abstract

12 The Sahelian rural population is considered to be one of the most vulnerable on earth
13 and this vulnerability is considered to be caused mainly by the variability of the climate that
14 prevails in this region. Sahelians have been also the most hit by droughts in the seventies and
15 eighties. Farmers and herders are now recovering as rainfalls have improved lately but the
16 question remains whether they have improved their capabilities and how they can cope with
17 future changes. To answer these questions, focus groups discussions and two detailed surveys
18 were conducted in a small catchment in northern Burkina Faso, among a random sample of
19 one hundred heads of households. The interviews aimed to estimate their level of
20 vulnerability to climate variability and to evaluate the likely impact of mitigation strategies. A
21 statistical analysis was carried out including a cluster analysis to distinguish farmers' groups
22 regarding to their assets and their strategies.

23 The results show that the main discriminate factors were family size, access to small
24 irrigation plots and number of animals. The groups react differently to climate variability and
25 are likely to follow contrasting pathways of adaptation. New migrations strategies are also
26 investigated. The likely impact of seasonal predictions is evaluated. Farmers feel that
27 predictions without credit for crop input cannot change much their investment plan. New
28 technology adoption is occurring fast but the impact is mixed because rapid population
29 growth and land degradation is masking the benefits of innovations.

30 Contrarily to some recent discourses farmers face difficulties to adapt to climate
31 variability. The reason is that at the same time as climate has changed, population pressure
32 has reached a crisis point. Now land has become scarce and mobility is more restricted.
33 External investments, new techniques and new organisations are required to help farmers
34 intensify agriculture in a sustainable way.

35 Keywords: climate, drought, vulnerability, adaptation, irrigation, Sahel, Burkina Faso

36 Introduction

37 The Sahelian rural population is considered to be one of the most vulnerable on earth
38 and its vulnerability is partly caused by the irregularity of the west African monsoon

¹ CIRAD- UMR GEAU (Centre de Coopération Internationale en Recherche Agronomique pour le Développement, 01 BP 596 avenue Kennedy, Ouagadougou 01, Burkina Faso

1 (Martineu and Tissot 1993; Lebel and Amani 1999; New, Hulme and Jones 2000). During the
2 20th century the Sahelian population has experienced several droughts of dramatic
3 consequences (Gado 1993). Famine struck in 1973. The drought of the mid eighties had a
4 more limited impact because food aid arrived on time, farmers were better prepared and some
5 development project might have had some positive impact. The international community was
6 however surprised when the region called again for help in 2004 after the rainy season failed
7 and a new locust invasion ravaged some regions. Why is the region still vulnerable? What has
8 been proposed so far by the governments, aid agencies and NGOs? What has been adopted
9 and what do farmers think of their future? Are the new instruments unable to mitigate deeper
10 crisis? Are farmers and herders prepared for future climate changes?

11 Two surveys were carried out among a sample of Sahelian farmers from a
12 representative community in northern Burkina Faso. Farmers' interviews helped to measure
13 their vulnerability to climate variability and their opinion on key new techniques, policies and
14 adaptation strategies. The questions involve consumption, migration, food aid, irrigation,
15 vulnerable groups, population pressure and agricultural dynamics, policies and adaptation to
16 new conditions.

17 In the first part of the document we review some recent debates about the concepts
18 that have been used in the region such as climate change, food security, poverty and
19 adaptation strategies. We then analyze the responses to the questionnaire and calculate a
20 vulnerability index developed for the Sahel. Finally we make some recommendations
21 regarding the existing and future adaptation strategies.

22 Climate variability, vulnerability and adaptation in the Sahel

23 Some climate model projections suggest that climate change might aggravate the
24 situation of African agriculture (Kurukulasuriya, Mendelsohn, Hassan and others 2006).
25 However these global models are in contradiction over the future climate directions for the
26 West African Monsoon. As many expects more variability in rainfall amount and distribution,
27 Sahelian countries are building mitigation plans to cope with the effect of new droughts or
28 floods (Adger, Aggarwal, Agrawala and others 2007). Most of these plans are based on the
29 identification of the most vulnerable regions and of the most vulnerable groups within these
30 regions.

31 In the Sahelian socioeconomic context, vulnerability refers to an individual, a group or
32 a community that is likely to suffer from hunger, sickness and increased poverty when
33 exposed to an external shock such as a drought, flood or a locust invasion that reduces crop
34 harvest and animal production (Maddison 2006; Smit and Wandel 2006). A vulnerable person
35 or group of persons has insufficient means to accumulate the necessary grain stocks to smooth
36 food intake. Such groups also require the human capital, skill, organization, connection to
37 react properly when production fails.

38 One can be poor and not vulnerable and vice versa. Small subsistence farmers of the
39 south of Burkina Faso are usually poor but not really vulnerable to droughts. Conversely
40 some herders from the Sahel own large herds but theses can be destroyed by a single drought
41 or an epidemic. There is a significant amount of turnover amongst the poor as households exit
42 and enter poverty. Some of this mobility can be attributed to regular movement back and forth
43 in response to exogenous variability in climate, prices and health. Other crossings of the
44 poverty line reflect more permanent shifts in long-term well-being associated with gains or
45 losses of production factor due to changes in asset productivity, adoption of improved
46 technologies or access to new market opportunities. Distinguishing structural mobility from

1 simple crossings clarifies the factors that facilitate such important structural changes (Barrett
2 2007).

3 Poverty is also closely linked to the concept of food security which has evolved over
4 time from food aid to capabilities, a concept closer to farmers' adaptation capacity and real
5 purchasing power of the vulnerable groups (Sen 1981; Drèze, Sen and Hussain 1995). Famine
6 can occur even when food is available, when some segments of the population cannot access
7 to food supply when they need it. Sen was among the first to promote the replacement of
8 direct food aid by "food for work" programs, quite popular today in the Sahel.

9 Strategies to reduce farmers' vulnerability have to take into account the link between
10 population density and resource management. The more optimistic stresses that rural
11 communities tend to adapt successfully to population pressure and external shocks when
12 policies are right (Boserup 1965; Lele and Stones 1989; Mortimore and Adams 2001). An
13 emphasis is made on local knowledge (Ajibade and Shokemi 2003). A more pessimistic line
14 stresses that, despite farmers' effort to adapt, communities easily run into Malthusian types of
15 situation such as famine, epidemics and political conflicts when they exceed some carrying
16 capacities and that some climate shocks unveil an inherent lack of productivity (Diamond
17 2005). In the Sahel evidences have been more pessimistic suggesting that communities
18 remain vulnerable especially when populations grow fast (Pieri 1989; Barbier 1998; Maire
19 and Delpeuch 2004; Maire and Delpeuch 2004). However convincing evidences from the
20 Sahel are still scarce because one needs a dynamic assessment of what is going on, a robust
21 indicator of vulnerability and a comprehensive analysis of the driving factors.

22 The catchment of Tougou

23 The selected sample is located in a small catchment which is part of the community of
24 Tougou in the Yatenga province in northern Burkina, 30 kilometers east of the large city of
25 Ouahigouya. Population density is 170 inhabitants per square kilometers which is common in
26 central Burkina Faso but high compared with Burkina Faso average density (Stéphenne and
27 Lambin 2001). Population growth is still close to 3% per year, which means that the
28 population doubles every twenty years (INSD).

29 According to Tougou's farmers, the arable land is completely cultivated. Almost half of
30 the farms no longer can obtain new land in the community. Most farmers no longer return
31 cropped plots into fallow when fertility is exhausted and three quarters of the farmers have
32 had to recuperate some exhausted land. The land that farmers consider exhausted covers 60%
33 of the total area. Farmers now cultivate quasi permanently the same plots and a majority of
34 them apply a type of soil conservation technique, the *zai*, which consists in preparing small
35 holes in the field, holes that will receive seeds and organic matter. This technique also
36 increases the water availability for the crop by capturing surface runoff. Half of the farmers
37 also installed stone lines in their field to reduce erosion. The village is located 3 kilometers
38 from a large reservoir where half of the community has access to very small irrigated plots:
39 0.25 hectares downstream of the dam, 0.1 hectares upstream and even less for women who are
40 sharing tiny plots within communal gardens.

41 The climate of Tougou is of the Sahelian type, close to the isohyets 650 millimeters.
42 Climate has changed over the last forty years throughout the Sahel. Rainfalls amount started
43 to decrease in the late sixties. Two droughts, in the early seventies and mid eighties, resulted
44 in a severe food crisis. From the mid eighties onward, rainfalls have been increasing again but
45 have not reached yet the level of the fifties and sixties. Some recent rainy seasons were still
46 displaying a lower than long term average but the 2006 and 2007 seasons were considered
47 wet.

1 Method

2 The study was carried in a typical Sahelian subwatershed in northern Burkina Faso
3 where the AMMA (Multidisciplinary Analysis of the West African Monsoon) project has
4 been studying biophysical and social aspects of the impact of climate variability. Several
5 focus groups discussions and two detailed surveys were carried out among a random sample
6 of 105 heads of farms in 2004 after a failed agricultural season, which was dry and infested
7 with locust, and in 2006 when the season was wet. The Fulani herders were excluded from the
8 sample because the study concentrated on sedentary farmers and because Fulani herders
9 consider taboo to provide information about their numbers of animals.

10 We interviewed the heads of compounds. The so called compound usually regroups
11 several households usually the household of the old father, and the households of his sons.
12 When the old father dies, sons create new compounds. Traditionally, the head of the
13 compound is the decision maker for agricultural practices but dependant sons increasingly
14 tend to decide for their own farming practices on their own plots, especially when it comes to
15 irrigated crops.

16 We evaluated farmers' vulnerability with a well known vulnerability index developed
17 by the *Comité International de Lutte contre la Sécheresse au Sahel* (CILSS) which stands for
18 International Committee to Fight Droughts in the Sahel. The index is called the Virtual Rate
19 of Satisfaction of Grain Needs. The index balances production and consumption of basic
20 grains and includes the terms of trades of some economic activities such as sale of small
21 ruminants and cash crops. Their cash value is converted into their equivalent grain quantities.
22 CILSS uses this indicator to map the most vulnerable administrative units. We used this
23 indicator at the compound level to identify vulnerability and adaptation capacity.

24 The statistical analysis is based on a cluster analysis. To take into account qualitative
25 data, we transformed all variables into two or three classes. We then applied a principal
26 component analysis to generate new factors from the correlated variables. These factors are
27 not correlated to each other. This step helps reduce the risk of multicollinearity between
28 variables. We then applied a clustering technique to distinguish homogenous groups of
29 compounds. We used the so called k-means clustering method (Hartigan and Wong
30 1979),(Lloyd 1957,1982). The four principal factors were used to realize the group
31 partitioning according to the similarities and proximities between compounds.

32 The major factors of differentiation

33 The first factor of differentiation is explained by the number of persons in the
34 compound. Most quantitative variables were divided by the number of persons to reduce its
35 weight in the analysis. Most variables are indeed correlated with the size of the compound.
36 Even so compound size remains the most significant factor explaining differences between
37 compound assets. Smaller households, tend to be headed by younger farmers while larger
38 compound are headed by an old farmer that has had the time to accumulate wealth, mainly
39 animals but that are less likely to innovate. That trait recalls the life cycle theory developed by
40 Alexander Chayanov when describing Russians farmers before the Bolshevik revolution
41 (Chayanov 1925). Chayanov analyzed how farmers develop contrasted strategies depending
42 upon their position in their life cycle. Younger farmers are usually the ones investing most
43 until they reach a more stable production system. When old, farmers tend to disinvest. This
44 life cycle is obviously the major driving force behind Tougou's farm structures.

1 The second major factor of differentiation is related to irrigation. A majority of
 2 farmers in Tougou had access to a tiny plot to produce onion or potatoes during the dry
 3 season. The use of this plot makes a significant difference between farm characteristics and
 4 farmers' behaviour. The third factor is the number of animals per worker. Cattle, sheep and
 5 goats are the main farmers' asset. This factor usually distinguishes poor farmers from
 6 wealthier ones.

7 Groups' characteristics

8 We named the four groups according to the activity that better characterize them, even
 9 if the activity is not their major activity. For example, the major activity of the group known
 10 as "gardeners" remains the rainfed crops and individuals within other farmers' groups also
 11 produce vegetables. The four groups are the gardeners, the animal breeders, the grain growers
 12 and the off-farm workers (Table 1). The groups were not statistically very stable. A small
 13 change in the number of variables or in the number of groups changes significantly the
 14 number of compounds per group. This is because compounds characteristics are quite similar
 15 in the village (table 1 and 2). They can easily pass from one group to another.

17 Table 1: Compound characteristics

| | gardeners | off-farm workers | breeders | grain growers |
|-------------------------------------|-----------|------------------|----------|---------------|
| age (average) | 46 | 50 | 55 | 60 |
| household size | 09 | 16 | 25 | 20 |
| vulnerable (%) | 24 | 79 | 56 | 52 |
| dependency ratio<1 (%) | 67 | 37 | 50 | 52 |
| hiring for weeding (%) | 48 | 43 | 56 | 21 |
| hiring for harvesting (%) | 05 | 21 | 13 | 15 |
| temporary migration (%) | 14 | 44 | 21 | 15 |
| permanent migration (%) | 48 | 71 | 69 | 70 |
| at least one child in schooling (%) | 62 | 71 | 94 | 97 |
| sheep (%) | 52 | 71 | 88 | 67 |
| goat (%) | 48 | 71 | 81 | 76 |
| oxen (%) | 14 | 14 | 19 | 45 |

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21 Table 2: Crop production by farm type

| vegetables and grains (% involved) | gardeners | off-farm workers | breeders | grain growers |
|------------------------------------|-----------|------------------|----------|---------------|
| potato (%) | 40 | 29 | 44 | 09 |
| onion (%) | 86 | 60 | 75 | 64 |
| fonio (%) | 62 | 43 | 50 | 21 |
| maize (%) | 10 | 07 | 50 | 21 |
| millet (%) | 57 | 73 | 88 | 79 |
| sorghum (%) | 71 | 57 | 85 | 88 |
| bean (%) | 62 | 86 | 67 | 88 |
| rice (%) | 21 | 24 | 38 | 36 |

22 23 24 *The gardeners*

25 The group called *gardeners* is made of young farmers heading small families of 8
 26 members in average. They invest more in irrigated crops during the dry season. Almost all
 27 group members produce onions or potatoes. Three quarters of them are not considered
 28 vulnerable as they cover their grain needs with their own production and generate enough
 29 cash during the dry season to buy extra food. Thanks to irrigation they migrate less than the
 30 other groups. This group has the lower dependant/workers ratio because they are younger and

1 have less children and elders to take care of. It is also the group where the compound's head
2 contributes most to the family budget with off-farm activities, as if gardening helps starting
3 small off-farm businesses.

4 *Off-farm workers*

5 The family heads in this group are slightly older than the gardeners group and families
6 are much larger (16 members). They are more involved in off-farm activities such as fishing,
7 small-trading and masonry. They cultivate during the rainy season and work off-farm or
8 migrate during the dry season. Almost 60 % of the households are not covering their grain
9 needs with their own production. It is the most vulnerable group of the four. However
10 remittances from family members are not accounted for in our vulnerability index. It is
11 probable that this group covers its need with remittances. Because of migrations, they lack the
12 manpower to cultivate enough grain. This group hires more workers during harvest time
13 because many migrants leave after the crops are planted.

14 *Breeders*

15 The head of the compound of the so called breeders group are 60 years old in average
16 and head large families of 25. They own more animals than the other groups. Animals are
17 mainly sheep and goats. After the group of gardeners, this group is the least vulnerable thanks
18 to the accounting of small ruminants in the calculation of the virtual rate of grain satisfaction.
19 They have by far the strongest production of grains and beans, probably because their flocks
20 provide manure to the crops. This group often sells their animals to hire workers during
21 weeding and harvest time.

22 *Grain growers*

23 The group of "Grain growers" is the larger group. The head of the household is older
24 than in the other groups and family size is the largest. This group is less interested in
25 irrigation, has less animals and less off-farm activities. It is specialized in the production of
26 millet and sorghum. This group is slightly more vulnerable than the previous group. It
27 produces more grains than the other groups but they have no known recourse in case of
28 drought. This group hires fewer workers than the other groups but tend to own more draft
29 animals which reduces labor need. It is probably the most conservative group.
30

31 Farmers' groups and innovation process

32 In the former section we have seen how households' characteristics affect the choice
33 of activities. In this section we investigate each groups' innovation strategy. We asked the
34 head of household which techniques he adopted and the ones he plans to adopt or rejects
35 Table 3-a and b).

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37

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Table 3-a: Farmers' adoption of innovations in cropping

| | | gardeners | off-farm workers | breeders | grain growers |
|------------------------------|----------------|-----------|------------------|----------|---------------|
| Soil restoration (%) | adopted | 57 | 78 | 75 | 21 |
| | will adopt | 14 | 7 | 12 | 15 |
| | will not adopt | 28 | 14 | 12 | 63 |
| Row planting (%) | adopted | 28 | 0 | 81 | 18 |
| | will adopt | 38 | 85 | 6 | 24 |
| | will not adopt | 33 | 14 | 12 | 57 |
| Improved seed (%) | adopted | 9 | 0 | 12 | 12 |
| | will adopt | 47 | 85 | 62 | 18 |
| | will not adopt | 42 | 14 | 25 | 69 |
| Irrigation (%) | adopted | 90 | 55 | 62 | 69 |
| | will adopt | 4 | 37 | 25 | 15 |
| | will not adopt | 4 | 7 | 12 | 15 |
| Mineral fertilization (%) | adopted | 14 | 21 | 0 | 36 |
| | will adopt | 0 | 14 | 0 | 3 |
| | will not adopt | 85 | 64 | 100 | 60 |
| Corralling (animal dung) (%) | adopted | 42 | 28 | 75 | 6 |
| | will adopt | 19 | 57 | 6 | 0 |
| | will not adopt | 38 | 14 | 18 | 93 |
| Manure (%) | adopted | 28 | 42 | 68 | 15 |
| | will adopt | 0 | 35 | 0 | 0 |
| | will not adopt | 71 | 22 | 31 | 84 |
| Compost (%) | adopted | 57 | 64 | 93 | 66 |
| | will adopt | 33 | 35 | 6 | 15 |
| | will not adopt | 9 | 0 | 0 | 18 |
| Boulis (%) | adopted | 42 | 42 | 68 | 36 |
| | will adopt | 42 | 42 | 12 | 9 |
| | will not adopt | 15 | 15 | 18 | 54 |
| Plough (%) | adopted | 33 | 14 | 87 | 57 |
| | will adopt | 61 | 85 | 6 | 15 |
| | will not adopt | 4 | 0 | 6 | 27 |
| Weeders (%) | adopted | 0 | 0 | 43 | 3 |
| | will adopt | 47 | 92 | 18 | 15 |
| | will not adopt | 52 | 7 | 37 | 81 |
| Lowland production (%) | adopted | 42 | 78 | 56 | 60 |
| | will adopt | 29 | 7 | 6 | 0 |
| | will not adopt | 29 | 14 | 37 | 39 |
| Stone lines (%) | adopted | 72 | 78 | 87 | 60 |
| | will adopt | 23 | 7 | 0 | 6 |
| | will not adopt | 4 | 14 | 12 | 33 |
| water harvesting (Zai) (%) | adopted | 52 | 64 | 81 | 48 |
| | will adopt | 33 | 21 | 12 | 12 |
| | will not adopt | 14 | 14 | 6 | 39 |

3

Table 3-b : Farmers' adoption of innovations in livestock production

| | | gardeners | off-farm workers | Breeders | grain growers |
|--------------------------|----------------|-----------|---------------------|----------|------------------|
| sheep fattening (%) | adopted | 43 | 57 | 94 | 9 |
| | will adopt | 28 | 14 | 6 | 24 |
| | will not adopt | 28 | 28 | 0 | 66 |
| bull fattening (%) | adopted | 14 | 35 | 87 | 3 |
| | will adopt | 38 | 50 | 12 | 48 |
| | will not adopt | 47 | 14 | 0 | 48 |
| more animal breeding (%) | adopted | 0 | 0 | 18 | 3 |
| | will adopt | 33 | 50 | 37 | 24 |
| | will not adopt | 66 | 50 | 43 | 72 |
| more nomadism (%) | adopted | 14 | 7 | 25 | 9 |
| | will adopt | 0 | 35 | 18 | 3 |
| | will not adopt | 85 | 57 | 56 | 87 |
| more animals (%) | adopted | 0 | 7 | 0 | 6 |
| | will adopt | 0 | 0 | 12 | 0 |
| | will not adopt | 100 | 93 | 87 | 94 |
| animal draft (%) | adopted | 14 | 0 | 94 | 3 |
| | will adopt | 71 | 100 | 0 | 6 |
| | will not adopt | 14 | 0 | 6 | 91 |
| hay (%) | adopted | 43 | 71 | 87 | 6 |
| | will adopt | 4 | 7 | 0 | 3 |
| | will not adopt | 52 | 21 | 12 | 91 |

Young gardeners

Young gardeners are more likely to adopt land conservation techniques. Almost all gardeners practice *Zaï*, an old technique now promoted by NGOs. As the technique is labor intensive, young farmers are more likely to adopt it. Few gardeners use improved grain seeds but are more open to the idea than the other groups. This group has a lesser access to lowlands because lowland is controlled by older farmers. Since this group has no animals, they practice less cattle fattening and do not compost farm residues.

Animal breeders

This group is more involved in animal production. A quarter of the producers bring animals to other regions but more than half prefer to keep their animals close to the compound and feed them with hay or fresh grass. Nearly all producers of this group collect hay to feed their animals. They increasingly hesitate to entrust their animals to the Fulani herders because of the risk of theft.

This group invests more in agricultural equipment for rainfed cultivation. The producers of this group apply less mineral fertilizer, probably because they think that their animals are sufficient to fertilize their crops. Most park their animals in their fields. This group buys a little more improved seeds than the others. This low percentage for all groups is due to the unavailability of seeds. Almost all producers of this group plant in line because they plough with animals. They adopt more stone lines and the *zai* waterharvesting technique. This group has built more *Boulis* than the other. *Boulis* are small pounds dug by hand used to water animals.

1 *Off-farm workers invest less in agriculture*

2 Farmers in this group do not use improved seed considered too expensive. The vast
3 majority has adopted soil and water conservation techniques and restores degraded land. This
4 group is less equipped than the others. A characteristic of this group is that of the fields of the
5 producers of this group are located in lowland. This group does not invest much in agriculture
6 though they have more lowland than the others and filed from the lowlands are in high
7 demand. This group consider animal breeding. Half of the group says that they will invest in
8 animal production.

9 *Grain growers*

10 Grain growers invest less in off-farm activities, in animal breeding or irrigated crops.
11 They concentrate on gain production, but they have adopted less innovation than the other
12 groups. They do not restore degraded land, do not conserve soils and do not practice water
13 harvesting. Most are not interested in new seeds. They do not apply mineral fertilizer. They
14 are not interested in animal breeding. However they use intensively animal draft to plough
15 and weed their rainfed crops. As such they can crop larger areas.

16 **Adaptation to new drought**

17 When asked about their adaption to a future series of droughts, most farmers tend to be
18 defiant. The vast majority consider that they will not change their activities, will remain
19 farmers and stay in the community. Half of the off-farm workers will seek another activity
20 such as gold mining or small trade (Table 4). There are too few off-farm job opportunities in
21 the region and illiteracy does not favor diversification towards off-farm activities such as
22 commercial activities. Also the neighboring country, Côte d'Ivoire, no longer welcomes
23 migrants. Even short term migration is no longer considered a suitable option. However we
24 interviewed only heads while the ones who migrate are usually dependants. These are the
25 ones that left definitively the village of Tougou during the droughts of the seventies and
26 eighties.

27 Table 4: Groups adaptation to new droughts

| | gardeners | off-farm workers | grain growers | breeders | Average |
|--|-----------|------------------|---------------|----------|---------|
| more animals sale (%) | 62 | 100 | 73 | 88 | 82 |
| less food (%) | 67 | 86 | 70 | 69 | 70 |
| less meal (%) | 67 | 86 | 27 | 81 | 56 |
| waiting for irrigation during the dry season (%) | 62 | 71 | 39 | 63 | 44 |
| short cycle grain variety (%) | 24 | 29 | 55 | 31 | 32 |
| Move to other regions (%) | 24 | 7 | 15 | 19 | 20 |
| nomadism (%) | 0 | 0 | 12 | 13 | 15 |
| temporary migration (%) | 19 | 7 | 6 | 25 | 12 |
| look for other activities (%) | 10 | 43 | 6 | 6 | 10 |
| more fertilization (%) | 0 | 0 | 9 | 19 | 6 |

28
29 The most common strategy to cope with new droughts is to sell small animals
30 (Table 4). Farmers first sell chicken, goats and sheep. Off-farm workers are more likely to sell
31 small animals. Only when the situation becomes more difficult, do they start selling cattle for
32 food. The second most practiced strategy is to reduce the number of meals per day and overall
33 food intake. The group of Off-farm workers which reduce more the number of daily meals
34 and the family feed ration because it is also the most vulnerable group.

1 A more positive strategy proposed by farmers in Tougou is to develop dry season
 2 irrigated vegetable production. Incomes generated by vegetable irrigation smooth food
 3 consumption because vegetables' sales occur in the middle of the dry season when granaries
 4 are almost empty.

5 A third of the farmers will search and use shorter cycle varieties in case of persistent
 6 drought. The farmers who do not consider this option, are satisfied with their current varieties
 7 with contrasting cycles. In case of drought they will reallocate the existing seeds between the
 8 different types of plots. Grain growers are the most likely to buy more short cycle grains
 9 varieties.

10 In case of prolonged drought most interviewed farmer will not try to improve soil
 11 fertility because improving soils makes sense when rainfalls are more regular. Also if the
 12 climate get's dryer farmers will not be able to generate the income necessary to buy fertilizers
 13 or manure. Animal's breeders will apply more organic fertilizers than the others.

14 Most breeders do not consider nomadism as an option in case of a drier climate. They
 15 also do not consider sale of cattle as a good risk coping strategy. Sales of goat and sheep is the
 16 traditional way of dealing with droughts. Animal's breeders and off-farm worker groups are
 17 the most likely to sell animals.

18 Farmers' vulnerability

19 We calculated the CILSS vulnerability index for a sample of compounds in Tougou in
 20 2004 and 2006 is presented in table 5. In 2004 only a third of the farms were able to cover
 21 their grain needs. If the purchasing power of dry season irrigation is factored in, the number
 22 of vulnerable farm is reduced by ten percent. Surprisingly in 2006 half of the farms were still
 23 vulnerable. When the incomes from irrigation are calculated, the number of vulnerable people
 24 is still forty percent and the number of very vulnerable farms is still thirty percent. These
 25 results confirm two things. First Tougou's farmers are no longer self sufficient and have to
 26 rely heavily on non- farm incomes, remittances and food aid to cover their basic food need
 27 despite the development of small scale irrigation. Second small scale irrigation is no panacea.
 28 Generated incomes are small because plots are very small and the required labor is important.

29
 30 Table 5: Vulnerability index for the community of Tougou in 2004 and in 2006

| | 2004 | | 2006 | |
|----------------------------|---------------|------------|---------------|------------|
| | No irrigation | Irrigation | No irrigation | Irrigation |
| Very vulnerable (<90%) | 60% | 50% | 41% | 31% |
| Vulnerable (<90% and 110%) | 9% | 8% | 8% | 8% |
| Not vulnerable (>110%) | 31% | 42% | 51% | 61% |

31
 32
 33 Farmers confirmed this perception of continuing vulnerability. They consider their
 34 typical grain stocks insufficient to cover their need during one full year, even if the rainy
 35 season has been regular. In the past they were able to store grains for several years. The
 36 reason for this decreasing stock is not necessarily due to lower production. The increasing
 37 need for cash explains why farmer sell early and store less. Most farmers do sell some grain at
 38 harvest time and have to buy food before the next harvest. Smaller storage is more an
 39 indicator of increased need for cash and integration to the market than of increasing food
 40 vulnerability. Farmers increasingly rely on off-farm jobs, remittances, animal sales and food
 41 aid to get food. Farmers have moved from a subsistence farming system to a more
 42 commercialized one.

43 The food crisis of 2004/2005 in the Sahel was a crisis of buying power rather than a
 44 deficit of production. Farmers were unable to buy grain because the terms of trade became too

1 unfavorable. While grain prices shot up because markets did not function well, most sources
 2 of farmers' incomes were also depressed (animal prices, remittances from Côte d'Ivoire,
 3 remittances from the cotton area). The only stable source of income in the region was the
 4 production of onions and potatoes. During the crisis, young farmers rushed to the last
 5 unoccupied reservoirs to start producing vegetables.

6 Policies to promote farmers' adaptation

7 Farmers were also asked to rank the policies more likely to improve the current
 8 situation (table 6). "Agricultural credit" is ranked first by a third of the interviewed farmers
 9 and second by a fifth. Previous governments provided credit for farm inputs and ploughs until
 10 the structural adjustment programs cancelled them because credit defaults were considered
 11 too high. Even during favourable agricultural seasons it was difficult for subsistence farmers
 12 to find the necessary cash to reimburse the credit. Some farmers used remittances from
 13 migrants to pay back the loans.
 14

15 Table 6: Ranking of the best perceived policies by farmers

| | 1 st | 2 nd | 3 rd |
|--------------------|-----------------|-----------------|-----------------|
| Credit | 38 | 19 | 15 |
| Irrigation | 21 | 29 | 13 |
| Food aid | 14 | 7 | 10 |
| Input price | 8 | 33 | 17 |
| Of-farm wage labor | 8 | 7 | 6 |
| Improved seeds | 7 | 6 | 20 |
| Insurance | 1 | 4 | 11 |
| Diversification | 3 | 1 | 7 |
| Migration | 0 | 0 | 1 |

16
 17 Farmers' need for credit in Tougou is now more pressing because most of them
 18 produce onions and potatoes which are input intensive. Farmers have to contract expensive
 19 credit with traders. The government input credit was usually provided with low interest rates
 20 but have all but disappeared. NGOs have tried to fill this gap with so-called microcredit
 21 programs. But these are shorter term and aimed at women engaged in small commercial
 22 activities and better adapted to risk and uncertainty (Nguyen, Wampfler, Benoit-Cattin and
 23 others 2002). Recently NGOs started new credit programs for horticultural production to local
 24 groups of farmers, men and women.

25 The second most popular policy is to provide irrigation. Irrigation in Burkina Faso has
 26 become central to the government's program against poverty and vulnerability. Hundreds of
 27 dams have been built in the region after the drought of the seventies and small scale irrigation
 28 is now spreading very fast. During the time of adjustment programs in the seventies and
 29 eighties, several reports criticized irrigation because many reservoirs did not seem to be used
 30 efficiently (Abernethy, Bunting and Kassam 1985; CILSS 1991). But the increasing
 31 constraints of rainfed agriculture have pushed young farmers towards irrigation. They now
 32 cultivate and irrigated the land around the hundreds of reservoirs of northern Burkina Faso,
 33 where they started producing onions, tomatoes, cabbage and potatoes. In the past irrigation
 34 was prohibited upstream of the dams around the artificial lakes for fear of erosion and
 35 sedimentation of the reservoir. Irrigation was only allowed downstream of the dams. Under
 36 population pressure, most reservoirs are now surrounded by gardens. One should investigate
 37 if such gardens really generate more erosion. In the absence of gardens, herds gather around
 38 the lake creating probably as much erosion.

39 The third most popular policy is food aid. Food aid systems have been improved in the
 40 Sahel since the government and NGOs put in place a common strategy based on early

1 warning systems, on targeting the most vulnerable, subsidizing sales of grain in local markets
2 and “food for work” programs. The food crisis of 2004/2005 created a controversy because
3 some NGOs criticized the subsidized systems put in place by large aid agencies. Market Food
4 prices of grain increased while the rainy season did not really fail because of complex market
5 failures. Finally the agencies have revised their policies. Farmers count less on aid during
6 normal years but still need help during droughts.

7 The fourth most popular policy is to subsidize input prices. The progressive decrease
8 of the fallow land reduces the recourse to the traditional land clearing. Maintaining soil
9 fertility with short term fallow is now impossible. Permanent agriculture requires the
10 application of inorganic fertilizers (Pieri 1989). Also fertilizers are required for vegetable
11 production. However fertilizers prices have increased significantly recently because fuel
12 prices have increased. Nitrogen production requires intensive energy and fertilizers’ cost is
13 also related to transport cost from the coast. In the past subsidies were provided by the
14 governments but the schemes were dismantled under the Structural Adjustment Programs.
15 Experts still argue whether subsidizing fertilizers would not be more effective than providing
16 food aid to deal with farmers’ vulnerability.

17 The fifth most popular policy is to provide jobs, such as food for work programs now
18 common in the Sahel. Since the Nobel price Amartya Sen has compared famines in India and
19 the Sahel, improving farmers’ buying power is considered to be one of the best policies to
20 reduce poverty and vulnerability. Burkina Faso will struggle to provide jobs in the industrial
21 and service sector but there are jobs in infrastructures building such as roads and dams.

22 No farmers thought that facilitating migrations would be a good policy. However
23 many experts think that it has been the best policy to alleviate poverty in the Sahel after the
24 droughts of the seventies. Hundreds of thousands of Sahelian farmers migrated to Côte
25 d’Ivoire to participate to the Cocoa boom. More than two millions burkinabè still live there,
26 some of them send remittances to their families back home. The recent crisis in Côte d’Ivoire
27 has increased Sahelian farmers’ vulnerability and the Burkinabè government is participating
28 to the resolution of the conflict. Migration has also increased within the Burkina Faso.

29 Providing improved seed is rarely mentioned as a sound policy. Farmers do not expect
30 to buy new seeds for rainfed crops. However, seed for vegetables production is considered a
31 key problem in the area. To buy these, farmers need better access to the credit market.

32 Individual insurances are never considered a sound policy by the interviewed farmers
33 because they do not really know how it works. When explained what it means, the majority of
34 the interviewed farmers said they would enrol in such a scheme if proposed. However
35 experiences of insurance schemes for small farmers in other countries have had mixed results.
36 Such schemes are based on rainfall amount rather than yields. Tougou’s farmers recall that in
37 2004 rainfalls were not that bad but harvests were destroyed by locusts. In such case an
38 insurance based on rainfall would be useless.

39 Seasonal forecast are not considered a serious instrument to reduce risk. First farmers
40 express disbelief towards such predictions. Then they do not really see how they would react
41 to seasonal forecasts because they lack the capital to invest in alternative techniques. Some
42 confirm that they would allocate their crops differently between lowland and upland fields as
43 already explained in other studies (Ingram, Roncoli and Kirshen 2002).

44 Conclusion

45 The study performed in the catchment of Tougou in northern Burkina Faso helped
46 distinguish four homogenous groups of farmers. We analyzed their respective vulnerability to

1 climate variability, their current and expected strategies and their own perception of the
2 solutions.

3 The gardeners' group is made of young farmers with small families. It produces more
4 vegetables and is less food insecure. It invests more in irrigated crops because, gardening and
5 irrigation is labor intensive and technically more complex than the production of traditional
6 rainfed crops. The group is less vulnerable because it can buy food when necessary. Small
7 scale irrigation is increasingly considered a winning strategy to reduce poverty and
8 vulnerability in the Sahel. Small scale irrigation is expanding fast, especially in Burkina Faso.
9 Now that world food prices have increased dramatically, the government is likely to invest
10 more in irrigation. However this will put an increasing pressure on available water in a
11 context of increasing water scarcity and climate uncertainty.

12 The group of off-farm workers is the most vulnerable group in terms of potential
13 satisfaction of basic food needs. This group is the less involved in agricultural production as it
14 has fewer workers than others, it invests and innovates less. It also displays larger families
15 than the gardeners and the heads are older. This group is also affected by climate variability
16 because their activities are closely related to incomes of the other groups that are more
17 involved in farming. A poor harvest means less demand for off-farm goods and services.

18 The group of the breeders displays even larger family size than the others. It is the
19 group that innovates most in terms of soil and water conservation techniques, because they
20 can apply more manure. With manure they can plant more maize, which is more productive
21 and they can improve water harvesting techniques. This group is more vulnerable than the
22 gardeners but less than the off-farm workers. Selling animals during droughts is the most
23 common strategy in the Sahel but it is deceiving because the price of animals falls during
24 droughts.

25 The group of the grains producers regroups the traditional farmers. They display the
26 largest family size because the head of the family is older than the ones from the three
27 preceding groups. They concentrate on rainfed crops and are the most vulnerable group in
28 terms of food security. The interviewed farmers are conscious that rainfed traditional grain
29 production is difficult to improve. They need to engage in the three sectors of the preceding
30 groups. They need to seek the right combination between agricultural and nonagricultural
31 activities, either by investing in irrigated crops, animal breeding or undertake off-farm
32 activities.

33 The statistical analysis shows that the four groups are not very different from one
34 another. Most groups are somehow involved in gardening, off-farm activities, animal
35 breeding and rainfed grain production. None is truly specialized. Farming characteristics
36 remain quite homogenous and households can move easily from one group to another. The
37 lack of insurances against droughts, reduce farmers ability to specialize. Sahelian farmers are
38 still vulnerable and need to diversify their activities to cope with new droughts. The
39 adaptation capacity of the Sahelian population to climatic variability should not be
40 overestimated. Most interviewed farmers consider that even during normal years they struggle
41 to eat two meals a day. The surveyed producers appeared pessimistic compared to their
42 capacities to face the challenges of a new period of drought. One third of the men of Tougou
43 already migrated definitively to the south over the last few decades. Though the remaining
44 farmers are willing to invest in farming, the majority wishes that some of their children can
45 find other activities, unless they can get access to an irrigated plot.

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