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A Typology for Vulnerability and Agriculture in Sub-Saharan Africa

Xiaobo Zhang
Marc Rockmore
and
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Development Strategy and Governance Division

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

www.ifpri.org

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ABSTRACT

This paper considers vulnerability reduction in Sub-Saharan Africa (SSA) from a more aggregated macro viewpoint. We focus on risk related to agriculture, since vulnerability and agriculture are intimately linked in SSA due to the location of the poor, their dependence on agriculture and the inherent risks of an agricultural livelihood. We argue that agricultural growth is one of the most effective means for improving permanent incomes and reducing vulnerability. However, agriculture is not homogeneous, and the inherent risks vary across countries and regions. Therefore, we also discuss appropriate investment strategies and policy instruments for different sets of risks.

Keywords: Africa, agriculture, vulnerability, typology

1. INTRODUCTION

The international community has set the ambitious goal of halving the proportion of poor by 2015. This increased focus on reducing poverty raises the question of who, exactly, are the poor? It is commonly assumed that there is a set of poor individuals, and that these individuals can be durably moved over a poverty line. However, the pool of poor is not fixed; the levels and composition of poverty change over time based on the incidence and effects of shocks on households. In fact, the levels of transitory poverty are often higher than those of chronic poverty (Baulch and Hoddinott, 2000). Therefore, development strategies should recognize the stochastic nature of poverty by incorporating vulnerability into their analysis.

The literature on vulnerability (*inter alia* Farrington, 2005; Holzmann and Jørgensen, 2000; 2000/2001 World Development Report) has traditionally focused on the response of households or small communities to risks and shocks, or on how vulnerable groups are unable to participate in income-generating opportunities. While this has broadened our understanding of the micro dynamics of vulnerability, we have not yet identified the most effective sets of instruments and strategies for reducing vulnerability at a more aggregate level. Moreover, by focusing on consumption variability, the micro vulnerability literature often tends to ignore the problems of the vulnerable, who require income growth in order to rise the above the poverty line (Chaudhuri, 2003).

This paper contributes to the literature by considering vulnerability reduction in Sub-Saharan Africa (SSA) from a more aggregated macro viewpoint.1 We review vulnerability in SSA from the viewpoints of outcome, sources of shocks, and capacity. We then focus on risk related to agriculture, since vulnerability and agriculture are intimately linked in SSA due to the location of the poor, their dependence on agriculture and the inherent risks of an agricultural livelihood. We argue that agricultural growth is one of the most effective means for improving permanent incomes and reducing vulnerability. However, agriculture is not homogeneous, and the inherent risks vary across countries and regions. Therefore, we also discuss appropriate investment strategies and policy instruments for different sets of risks.

The remainder of the paper is organized as follows. In section 2, we review the literature on vulnerability and the patterns of vulnerability in Africa. Section 3 examines the role of agriculture in reducing vulnerability, while section 4 discusses investment options. Section 5 concludes.

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1 In this paper, we use the term “macro” to refer to the aggregation of micro vulnerability, as opposed to macro events such as inflation, exchange rate movement, etc.

2. A REVIEW OF VULNERABILITY IN SSA

The meaning *vulnerability* differs across the various literatures (Alwang, Siegel and Jorgensen, 2001). In the development literature, it is generally used relative to poverty, and is defined as the *ex ante* risk that non-poor households will fall below the poverty line and poor households will remain poor (Tesliuc and Lindert, 2002 citing Holzmann, 2001). This is a dynamic process, in that it is affected by *ex ante* and *ex post* responses. In contrast, poverty is a more static concept, in that it is an *ex post* measure of welfare.

Defining vulnerability relative to both current and potential future poverty is important from a policy perspective, insofar as poverty is a stochastic phenomenon (Chaudhuri, 2003). In other words, even if poverty rates stay the same, the poor of today may not be the poor of tomorrow, and conversely, the non-poor of today may be the poor of tomorrow. This can be seen in Murdoch's (1994) distinction between chronic and transitory poverty. Looking at poverty as relating to a single group ignores this dynamism. In chronic poverty, both current consumption and permanent income are below the poverty line. Therefore, increases in current consumption will only temporarily lift the household out of poverty. In transitory poverty, however, only current consumption is below the poverty line, meaning that programs such as safety nets can be effective.

Sustainable reductions in vulnerability, therefore, have two components: increasing permanent income through growth, and reducing the variability of current consumption. High levels of permanent income will increase consumption levels, thereby reducing the likelihood of a shock pushing current consumption below the poverty line.

"Vulnerability" broadly reflects three components: (1) the sources of risk (shocks); (2) the responses of households and communities (which include the capacity to cope with shocks, as well as both *ex ante* strategies and *ex post* responses); and (3) the outcomes. Households face a variety of shocks and typically experience numerous shocks throughout the year. The ability of households to mitigate the effects of the shocks through either *ex ante* or *ex post* responses determines which shocks are important to each household.

Outcomes

An examination of outcome indicators at the national level shows that outcomes vary across countries. In the present work, we focus on hunger and undernourishment, since these are the most commonly observed outcomes of vulnerability in SSA.2 Specifically, we use three measures: the FAO's estimate of

2 Relatively little data on the levels of poverty are available for SSA. In the 2006 WDI, only 17 countries have two observations of poverty between 1980 and 2005. None have three. This is further illustrated in Baulch and Hoddinott's (2000) compilation of data on chronic and transitory poverty.

undernourishment, variability in cereal production and consumption, and the Global Hunger Index. The FAO's measure of undernourishment essentially reflects the national availability of food after some adjustments for the distribution of food within each country.3 We use the national time series data of per capita cereal production and consumption data for the period of 1981-2004 to calculate the coefficient of variation (CV) as a measure of volatility in food supply and consumption. The Global Hunger Index is a composite measure of macro (undernourishment) and micro (child mortality and child malnutrition) indicators (Wiesmann, 2006).

Table 1 presents the three indicators by country. Several findings are apparent from the table. First, while the average and median for undernourishment in SSA is approximately 30%, a large variation exists among the levels, with 10 countries falling below 15% and six countries exceeding 60%. Second, with the exception of Angola, the variability in cereal production in general is larger than that in cereal consumption. A good example may be seen in the case of Mauritius, where the CV in cereal production is the highest at 1.08, while its variability in consumption is the lowest at 0.03. Interestingly, most of the countries with high production variability are either islands or small economies. This suggests that production variability may not necessarily lead to consumption variability if a country has the capacity to smooth out production fluctuation-related consumption changes by importing food.

Risk

When talking about vulnerability, a key question is "vulnerable to what?" In general, shocks can be divided into two categories: idiosyncratic and covariate (systemic). The former affects individuals or households and includes such things as the illness or death of a family member. In contrast, systemic shocks affect groups of households or a given geographical area. Examples include drought, conflict, declining commodity prices, rising input prices, or the collapse of markets. In this paper, we focus on the covariate shocks, including both man-made and natural shocks.

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3 The FAO's estimate of undernourishment is primarily comprised of three parts. The daily per capita dietary energy supply (DES) represents the total energy available for human consumption per day per capita, and is calculated based on the country-level food balance sheets of the FAO. The coefficient of variation (CV) in dietary energy intake reflects the distribution of dietary energy intake within each country. The CV is fixed and does not change across time. The minimum daily per capita dietary energy requirement represents the threshold below which a person is considered undernourished. Smith (1998), Naiken (2002), Haddad (2001), and Svedberg (2001) provide discussions about the FAO measure and its perceived flaws.

Table 1. Undernourishment and variability in cereal production and consumption

Variable	Undernourished (%)		Coefficient of variation: Cereal Production		Coefficient of variation: Cereal Food Consumption		Global Hunger Index	
Year(s)	**2003**	**Rank**	**1981-2004**	**Rank**	**1981-2004**	**Rank**	**2003**	**Rank**
Angola	38	13	0.18	23	0.34	1	32.17	7
Benin	14	34	0.15	31	0.07	26	17.77	34
Botswana	30	22	.	.	.	.	18.57	32
Burkina Faso	17	33	0.18	23	0.15	8	25.8	19
Burundi	67	3	0.13	35	0.11	12	42.7	1
Cameroon	25	26	0.13	35	0.08	19	19.52	28
Cape Verde	.	.	0.71	2	0.06	32	.	.
Central African Republic	45	9	0.22	20	0.07	26	28.43	14
Chad	33	19	0.24	18	0.12	10	27.33	16
Comoros	62	4	0.11	38	0.04	37	30.81	10
Congo, Dem. Rep.	72	2	0.08	42	0.04	37	40.83	2
Congo, Rep.	34	17	0.63	3	0.21	2	.	.
Cote d'Ivoire	14	34	0.1	41	0.07	26	18.13	33
Equatorial Guinea	.	.	.	.	.	.	.	.
Eritrea	73	1	.	.	.	.	40.37	3
Ethiopia	46	8	0.16	29	0.08	19	36.7	4
Gabon	5	43	0.18	23	0.17	5	9	39
Gambia, The	27	24	0.18	23	0.08	19	18.83	30
Ghana	12	36	0.22	20	0.18	4	14.87	36
Guinea	24	28	0.13	35	0.04	37	21.73	23
Guinea-Bissau	37	15	0.18	23	0.06	32	26.61	18
Kenya	31	21	0.21	22	0.08	19	21.73	23
Lesotho	12	36	0.29	15	0.07	26	12.8	38
Liberia	49	6	0.55	5	0.21	2	32	8
Madagascar	38	13	0.11	38	0.1	15	29.92	12
Malawi	34	17	0.23	19	0.06	32	25.4	21
Mali	28	23	0.14	33	0.09	16	28.07	15
Mauritania	10	39	0.38	8	0.09	16	20.03	27
Mauritius	6	42	1.08	1	0.03	42	3.8	42
Mayotte	.	.	.	.	.	.	6.42	41
Mozambique	45	9	0.36	10	0.17	5	28.83	13
Namibia	23	29	0.3	14	0.04	37	17.5	35
Niger	32	20	0.16	29	0.04	37	33.43	6
Nigeria	9	40	0.17	28	0.11	12	19.17	29
Rwanda	36	16	0.27	17	0.16	7	27.2	17
Sao Tome and Principe	12	36	0.58	4	0.12	10	.	.
Senegal	23	29	0.28	16	0.08	19	20.13	26
Seychelles	9	40	.	.	0.06	32	.	.
Sierra Leone	50	5	0.32	12	0.07	26	35.2	5
Somalia	.	.	.	.	.	.	7.66	40
South Africa	.	.	0.32	12	0.02	43	25.67	20
Sudan	27	.	0.34	11	0.08	19	14.87	36
Swaziland	19	31	0.42	7	0.13	9	29.97	11
Tanzania	44	12	0.15	31	0.05	36	21.1	25
Togo	25	26	0.14	33	0.07	26	2.47	43
Uganda	19	31	0.11	38	0.11	12	18.63	31
Zambia	47	7	0.38	8	0.08	19	31.77	9
Zimbabwe	45	9	0.48	6	0.09	16	23.2	22

Note: Data for the first three indicators are drawn from FAOSTAT. The coefficient of variation was calculated by the authors. The last column is from "A Global Hunger Index, Measurement Concept, Ranking of Countries, and Trends" by Doris Wiesmann, FCND Discussion Paper 212 (2006, IFPRI).

Civil wars and, more broadly, instability have plagued SSA since the wave of independence began in the 1960s. For instance, Miguel *et al.* (2004) report that during the 1980s and 1990s, civil conflict existed in 29 of the 43 countries in Sub-Saharan Africa. While the severity of conflicts has arguably declined in recent years with the end of long-standing conflicts in Angola, Liberia, Mozambique and Sierra Leone, conflict remains an important factor, in part because it has lasting effects on the civil population and current stocks of infrastructure, and may also influence potential future investment. Recently, the FAO identified decreasing conflict as one of the five major common factors important to reducing food insecurity.4 To measure this, we use the number of years during which a given country endured conflict, which is defined at least 1,000 deaths due to politically-motivated violence during the year. These data are drawn from the armed conflict database available through the Centre for the Study of Civil War at the International Peace Research Institute. Table 2 presents the number of years with a conflict (as defined above) for different countries over different periods. Among the 47 countries surveyed, 18 experienced conflict during the period of 1970-2004.5 When comparing Table 1 and Table 2, it becomes obvious that the countries subject to high food insecurity and consumption variability are also war-stricken countries. It is also apparent that conflict-bearing countries generally perform worse in the major outcome variables of vulnerability compared to non-conflict countries. Thus, it is important to consider the role of conflict when addressing vulnerability in SSA.

Tropical diseases have long been identified as a key constraint to economic growth (*inter alia* Gallup *et al.*, 1999; Murray and Lopez, 1996). Malaria has historically been an impediment to development in the tropics. More recently, HIV/AIDS has dramatically increased, leading to potentially serious results in terms of increased mortality and foregone economic growth. Gillespie and Kadiyala (2005) provide an overview of the links between HIV/AIDS and food and nutritional security. HIV/AIDS has been shown to affect cropping patterns and crop value across a variety of Sub-Saharan African countries (*inter alia* Donovan *et al*., 2003; Kwarmba, 1997; Muwanga, 2002; Yamano and Jayne, 2004;), the availability of labor (Shah *et al*., 2001), and the sale of livestock following the death of family members (Engh *et al*., 2000; and Haslwimmer, 1994).

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4 Based upon a study of 13 countries, the FAO (2001-CL 120th session) identified the following factors: (a) peace and social stability; (b) strong economic growth; (c) primacy of policy support; (d) social safety nets for the poor; and (e) access to food imports including food aid.

5 The apparent difference between Table 2 and the number of conflicts reported by Miguel *et al.* (2004) results from the use of different data sets and definitions. Regardless of the data, a large percentage of countries in Sub-Saharan Africa have suffered from conflict.

Table 2. Number of years with conflicts killing at least 1,000

	1970-2004	1970-1980	1981-2004
Angola	24	6	18
Benin	0	0	0
Botswana	0	0	0
Burkina Faso	0	0	0
Burundi	4	0	4
Cameroon	0	0	0
Cape Verde	0	0	0
Central African Republic	0	0	0
Chad	20	11	9
Comoros	0	0	0
Congo, Dem. Rep.	4	0	4
Congo, Rep.	2	0	2
Cote d'Ivoire	0	0	0
Equatorial Guinea	0	0	0
Eritrea	3	0	3
Ethiopia	21	7	14
Gabon	0	0	0
Gambia, The	0	0	0
Ghana	0	0	0
Guinea	0	0	0
Guinea-Bissau	1	0	1
Kenya	0	0	0
Lesotho	0	0	0
Liberia	3	0	3
Madagascar	0	0	0
Malawi	0	0	0
Mali	0	0	0
Mauritania	0	0	0
Mauritius	0	0	0
Mayotte	23	3	20
Mozambique	12	0	12
Namibia	0	0	0
Niger	0	0	0
Nigeria	1	1	0
Rwanda	4	0	4
Sao Tome and Principe	0	0	0
Senegal	0	0	0
Seychelles	0	0	0
Sierra Leone	2	0	2
Somalia	4	0	4
South Africa	7	1	6
Sudan	0	0	0
Swaziland	0	0	0
Tanzania	0	0	0
Togo	0	0	0
Uganda	12	1	11
Zambia	0	0	0
Zimbabwe	4	4	0

Source: Data are drawn from the Centre for the Study of Civil War at the International Peace Research Institute.

Table 3 lists the incidence rates of malaria for the most recent year and the adult HIV/AIDS levels.6 We choose these indicators as measures of tropical diseases since they are widely available, and the "pattern for malaria is common to a range of infectious diseases" (p. 22, Gallup *et al.*, 1999). In addition to being severe idiosyncratic shocks, these two diseases may also have systemic effects through such pathways as labor markets. As can be seen in the table, malaria is primarily concentrated in tropical areas, with the highest levels seen in Sao Tome, Principe and Uganda.7 HIV/AIDS is primarily concentrated in South and East Africa. In particular, countries with high levels of HIV/AIDS tend to rank worse on the Global Hunger Index. Because health itself is an important outcome variable, the risk associated with malaria and HIV/AIDS cannot be understated when discussing malnourishment, even though these factors may not directly relate to malnutrition.

In this paper, we focus on covariate agricultural risk due to the importance of agriculture with respect to vulnerability in SSA, and the natural role of government policy in dealing with covariate risk. Climate change is expected to increase this agricultural risk in many areas by altering the levels and variance of rainfall (Table 3) and the length of the growing season (Table 5). Among the many biophysical factors that affect agricultural choices and performance, moisture availability is key.

As can be seen in Figures 1 and 2, there is a strong spatial component to the levels and variability of rainfall in Africa. The majority of the high rainfall areas are found in the central and western areas of SSA (from Gabon to Congo), and some areas in eastern Africa. The variability of rainfall in these areas is relatively low. Total rainfall is roughly equal across the remainder of SSA (although it is somewhat higher in the southeast); however rainfall variability differs across these regions, with Madagascar, Angola and Somalia considered lower rainfall regions, while countries bordering the Sahara tend to show high levels of rainfall variability.

These general impressions are reflected in Table 4, which shows the estimated share of rural population by the level and variability of annual rainfall in SSA. Interestingly, although Rwanda ranks in the bottom third in terms of the prevalence of undernourishment and variability in cereal consumption, the share of rural population affected by low rainfall and high variability is only 1%. By and large, Rwanda has good agricultural production conditions with little exposure to natural shocks. Therefore, it is likely that the vulnerability in Rwanda mainly comes from man-made shocks, such as civil conflict or structural problems (e.g. land scarcity and low crop yields). This example highlights the importance of examining the sources of vulnerability.

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6 We calculate the incidence by dividing the total reported cases by the population for the year.

7 The surprisingly high levels in Uganda are driven by increasing treatment failures due to drug resistance and the abolition of user fees in the public sector (CDC, 2004).

Table 3. Levels of tropical disease

Country	Malaria Rate*	Adult HIV/AIDS Rate**	Country Rank: Malaria Rate*	Country Rank: Adult HIV/AIDS Rate**	Country	Malaria Rate*	Adult HIV/AIDS Rate**	Country Rank: Malaria Rate*	Country Rank: Adult HIV/AIDS Rate**
Angola	9.6%	3.7%	20	22					
Benin	10.5%	1.8%	15	33	Liberia	28.8%	5.9%	4	16
Botswana	1.3%	24.1%	37	2	Madagascar	12.0%	0.5%	13	44
Burkina Faso	12.1%	2.0%	12	32	Malawi	23.6%	14.1%	7	9
Burundi	26.5%	3.3%	6	24	Mali	6.4%	1.7%	26	34
Cameroon	4.7%	5.4%	29	17	Mauritania	6.0%	0.7%	27	42
Cape Verde	0.0%	.	44	.	Mauritius	0.0%	0.6%	44	43
Central African Republic	2.4%	10.7%	33	10	Mozambique	26.7%	16.1%	5	8
Chad	4.5%	3.5%	30	23	Namibia	22.4%	19.6%	8	5
Comoros	0.7%	0.0%	39	45	Niger	5.4%	1.1%	28	39
Congo, Dem. Rep.	8.1%	3.2%	23	25	Nigeria	2.1%	3.9%	35	20
Congo, Rep.	0.5%	5.3%	41	18	Rwanda	9.8%	3.1%	18	27
Cote d'Ivoire	2.3%	7.1%	34	12	Sao Tome and Principe	42.3%	.	2	.
Djibouti	0.7%	3.1%	39	27	Senegal	10.8%	0.9%	14	40
Equatorial Guinea	3.1%	3.2%	32	25	Sierra Leone	9.4%	1.6%	21	35
Eritrea	1.8%	2.4%	36	29	Somalia	0.3%	0.9%	43	40
Ethiopia	0.8%	4.4%	38	19	South Africa	0.0%	18.8%	44	6
Gabon	6.6%	7.9%	25	11	Sudan	8.8%	1.6%	22	35
Gambia, The	10.0%	2.4%	17	29	Swaziland	3.3%	33.4%	31	1
Ghana	16.7%	2.3%	10	31	Tanzania	29.0%	6.7%	3	13
Guinea	10.5%	1.5%	15	38	Togo	7.8%	6.5%	24	14
Guinea-Bissau	13.5%	3.8%	11	21	Uganda	45.9%	17.0%	1	7
Kenya	0.4%	6.1%	42	15	Zambia	18.4%	20.1%	9	4
Lesotho	0.0%	23.2%	44	3	Zimbabwe	9.8%	1.6%	18	35

*The Malaria information is based on the most recent data from the WHO Global Health Atlas, with the exception of that from Lesotho, which is drawn from the 2003 Millennium Indicators Database. Percent values are calculated by dividing the total number of reported cases by the total population, as given in the WDI.
**The HIV data are from the UNAIDS 2006 Global Report and are for Adults 15+ in the year 2003. The data for Liberia and Ethiopia were drawn from the WDI and are for adults (15-49) in 2003.

Table 4. Percentage of rural population affected by rainfall risk

Country	Rainfall*	Rank	Country	Rainfall*	Rank
Angola	18.7%	26			
Benin	13.9%	27	Liberia	0.0%	38
Botswana	100.0%	1	Madagascar	100.0%	1
Burkina Faso	21.4%	24	Malawi	50.3%	18
Burundi	2.7%	31	Mali	50.2%	19
Cameroon	4.7%	30	Mauritania	100.0%	1
Central African Republic	0.2%	37	Mozambique	40.7%	20
Chad	33.9%	22	Namibia	100.0%	1
Congo, Dem. Rep.	0.5%	35	Niger	89.8%	9
Congo, Rep.	0.0%	38	Nigeria	20.9%	25
Cote d'Ivoire	0.0%	38	Rwanda	0.7%	33
Djibouti	100.0%	1	Senegal	82.8%	12
Equatorial Guinea	0.0%	38	Sierra Leone	0.0%	38
Eritrea	100.0%	1	Somalia	100.0%	1
Ethiopia	34.9%	21	South Africa	80.0%	13
Gabon	2.5%	32	Sudan	80.0%	13
Gambia, The	88.5%	10	Swaziland	88.0%	11
Ghana	9.1%	28	Tanzania	52.4%	17
Guinea	0.0%	38	Togo	6.2%	29
Guinea-Bissau	0.3%	36	Uganda	0.7%	33
Kenya	32.8%	23	Zambia	55.9%	16
Lesotho	66.9%	15	Zimbabwe	94.4%	8

*Rainfall risk refers to areas with 1000 mm or less average annual rainfall and a coefficient of variation of 18 or higher. The rainfall data are drawn from the University of East Anglia's Climate Research Unit (Mitchell *et al*. 2003). These data are interpolated globally from weather station records at a 0.5 decimal degree resolution for the period 1951-2005.

Expected changes in climate are likely to exacerbate moisture-related agricultural risk by altering the levels and variance of rainfall (Table 3) and the length of the growing season (Table 5). However, the geographical distribution of this vulnerability to climate change is not uniform. Figure 3 shows the expected change in length of growing period between the years 2000 and 2030. The areas where the growth period is expected to decrease by more than two weeks over this time are primarily concentrated in southern and central Africa (particularly Angola), although the coincidence with rural population distributions highlights several countries in other sub-regions where this will become an issue. As a general observation, areas that are already characterized by relatively short growing periods are most often predicted to experience significant reductions over the next several decades. We include these data to highlight climate change as an important issue in the strategic discussions of agricultural risk. However, the nature of climate predictions is speculative (Govindasamy *et al*., 2003) and it is beyond the scope of this paper to quantify the likelihood of these outcomes or their spatial accuracy. Thus, while we include these data to round out our discussion, we do not use them as quantitative inputs in our typology.

Table 5. Length of growing season and arable land per capita

Country	Length of growing period (LGP)*	Arable land per capita (hectares)**	Country Rank			Country	Length of growing period (LGP)*	Arable land per capita (hectares)**	Country Rank		
			Land	Composite 1 (Land*LGP)	Composite 2 (Land*LGP^2)				Land	Composite 1 (Land*LGP)	Composite 2 (Land*LGP^2)
Angola	182.6	0.22	16	12	16						
Benin	179.3	0.34	19	7	7	Liberia	277.7	0.12	2	17	30
Botswana	30.6	0.21	42	40	39	Madagascar	183.4	0.17	15	22	24
Burkina Faso	95.9	0.39	30	15	11	Malawi	152.3	0.20	22	24	21
Burundi	223.7	0.14	10	21	26	Mali	88.6	0.37	32	19	12
Cameroon	209.3	0.38	13	3	5	Mauritania	31.2	0.17	41	42	41
Central African Republic	216.2	0.49	11	1	1	Mozambique	128.6	0.23	26	25	19
Chad	97.0	0.39	29	14	10	Namibia	35.4	0.41	40	38	22
Congo, Dem. Rep.	258.0	0.12	4	23	31	Niger	40.3	1.11	38	9	2
Congo, Rep.	252.9	0.13	5	18	28	Nigeria	172.1	0.24	20	11	13
Cote d'Ivoire	225.2	0.19	8	10	17	Rwanda	240.9	0.14	6	16	25
Djibouti	30.0	0.00	43	43	43	Senegal	88.6	0.22	32	33	27
Equatorial Guinea	296.2	0.27	1	2	6	Sierra Leone	231.2	0.11	7	29	35
Eritrea	50.6	0.14	37	39	40	Somalia	38.5	0.14	39	41	42
Ethiopia	136.9	0.16	25	32	33	South Africa	92.4	0.32	31	26	14
Gabon	261.2	0.24	3	6	9	Sudan	65.9	0.49	36	20	8
Gambia, The	85.1	0.22	34	35	29	Swaziland	117.4	0.16	27	34	34
Ghana	224.9	0.20	9	8	15	Tanzania	165.2	0.11	21	36	38
Guinea	192.2	0.12	14	31	36	Togo	180.8	0.43	18	4	3
Guinea-Bissau	145.7	0.20	23	27	23	Uganda	210.8	0.19	12	13	18
Kenya	181.9	0.14	17	28	32	Zambia	137.0	0.47	24	5	4
Lesotho	81.9	0.18	35	37	37	Zimbabwe	100.0	0.25	28	30	20

* LGP estimates are based upon on 1-km^2 estimates of the length of growing period in days for 2000 (Thornton, unpublished). LGP, which is defined as the number of days in a year with conditions suitable for plant growth, is calculated on the basis of the number of days with minimum temperatures greater than 5 degrees Celsius during which precipitation exceeds evapo-transpiration by 50%, taking into account the water holding capacity of the predominant soil type. The country numbers are generated using a rural population weighted by the average of the different growing periods. The values for the growing periods are the medians of the following categories: 0-60, 61-120, 121-180, 181-240, 241-300 and 301-365 days.

** 2003 data from the WDI.

Figure 1. Precipitation

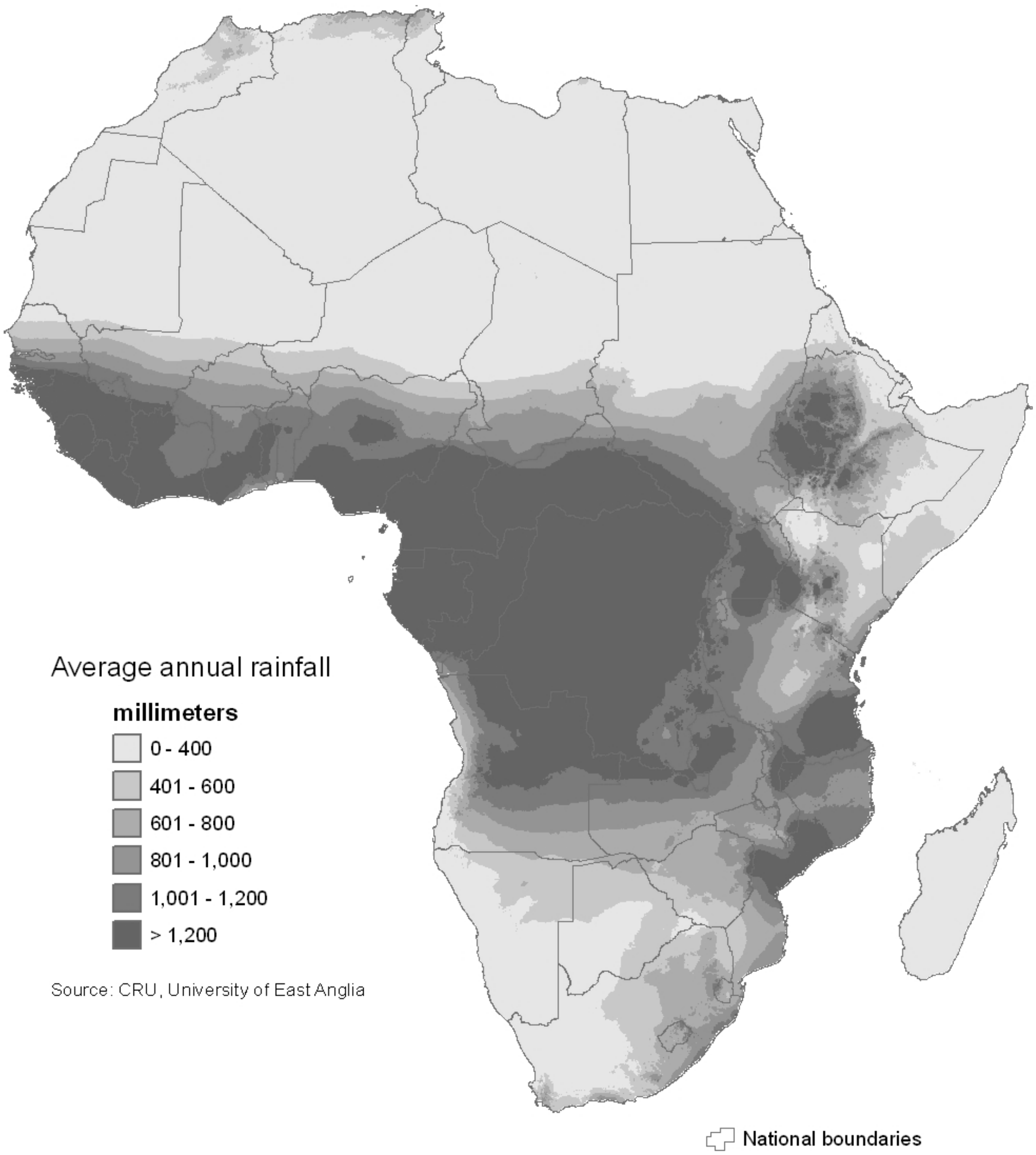


Figure 2. Precipitation variability

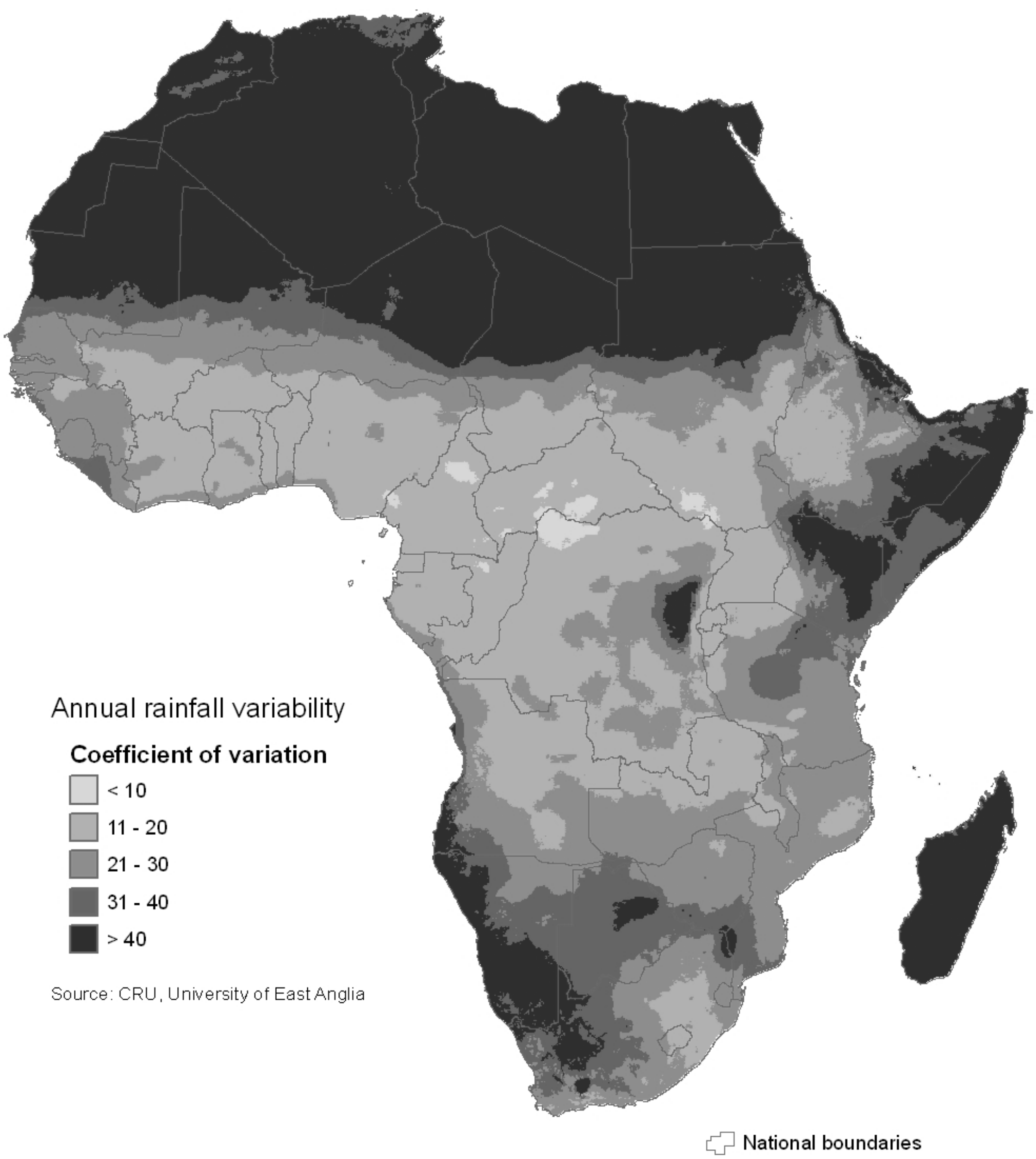
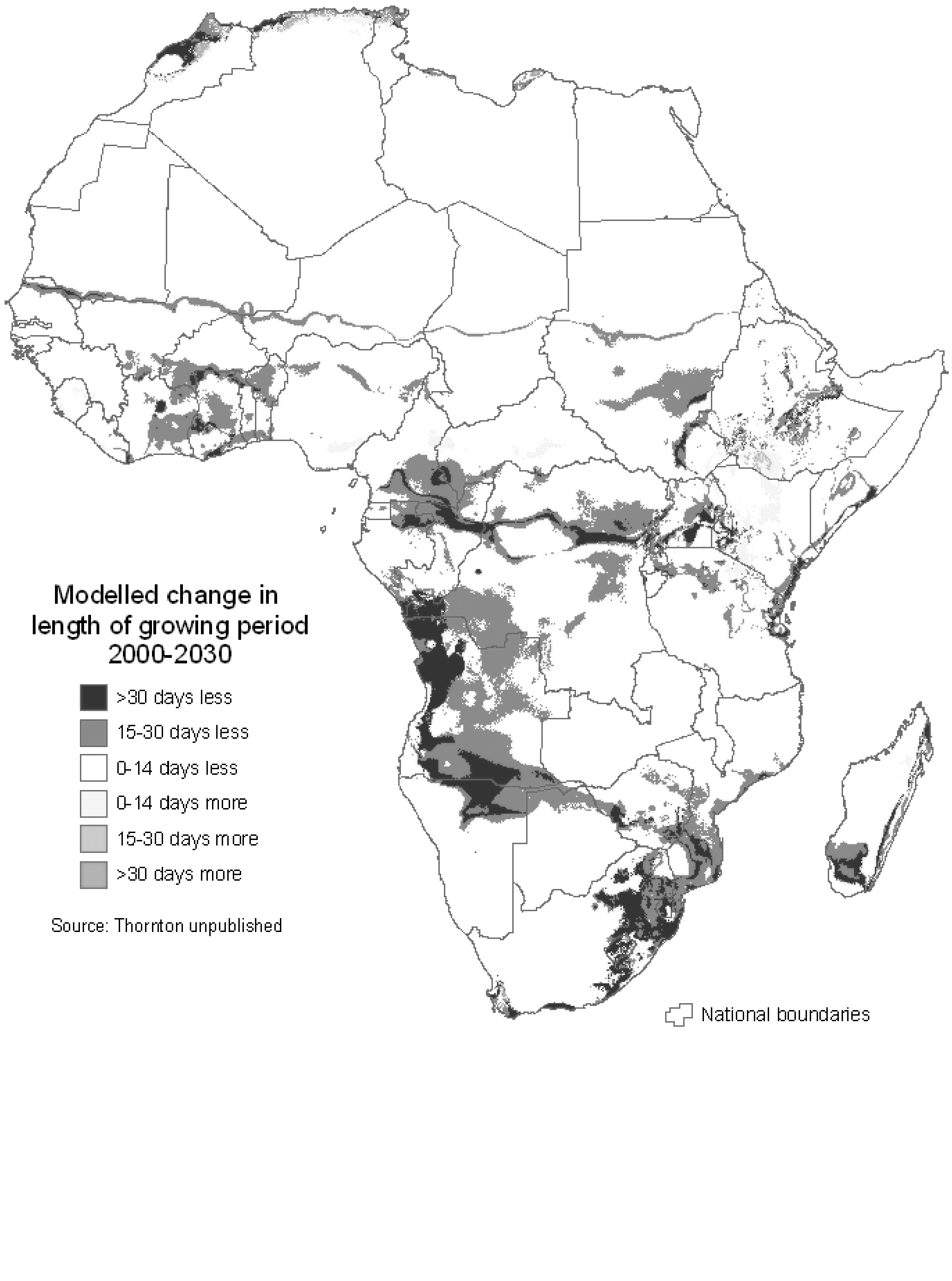


Figure 3. Estimated change in length of growing period



Responses (capacity)

The third dimension of vulnerability is related to the responses of households and communities to both risks (*ex ante* strategies) and the realization of risks, i.e. shocks (*ex poste* responses). Informal risk mechanisms are generally more successful with dealing with idiosyncratic risk. Households are typically able to mitigate the effects of small and frequent shocks, but tend to have difficultly insuring against large, infrequent shocks that have lasting effects (e.g. disability or chronic illness). However, these informal mechanisms are not completely effective; they are often costly and may result in the household forgoing income-generating opportunities (Murdoch, 2004).

By and large, both informal and formal copying strategies at the micro level fail to adequately address covariate shocks (Holzmann, 2001). In contrast, government investment and policies are thought to effectively address covariate shocks. For instance, commodity price stabilization programs can reduce price risk, while food imports and food aid are widely used in the event of war or natural disasters. Governments, however, often have difficultly dealing with idiosyncratic shocks, for a variety of reasons including asymmetric and imperfect information, as well as high transaction costs (Murdoch, 2004).

More broadly, countries have different abilities to respond to large covariate shocks. Table 6 shows two aggregate proxies for the ability of countries to respond, namely the share of the rural population and the food imports as a percentage of exported goods and services. These are valid proxies because the sources of shocks and coping strategies in an urbanized economy differ greatly from those in an agrarian economy. More urbanized economies tend to have additional resources for importing food when necessary, and the non-farm sector is generally more immune to weather shocks than the farming sector. When facing food shortages, countries have the option of importing food. The ability to import food relies on hard currency generated from exports. Therefore, we also examine the burden of total food bill (Díaz-Bonilla, Thomas, and Robinson, 2002). During the period of 1993-2004, Rwanda spent 42% of its export revenue on food imports, whereas Nigeria, which has rich oil resources, spent only 0.11% of its export revenue on food over the same period.

In the absence of trade, food availability is largely determined by the land-population ratio and other natural conditions (e.g. the length of the growing season). A simple examination of arable land per capita can be misleading, as it does not account for the quality of the land or the length of the growing season. For instance, Niger and Sudan have two of the three highest amounts of arable land per capita in SSA. However, this is largely the result of poor agro-ecological conditions, which result in low population densities and large farm sizes. However, examination of a composite index such as the product of the amount of effective land per capita and the length of the growth period (or its square), it is apparent that countries like Mali and Niger are particularly vulnerable due to their lack of domestic capacity and low overall trade.

Table 6. Proxies for country coping capacity

Country	Rural Population (%)*	Ratio of food imports to exports of goods and services**
Angola	63.5	.
Benin	54.7	0.45
Botswana	48.0	0.09
Burkina Faso	81.8	0.42
Burundi	89.7	0.38
Cameroon	47.8	0.1
Cape Verde	43.3	0.61
Central African Republic	56.8	0.2
Chad	74.6	0.28
Comoros	64.3	0.62
Congo, Dem. Rep.	67.7	.
Congo, Rep.	46.0	0.1
Cote d'Ivoire	54.6	0.12
Equatorial Guinea	51.0	.
Eritrea	79.6	.
Ethiopia	84.1	0.18
Gabon	15.6	0.07
Gambia, The	73.8	0.42
Ghana	54.2	0.16
Guinea	64.3	0.21
Guinea-Bissau	65.2	1.96
Kenya	59.5	0.14
Lesotho	81.9	.
Liberia	52.7	.
Madagascar	73.2	0.12
Malawi	83.3	0.2
Mali	67.0	0.23
Mauritania	37.0	0.23
Mauritius	56.5	0.13
Mayotte	.	.
Mozambique	63.2	0.27
Namibia	67.0	0.14
Niger	77.3	0.46
Nigeria	52.5	0.11
Rwanda	79.9	0.42
Sao Tome and Principe	62.1	.
Senegal	49.7	0.31
Seychelles	49.9	0.21
Sierra Leone	60.5	0.39
Somalia	64.6	.
South Africa	42.6	0.05
Sudan	60.2	0.29
Swaziland	76.3	0.18
Tanzania	63.5	0.18
Togo	64.3	0.25
Uganda	87.7	0.28
Zambia	63.8	0.12
Zimbabwe	64.6	0.11

*2005 rural population data from the WDI
** Authors' calculation based on 1995-2004 data from the WDI

Moreover, any judgment regarding the ability of households and governments to respond effectively presupposes a certain level of stability. Conflicts not only directly cause hunger and poverty, but also impede the ability of governments and international relief organizations to respond effectively. Beyond its immediate impact, conflict may also therefore result in longer-term effects such as the destruction of infrastructure and decreased agricultural productivity (Fulginiti, Perrin and Yu, 2004). These effects are particularly severe and long-lasting when food is used as a weapon (i.e. when food systems are intentionally destroyed as part of the conflict) (Macrae and Zwi, 1993; Messer, 1990). In this situation, the ability of government to directly intervene post-conflict may be limited to food aid until the necessary infrastructure and food systems are rebuilt.

3. GROWTH AND VULNERABILITY REDUCTION: THE ROLE OF AGRICULTURE

As the previous section illustrates, aggregate vulnerability varies greatly across countries. In large part, agriculture is the source of much of the risk, and is arguably central to reducing vulnerability and poverty.

Agriculture and vulnerability are linked in SSA due to the location of the poor and their dependence on the agricultural sector. Maxwell (2001) estimates that roughly 70% of the workforce in Africa is at least partially engaged in agriculture. Farming is largely a risk business because weather is highly variable and income streams are lumpy. Therefore, agricultural production variability has a pronounced impact on farmers' incomes. Slight changes in temperature or rainfall can dramatically change yields. Moreover, agricultural income is generally obtained in a lump sum during the harvest and post-harvest period, and this income must be spread throughout the year. However, the general lack of financial development in SSA makes it difficult for households to smooth their income throughout the year. In addition, risks associated with storage also mean that agriculture is inherently risky.

The rural non-farm sector, which corresponds to roughly 40-60 percent of rural income (Davis, 2003), is also closely tied to rural livelihoods. Moreover, diversification has long been recognized as an important strategy for reducing risk and vulnerability (Ellis and Freeman, 2004). In particular, non-farm income diversification leads to both higher incomes and an increased ability to cope with shocks such as droughts. Unsurprisingly, therefore, a number of studies have found that non-farm income and household welfare indicators are positively related in rural Sub-Saharan Africa (Barrett *et al.*, 2001).

However, there are a number of reasons to believe that the rural non-farm sector may not be a sufficient avenue for reducing vulnerability and poverty. Since the rural non-farm sector is usually less vulnerable to weather shocks, a vibrant rural non-farm sector would help to diversify agricultural risks. However, due to the aggregate size of the agricultural sector, risks in agricultural production would still dominate. In these countries, variability in agricultural production may affect other sectors and, more broadly, affect the macro economy. In particular, industries that depend upon the agricultural sector, such as food processing and textiles, are often adversely affected by volatility in the agricultural supply. Moreover, large decreases in agricultural production (e.g. due to drought) can deteriorate the balance of payments, increasing the amount of government funds being spent on food aid and relief as opposed to other equally important public goods and services. Certainly, as a given economy develops, the share of agriculture in the overall economy declines and people are likely to become less vulnerable to weather shocks. However, this is not yet the case in SSA.

Within the agricultural sector, production diversification is often used as a coping strategy for reducing vulnerability. Due to a general lack of data, we cannot address this point directly in the present paper. To some extent, however, the agricultural potential variables examined herein, such as rainfall and the length of growth period, capture the ability of diversification. Higher rainfall and a longer growth period will allow a broader range of strategies compared to other end of the spectrum, such as the conditions experienced by pastoral nomads in marginal areas. In support of this, Jansen, Siegel and Pichón (2005) show that higher rainfall is linked with diversification in Honduras.

By targeting rural and vulnerable populations, growth in agriculture will play a large role in reducing vulnerability in both the short and long terms. Such growth will increase permanent incomes and improve the capacity of households to deal with shocks. Moreover, depending how the growth is stimulated and supported by policies and investments, it may also reduce some of the underlying risk in agriculture.

As previously noted, poverty can be divided into chronic and transitory poverty. Growth is the major instrument for achieving sustainable reductions in the vulnerability of production and the variability of current consumption. Agricultural growth may be the most appropriate way to achieve both of these goals for several reasons.

Firstly, in the short term, agricultural growth reduces vulnerability by increasing farmers' incomes, providing employment for agricultural labor, increasing the wages of agricultural labor, and lowering food prices for both the urban and rural poor (Chaudhuri, 2003; Timmer, 1988). Apart from net food consumers, households involved in agriculture, especially those who are linked to markets, will be the primary beneficiaries. This increased income will help vulnerable households build their assets, thereby increasing their ability to generate income and resist shocks.

Secondly, in the medium term, agricultural growth has important indirect effects through growth linkages that stimulate the non-agricultural sector (Stern, 1996; Timmer, 1988). At lower levels of development, the backward linkages from agriculture are especially strong (Vogel, 1994). Agricultural productivity is also positively linked with non-farm activity in Africa (Barrett et al., 2001).

Thirdly, as a sector, agriculture is important for both overall growth and export earnings. It lies at the center of the rural economy and is often integral to national growth in countries without mineral resources (WFP, 2002). For instance, in 1997/1998, the cotton sector in Mali represented close to half of the country's export revenue, and 6 and 9 percent of the total tax revenue and GDP, respectively (IMF, 2002). Thus, the sector directly affected the livelihoods of roughly a third of the population.

Agricultural Growth Typology

While agricultural growth is important to reducing vulnerability and supporting the overall growth process, its role will vary across countries based upon the overall economic structure and potential for agriculture (Diao *et al*. 2006). Table 7 shows the countries in SSA grouped based upon these two considerations.

Table 7. A typology of agricultural risk and the role of agriculture in growth

		Resource-Rich	Non Resource-Rich	
			Coastal	Inland
Agricultural Risk (based on rainfall and growth period)	**Low**	**(1)** **Nigeria**	**(2)** **Mozambique** Togo	**(3)** **Uganda** Rwanda
	Medium	(4) Angola Cameroon Chad Congo Dem Rep Gabon Guinea Liberia Mauritania Namibia Sao Tome and Principe Sierra Leone Sudan **Zambia**	(5) Benin **Ghana** Guinea Bissau **Kenya** Madagascar Mauritania Senegal Somalia South Africa Tanzania	(6) Burkina Faso Burundi Central African Republic **Ethiopia** Malawi **Mali** Niger Swaziland Zimbabwe
	High	(7) Botswana	(8) Cote d'Ivoire Eritrea Gambia	(9) Lesotho

Note: The county names in bold are included in the USAID Presidential "Initiative to End Hunger in Africa." Several countries are omitted due to a lack of rainfall data. A country is defined as having a low agricultural risk if the rainfall risk is below the SSA sample median and the length of growth period is above the median. If a country scores higher than the median of rainfall risk in the sample and lower than the median value of the length of growth period, it is classified as high agricultural risk. The remaining countries are in the medium category.

The use of geography and resource endowment to group SSA countries is well established (UNIDO, 2004; Collier and O'Connell, forthcoming). In combination, these two factors shape the overall structure of the economy and its opportunities for future economic growth. For instance, resource-rich countries often have over-valued exchange rates due to the export of natural resources, thereby creating unfavorable terms of trade for the agricultural sector. Likewise, land-locked resource-poor countries are more dependent on their neighbors for trade and infrastructure compared to coastal economies.

Our classification of resource-rich versus non-rich countries draws on the work of Diao *et al*. (2006), UNIDO (2004), and Collier and O'Connell (forthcoming). The classifications largely overlap, with 14 resource-rich countries commonly identified among the three papers. However, some differences exist between these studies.8 The UNIDO list of resource-rich countries contains only the overlapping

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8 The following countries are considered resource-rich in all three prior papers as well as the present work: Angola, Botswana, Cameroon, Republic of Congo, Equatorial Guinea, Gabon, Guinea, Mauritania, Namibia, Nigeria, Sao Tome and Principe, Sierra Leone, and Zambia.

countries, and the basis of the classification is unclear.9 While based on the UNIDO (2004) report, Diao et al. (2006) includes Sudan on the list of resource-rich countries without explanation. The Collier and O'Connell classification (forthcoming) relies on the natural rents and the share of primary commodity exports for classification,10 and includes the common 14 countries as well as Liberia and Swaziland under the category of 'resource-rich.

Our list of resource-rich countries includes the 14 common rich countries along with Chad, the Democratic Republic of Congo, Liberia, and Sudan.11 The addition of these countries reflects the actual and likely effects of natural resources. Chad and Sudan both have significant oil potential. In particular, The International Energy Outlook 2007 from the United States Government notes that Sudan has the potential to exceed 700,000 barrels per day by 2010. We follow Collier and O'Connell by including Liberia based on their diamond and other natural resources. The April 2007 repeal of the ban on the export of Liberian diamonds will increase their impact on the economy. Likewise, Mittal recently signed a contract for the export of iron ore. Similarly, we include the Democratic Republic of Congo based on its under-exploited natural resources. Arguably, these helped fuel and cause conflicts in the eastern regions of the country. The non-inclusion of Swaziland is debatable, since according to the IMF (2006), sugar accounts for 12 percent of exports from this country. However, the report also notes that the preferential sugar prices the country enjoys from the EU will potentially decline by 36 percent over a 4-year window beginning in 2007. Due to this uncertainty, we follow the other reports and do not include Swaziland as a resource-rich country.

Agricultural potential is measured using rainfall risk data and the length of the growth period faced by the rural population. A country is defined as having a low agricultural risk if the rainfall risk is below the SSA sample median and the length of the growth period is above the median.12 If a country scores higher than the median of the rainfall risk variable and lower than the median value of the length of growth period, it is classified as high agricultural risk. The remaining countries are in the medium-risk category.

In resource-rich economies, although the bulk of GDP is derived from the natural resource, the resource itself is rarely the leading source of employment, and large portions of the population and economy may be relatively unconnected to the natural resource. This is the so-called "enclave" economy. Despite the lack of linkages with other sectors, the government can use the receipts from the natural

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9 The table states that it is based on Collier, 2004, which is listed in the bibliography as "Collier, P. 2004. Background paper for this report. Processed" (p. 25).

10 In footnote two, they provide a more complete explanation. Essentially, countries had to meet the following criteria: "current rents from energy, minerals and forests exceed 5% of GNI, a forward moving average of these rents exceeds 10% of GNI, the share of primary commodities in exports exceeds 20% for at least a 5-year period following this initial year" (p. 6).

11 However, due to data constraints not every country is included in Table 7.

12For the length of growth period variable, we use the second composite indicator listed in Table 5.

resource to spread the benefits to rural populations through public sector investment. However, with the exception of Botswana, natural resources have generally been linked with bad governance and instability in these countries. In this context, agricultural growth may act as an important secondary engine of growth, since (unlike the resource industries) it has strong linkages to the poor and the broad economy. Even when agricultural risk is high, agriculture may still play an important role in providing livelihoods for the rural poor.

In resource-poor risk countries, especially those that are land-locked, agriculture can play a crucial role as a primary engine of growth. It also contributes to the development of the manufacturing sector, particularly in coastal countries, by freeing up labor and capital, reducing workers' food costs, and supplying some raw materials. In land-locked countries, agriculture may provide the only engine of growth, due to larger distances to major markets and comparably lower levels of transportation infrastructure in the region. Since SSA is a net cereal and staple crop-importing region, there may be agricultural growth options for land-locked countries with high agricultural risk, where the sector may provide subsistence for the poor rural farmers until the economy is able to diversify and farmers are able to move out of agriculture.

4. INVESTMENT OPTIONS

In the above discussion, we argue that agricultural growth is still one of the most effective instruments for improving permanent income and reducing vulnerability. While safety nets are important (under certain conditions) to allow households to participate in growth, they are typically not sufficient to generate broad growth. Rather, they provide an instrument to link households or regions with opportunities.

However, agriculture is not homogeneous and the risks faced by countries and regions vary. We therefore discuss investments in the context of the typology outlined above. Moreover, as Farrington (2005) notes, different segments of the rural population face different risks and constraints to participating in agricultural growth. Therefore, investments and policy responses should be targeted accordingly.

Rural Infrastructure and Access to Markets

While rural infrastructure and access to markets are important for all countries, they may be especially important for countries that rely on agriculture (typically countries in boxes 3, 6 and 9 in Table 7), due to their lack of natural resources or abilities to export. Improved infrastructure may reduce transactions costs, link the labor and product markets, and promote division of labor (Bigsten and Shimeles, 2004; Dercon, 2001). Moreover, the construction of infrastructure can reduce vulnerability by providing income sources for households in the off-season (Peters, 1996). Lower transaction costs allow more people to participate in markets and may potentially increase the profits of those already engaged in markets. For instance, distance from markets (in terms of time of travel) largely influences both the choice and the manner of farmer-market interactions (Fafchamps and Shilpi; 2005).

With rapid advances in technology, timely and reliable climate seasonal forecasts have become more readily available. The information may help farmers to take precautionary actions to palliate the negative impacts of adverse climate. Given that climate change is looming large, it is likely that public investment in climate forecasting in Africa may generate high economic payoffs (Arndt, Hazell, and Robinson, 2000). Meanwhile, it is important to pass on the available information to users.

Markets may be important for a variety of reasons, including spreading risk and increasing incomes. Dercon (2001, p.58) argues that "[m]arkets are means of linking people both spatially and over time." That is, they allow (risks and) shocks to be spread over wider areas. In particular, markets should make households less vulnerable to (localized) covariate shocks. For instance, food prices will not increase as much in the aftermath of a local drought if traders can import food from other markets. Additionally, pre-existing coping strategies (e.g. the sale of productive assets) will be more effective, thereby avoiding potentially irreversible effects from their sale.

The World Bank's study "Operationalizing Pro-Poor Growth" highlights the importance of markets to reducing vulnerability, stating that "[a]mong the low income African countries in the sample, high transaction costs and low market access were among the most important constraints on expanding agricultural earnings, especially for small farmers and those in remote areas" (p. 5, World Bank, 2005).

Moreover, improved infrastructure should encourage the formation of non-farm enterprises, which as underlined above, is linked with decreased vulnerability. This may be especially important in countries with high risk in agriculture (boxes 6-9 of Table 7) as it will provide a source of diversification in the short run and, eventually, a transition out of agriculture. Infrastructure may also facilitate migration and remittances, which are an important *ex ante* and *ex post* mechanism for reducing vulnerability.

Irrigation and Agricultural Research and Development

In countries with medium or high levels of agricultural risk (boxes 6-9 of Table 7), irrigation and agricultural research and development (R&D) are important options. Irrigation may be particularly relevant, due to both its impact on chronic and transitory poverty and the conditions in SSA. Irrigation directly reduces poverty and vulnerability by reducing the impact of shocks such as droughts, by increasing yields and cropping intensity, and by encouraging farmers to switch towards more marketable crops. Indirectly, the labor-intensive nature of irrigation development (e.g. construction and maintenance) may increase demand for labor (Hussain and Hanjra, 2004).

Widespread irrigation, however, is costly and may not be feasible option in many areas. Alternatively, agricultural R&D can introduce drought- and disease-resistant crops to help small holders and less favored areas where agriculture is important (boxes 4-9 of Table 7) (Hazell and Haddad, 2001), and natural resource management practices can improve soil depth and fertility in less favored areas. Likewise, increasing yields in the main staple crops can directly benefit small holders, who tend to be poor and to consume their own production. Agricultural R&D can also help to alleviate nutritional deficiencies, which may lead to vulnerability and nutritional poverty traps. For instance, high vitamin-A sweet potatoes are currently being introduced to counteract the particularly high levels of vitamin A deficiency in children of East Africa (HarvestPlus, 2005). An estimated 38 and 68 percent of all children in Uganda and Mozambique, respectively, are vitamin A deficient, a condition associated with blindness in children and a 23 percent increase in child mortality.

Prices and Agricultural Insurance

Food price risks are particularly important in areas where food consumption is dominated by one staple, such as white maize in Eastern and Southern Africa or millet/sorghum in the Sahelian countries of West Africa (Byerlee *et al*., 2006). Price fluctuations adversely affect households in terms of food insecurity, labor productivity and aggregate growth. Counter-cyclical safety nets may help to reduce price risk as well as overall vulnerability. Recently, weather-based insurance has been used recently by the World Food Program, which purchased insurance against severe drought in Ethiopia. This may be an option in other countries (boxes 4-9 of Table 7) (Lacey, 2006). But if households are uncertain about aspects of the program (i.e. the payoff, timing and selection of recipients), they may simply persist in the same behavior and miss out on risky but potentially beneficial opportunities (Alderman and Haque, 2006).

The Productive Safety Net Program (PSNP), which is currently being evaluated, provides an example of how these types of problems may be overcome. Designed to make intervention more predictable from the perspective of chronically or transitorily food insecure households, the PSNP guarantees a certain amount of public infrastructure work during the dry season and provides the bulk of transfers before the beginning of the "hungry season." A second component, primarily focused on transiently food insecure households, provides payments based upon a rainfall-based index that allows payments in a predictable and timely fashion (World Bank, 2006b). These two components should allow beneficiaries to engage in riskier but more profitable activities because they are more certain of the timing and quantity of benefits they will receive from the program. Moreover, the timing of the program increases the likelihood of the transfer arriving before asset depletion (PSNP PPT, 2001).

Countries with high levels of agricultural exports (typically boxes 2 and 5 of Table 7) will be exposed to variations in international prices. As shown in Table 8, variations in prices differ significantly across countries and regions. The aggregate effect of price changes can be significant in countries where agricultural exports are primarily focused on one or two crops and which rely extensively on agricultural exports. For instance, as previously noted, the cotton sector in Mali represents close to half of the country's export revenue and 6 and 9 percent of total tax revenue and GDP, respectively (IMF, 2002). The sector directly affects the livelihoods of roughly a third of the population. Consequently, variation in international prices will directly affect large segments of the population as well as the government's budget. While the export base can be diversified in a case such as this, commodity exchanges may play a useful role in the shorter run.

Exporters in resource-rich economies (boxes 1, 4, 7 of Table 7) often face over-valued exchange rates as a result of exporting their natural resource. In turn, this creates unfavorable terms of trade for export sectors, including the agricultural sectors. This can be addressed through a combination of investments in the export sector and management of the exchange rate.

At the sub-national level, the risks and capacity of households may vary dramatically across regions. Consequently, the linking of specific investment options with different boxes from the typology is only broadly indicative at the country level. Moreover, emerging issues such as climate change may alter the underlying risks and shift countries across boxes (as would newly discovered of natural resources). As a result, the various governments need to constantly review and revise their investment plans, in order to address emerging and change risks and capacities.

Table 8. Cash crop volatility

Countries	% of cash crop earnings	volatility	% of cash crop earnings	volatility	% of cash crop earnings	volatility	% of cash crop earnings	volatility	% of cash crop earnings	volatility	% of cash crop earnings	volatility	% of cash crop earnings	volatility	volatility	Rank
Angola	.	.	.	0.26	.	.	.	.	.	.	.	.	.	.	.	.
Benin	0.1%	0.61	0.1%	0.56	0.0%	.	99.4%	0.25	0.3%	0.68	0.1%	0.33	0.0%	0.95	0.25	19
Botswana	38.7%	.	.	.	0.1%	.	3.4%	0.54	56.8%	0.88	0.8%	1.05	0.2%	0.53	0.53	4
Burkina Faso	0.1%	0.87	0.1%	0.62	0.4%	0.63	95.0%	0.25	4.4%	0.57	0.0%	0.61	0.1%	0.35	0.26	16
Burundi	14.4%	.	77.8%	0.33	.	.	0.6%	.	2.7%	.	4.1%	0.36	0.3%	1.15	0.28	14
Cameroon	0.0%	1.33	24.7%	0.19	45.0%	0.15	29.3%	0.20	0.5%	0.26	0.0%	1.59	0.3%	1.76	0.18	25
Central African Republic	0.1%	.	28.9%	0.59	0.2%	0.81	49.8%	0.32	16.9%	.	0.1%	0.03	4.0%	1.02	0.37	9
Chad	5.5%	.	.	.	.	.	.	.	94.5%	.	.	.	.	.	.	.
Congo	100.0%	.	.	0.75	.	.	.	.	0.0%	.	.	.	.	.	.	.
Cote d'Ivoire	0.1%	0.84	10.7%	0.38	78.8%	0.30	8.8%	0.16	1.2%	0.24	0.4%	0.23	0.0%	0.27	0.29	12
Djibouti	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DR Congo	0.0%	.	.	0.41	.	.	.	.	100.0%	.	.	.	.	.	.	.
Equatorial Guinea	100.0%	.	.	.	.	.	.	.	0.0%	.	.	.	.	.	.	.
Eritrea	100.0%	.	.	.	.	.	.	.	0.0%	.	.	.	.	.	.	.
Ethiopia	0.0%	.	93.8%	0.36	0.0%	.	1.8%	0.22	4.1%	0.31	0.3%	0.30	0.0%	.	0.35	10
Gabon	0.4%	.	3.3%	0.53	20.2%	0.63	15.9%	.	45.7%	.	1.1%	0.25	13.5%	.	0.15	26
Gambia	91.8%	.	0.4%	.	.	.	2.2%	0.26	5.1%	0.48	0.3%	0.79	0.2%	1.06	0.04	29
Ghana	0.1%	0.41	0.9%	0.38	98.3%	0.19	0.4%	0.30	0.1%	0.41	0.0%	0.83	0.1%	0.15	0.20	24
Guinea	0.1%	0.59	57.4%	0.58	16.5%	0.39	24.7%	0.27	0.1%	.	0.8%	0.32	0.4%	0.48	0.47	5
Guinea-Bissau	100.0%	.	.	.	.	.	.	.	0.0%	.	.	.	.	.	.	.
Kenya	0.0%	0.36	25.4%	0.48	0.0%	0.00	0.0%	0.54	4.1%	0.15	68.4%	0.16	2.0%	0.57	0.25	20
Lesotho	0.0%	.	.	.	.	.	.	.	0.0%	.	.	.	100.0%	0.02	0.02	30
Liberia	.	.	.	0.27	.	.	.	.	.	.	.	.	.	.	.	.
Madagascar	0.8%	.	66.9%	0.45	8.9%	0.27	12.1%	0.24	8.8%	0.33	1.4%	0.35	1.1%	0.52	0.39	8
Malawi	0.2%	0.44	1.7%	0.45	.	.	1.6%	0.23	11.1%	0.34	11.3%	0.12	74.1%	0.10	0.14	28
Mali	0.1%	0.39	0.0%	0.00	0.0%	.	99.2%	0.32	0.5%	1.13	0.0%	0.49	0.1%	1.04	0.33	11
Mauritania	100.0%	.	.	.	.	.	.	.	0.0%	.	.	.	.	.	.	.
Mozambique	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Namibia	2.0%	0.55	0.3%	.	1.0%	0.56	29.4%	0.82	66.5%	0.81	0.4%	0.41	0.4%	0.69	0.80	2
Niger	19.8%	0.30	0.9%	0.20	23.4%	.	36.5%	0.25	1.8%	0.75	11.8%	0.37	5.8%	0.90	0.26	18
Nigeria	0.0%	.	0.2%	0.37	93.0%	1.99	5.6%	0.32	0.8%	0.55	0.2%	0.30	0.1%	0.40	1.88	1
Rwanda	0.0%	.	49.3%	0.49	.	.	0.1%	0.82	0.0%	.	50.5%	0.39	0.0%	.	0.44	7
Senegal	95.7%	0.22	0.0%	0.49	.	.	0.1%	0.36	1.1%	0.30	0.1%	1.29	3.0%	0.33	0.22	23
Sierra Leone	0.0%	.	4.7%	.	14.2%	.	70.3%	.	0.0%	.	1.0%	.	9.8%	.	.	.
Somalia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
South Africa	3.9%	0.29	1.4%	0.29	0.0%	0.38	2.8%	0.40	74.9%	0.24	3.9%	0.40	13.0%	0.30	0.26	17
Sudan	11.6%	.	0.1%	.	.	.	73.9%	0.16	14.3%	0.15	0.0%	0.69	0.0%	0.31	0.14	27
Swaziland	0.1%	0.33	0.0%	.	0.0%	0.61	0.3%	0.27	99.5%	0.59	0.1%	0.32	0.0%	0.89	0.58	3
Tanzania	2.2%	0.34	33.7%	0.39	2.1%	0.25	22.6%	0.27	1.6%	0.27	12.5%	0.23	25.4%	0.22	0.29	13
Togo	0.3%	0.54	15.1%	0.44	17.1%	0.30	65.6%	0.21	1.6%	0.49	0.0%	0.65	0.3%	0.15	0.27	15
Uganda	1.0%	.	68.0%	0.41	0.1%	0.26	2.7%	0.37	11.9%	.	8.2%	0.96	8.1%	1.19	0.46	6
Zambia	0.2%	.	9.2%	.	0.0%	0.62	43.8%	0.30	44.6%	0.23	1.0%	0.46	1.1%	0.21	0.24	21
Zimbabwe	0.0%	0.37	6.3%	0.51	0.0%	0.66	54.3%	0.17	22.9%	0.29	6.4%	0.27	10.0%	0.15	0.22	22

Based on authors' calculation using FAOSTAT data of averages for the period 1996-2005. Volatility is calculated using the export unit value.
Volatility is the coefficient of variation. When a category has several components, it is the sum of the volatility of each component weighted by their share in total value of the category.
Groundnuts are defined as shelled groundnuts, groundnuts with shells and groundnut oil. Sugar is defined as confectionary sugar, raw centrifugal sugar, syrups, etc. Tobacco is un-manufactured tobacco.

4. CONCLUSIONS

This paper reviews the vulnerability in African countries and discusses the potential role of agricultural growth and investment in reducing vulnerability. In order to understand the role of agriculture in the broad macro economy context, we further develop a typology based on risk factors, resource endowment and geography. The typology does not include political and social instability; instead these factors are included in the framework, as they are more framing conditions. However, they are important both as a pre-condition for development and policies, and because rural populations may change their livelihoods as a result of instability. In turn, this exposes them to new risks. When making big investments in a country, governments take risks into account. The recent decline in large-scale civil conflict in Sub-Saharan Africa may present an opportunity for governments to reach populations that were heretofore unreachable. However, the effects of conflict may persist across time. Additionally, while large-scale conflict has declined, conflict continues to be a substantial issue in areas such as the Central African Republic, the Democratic Republic of Congo, Somalia and Sudan.

Generally, broad-based interventions or strategies mainly address the covariate shocks and may not reach all poor and vulnerable populations. Some households will need assistance to take advantage of the new income-generating opportunities resulting from the growth, while others, such as the disabled and the elderly, may be unable to participate at all (Barrett *et al*., 2001; Hoddinott and Quisumbing, 2003). Alternately, households may be constrained from participating in the growth due to lack of resources (e.g. modern agricultural inputs).

It should be noted that agricultural growth may not be a silver bullet capable of reaching the entire vulnerable population. Complementary risk-reducing and social protection programs may be important, particularly in the short run (Chaudhuri, 2003; Farrington *et al.*, 2004; Farrington, 2005). Instruments at the micro level, such as food aid and social safety nets (including asset-based safety nets), can also play an important supplemental role. The key is to maintain an appropriate balance between productive investments geared toward generating long-term growth and social spending aimed at buffering short-term risks. While keeping this in mind, this paper primarily focuses on the role of agricultural interventions in reducing vulnerability.

Not all rural groups will benefit from agricultural growth. For instance, agricultural growth driven by crop production may increase the vulnerability of pastoralists, while increased utilization of land for farming will decrease grazing land. This has already led to social conflict and unrest in several regions of SSA. Additional complementary measures, such as linking farmers to pastoralists through the production of fodder for animals may be necessary in certain countries.

Moreover, effective policies must consider the within-country variation in risk factors, as well as agricultural heterogeneity. Disaggregated analyses at the country level can help highlight the specific risks and corresponding response mechanisms within countries. Another area for future work is to consider how different investments reduce vulnerability within countries. One possible area for future research would be to consider the impact of different investments on the expected probability of future poverty (a micro measure of vulnerability), in order to see how the benefits of specific investments vary across regions and countries.

Finally, foreign aid itself is a risk factor for the countries receiving such aid. Many SSA countries devote precious human resources to meeting the needs of numerous donors, depleting their capacity to cope with market and natural risks.

APPENDIX: DATA SOURCES

LGP summaries were based on 1-km^2 estimates of the length of growing period in days for 2000 (Thornton, unpublished). The estimates are based on the on the intersection of mapped boundaries of the farming systems (Dixon *et al*., 2001) with those of national boundaries (FAO, 2006) and gridded estimates of rural population density (calculated from the GRUMP data from CIESIN/IFPRI/WB/CIAT, 2004). Calculations were performed in a raster (gridded environment) derived from the Geographic Information System (GIS). This analysis was performed using a 1-km^2 resolution in a modified Lambert Azimuthal Equal Area projection, an equal area projection appropriate for comparison of land areas across a large study region.

LGP, which is defined as the number of days in a year with suitable conditions for plant growth, is calculated on the basis of the number of days with minimum temperatures greater than 5 degrees Celsius during which precipitation exceeds evapotranspiration by 50%, taking into account the water holding capacity of the predominant soil type. This measure provides a broadly relevant measure of rainfed agricultural potential.

Mean rainfall and rainfall variability are from the time-series precipitation data from the University of East Anglia's Climate Research Unit (Mitchell *et al*., 2003). These data are interpolated globally from weather station records at a 0.5 decimal degree resolution for the period 1951-2005. For the analysis presented here, the ranges of these estimates were grouped as follows. Mean annual rainfall (mm) was grouped into 3 classes: low (less than 600 mm), medium (600-1000 mm) and high (greater than 1000 mm). Rainfall variability was measured as the coefficient of variation of annual rainfall for 1951-2005, and was grouped into 3 classes: low (less than 18), medium (18-27) and high (greater than 27).

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Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

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CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
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