**RP 168**
JULY 2007

# IMPLICATIONS OF RAINFALL SHOCKS FOR HOUSEHOLD INCOME AND CONSUMPTION IN UGANDA

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AFRICAN ECONOMIC RESEARCH CONSORTIUM
CONSORTIUM POUR LA RECHERCHE ECONOMIQUE EN AFRIQUE

# Implications of Rainfall Shocks for Household Income and Consumption in Uganda

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AERC Research Paper 168
African Economic Research Consortium, Nairobi
July 2007

**THIS RESEARCH STUDY** was supported by a grant from the African Economic Research Consortium. The findings, opinions and recommendations are those of the authors, however, and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat.

Published by: The African Economic Research Consortium
P.O. Box 62882 - City Square
Nairobi 00200, Kenya

Printed by: Modern Lithographic (K) Ltd.
P.O. Box 52810 - City Square
Nairobi 00200, Kenya

ISBN 9966-778-13-6

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# Abstract

Much of Uganda's agricultural production activities are rain-fed, meaning that changes in weather conditions have important implications for households' total agricultural production and wellbeing. This study uses a basic model of household production to assess the impact of rainfall shocks (using rainfall variability) on farm income and consumption expenditure and the response of households to such shocks. Pooled cross sectional data of farm households are derived from the Uganda National Household Surveys for 1992/93, 1999/2000 and 2002/03, which provide a rich source of information on individual and household characteristics (size, age, sex, education, employment, etc.), household income, expenditure, and exposure to risk/shocks. Rainfall statistics are obtained from various issues of the Statistical Abstracts and the Background to the Budget.

We show that rainfall shocks have important implications for both income and consumption of households, with strong policy implications towards cushioning agricultural households. Higher than average rainfall in the first planting and first harvest seasons is found to result in lower incomes and consumption. Given that about 40% of Uganda's total output is obtained from rain-fed agriculture, the impact of rainfall variability on household welfare has important implications for national income. It is also noted that other factors such as ownership of land, education of the household head and household size are important in the determination of household welfare. Community characteristics such as access to electricity, markets and infrastructure in general play a very important role in the welfare of agricultural households.

Programmes to protect households against rainfall shocks such as irrigation schemes, storage facilities for dry produce, staggered planting and crop diversification can provide helpful avenues to reduce income variability among agricultural households. In order to reduce welfare variability and poverty in general, it is necessary to continue the focus on education and targeting of poor and vulnerable households in terms of access to education, health care and other welfare programmes. Access to land has strong implications for both income and consumption - households with access to larger land areas are likely to have higher incomes and higher consumption expenditures - suggesting that land policies to improve access are needed so as to enhance incomes of agricultural households.

*Key words:* Farm households, income, consumption expenditure, shocks, rainfall variability

# Acknowledgements

We would like to acknowledge financial support from the African Economic Research Consortium that enabled us to undertake this study. We would also like to acknowledge the helpful comments received from members of the AERC resource persons and the entire research network, particularly the members of Group C. The helpful comments provided by the anonymous reviewer are also appreciated. However, we remain responsible for any errors that may exist in this paper.

# 1. Background

Agriculture provides about 40% of Uganda's gross domestic product (GDP), 85% of export earnings, 77% of total employment and the bulk of raw materials used by the mainly agricultural-based industrial sector (Republic of Uganda, 2006). In line with the structural transformation of the economy, agricultural output as a share of total GDP has declined over the years, but nevertheless continues to make a key contribution to the achievement of sustained economic growth and the realization of the Poverty Eradication Action Plan (PEAP) objectives. Much of the agricultural sector's output comes from smallholder subsistence farmers, however, and these are primarily engaged in the production of food crops for domestic consumption and only to a limited extent for the market.

Because of the large dependence on primary agriculture and basic means of production, economic performance in Uganda and many other developing countries is highly unstable. The agricultural practices depend on natural weather patterns, so that variations in rainfall levels result in large variations in total output and farm incomes. The volatility of agricultural output due to rainfall shocks can mean a large burden for the low-income households, given the limited government social security arrangements and incomplete credit/insurance markets. External shocks to production facing developing countries range from terms of trade fluctuations, international conditions and weather vagaries to aid volatility.

This study focuses on one particularly important shock to agricultural households – weather changes. We use rainfall fluctuations, measured as the ratio of the difference between current seasonal rains and the average over the long term, to examine the impact of weather changes on household income and consumption expenditure. Local area rainfall data – obtained from the 13 weather stations across the country – are merged with the household survey data for the respective years. We find that while positive rainfall shocks during the first planting season (first rains of March to May) result in lower total and agricultural incomes, the impact is much lower for consumption expenditure, suggesting the existence of some forms of consumption smoothing. Other factors such as access to land, education of the household head and household size, and community characteristics including access to electricity, markets and infrastructure, play a very important role in the welfare of agricultural households.

## Uganda's agriculture sector, an overview

According to the Republic of Uganda (2004), subsistence agriculture in Uganda contributed over 16% of total GDP. At the same time, the biggest proportion of poor people in Uganda rely on agriculture for a living: recent estimates show that more than two-thirds of the earned income of the poorest decile comes from agriculture (Deininger and Okidi, 2001). Within the agricultural sector, food crops form the largest subsector, accounting for about 25.6% of the country's GDP or about 65% of the total agricultural GDP, while cash crops for the export market account for less than 5% of total GDP (less than 9% of the sectoral GDP) (see Table 1). About 80% of the country's labour force is concentrated in agriculture, but receives less than half of the total income (Deininger and Okidi, 2001). The majority of the labour employed in the agricultural sector is drawn from family sources, largely comprising women and children. If Uganda's growth is to be sustainable, it is important to increase agricultural production and productivity and rural non-farm employment, which cannot be achieved without ensuring that farmers have some form of protection against shocks.

**Table 1: Distribution of Uganda's agricultural GDP**

| | 1992 | 1997 | 2000 | 2002 | 2004 |
|---|---|---|---|---|---|
| Agriculture as share of total GDP* | 51.2 | 42.8 | 42.0 | 39.7 | 38.5 |
| Monetary agriculture's share of agriculture | 24.6 | 22.7 | 23.0 | 22.6 | 22.2 |
| Food crops | 12.0 | 10.6 | 11.7 | 12.1 | 12.4 |
| Cash crops | 3.3 | 4.0 | 3.8 | 4.5 | 3.9 |
| Livestock | 6.0 | 5.2 | 4.8 | 3.3 | 3.2 |
| Forestry | 1.1 | 1.0 | 1.1 | 0.7 | 0.7 |
| Fishing | 2.3 | 1.9 | 1.7 | 2.1 | 2.0 |
| Non monetary agriculture's share of agriculture | 26.6 | 20.1 | 19.0 | 17.1 | 16.4 |
| Food crops | 22.6 | 16.6 | 15.8 | 14.1 | 13.3 |

*Uganda's agriculture is both monetary and non-monetary (subsistence). Because of structural change, the share of agriculture in total GDP (both monetary and non-monetary) is declining. This does not mean that the value of agricultural output is declining, but rather that other sectors are growing and new ones are emerging.
Source: Background to the Budget, several issues.

The agricultural sector provides most of the raw materials for the agro-based industrial sector. Agro-industries include coffee hulling, cotton ginning, tea processing, sugar production, soap industries, edible oil, textile mills and cigarette manufacturing. Others are grain milling, meat processing, and dairy and leather product manufacturing. Much of the agricultural production in the country is hinged on family labour, with women providing the bulk of the labour. For example, women form close to 80% of the agricultural labour force and contribute over 80% of all the food production in Uganda (Republic of Uganda, 1999). From the 1999/2000 national household survey, the predominant activity for both female- and male-headed households in the rural areas is agriculture. More than 80% of the rural-based, female-headed households and about 78% of the male-headed households engage in agriculture as their primary activity.

Two government policy documents on poverty eradication and modernization of agriculture – the Poverty Eradication Action Plan (PEAP) and the Plan for the Modernization of Agriculture (PMA) – enumerate a number of problems that limit the full exploitation of agriculture's potential in Uganda. These include lack of skilled labour, limited research and extension services, poor technology, lack of purchased inputs, and low capital (Republic of Uganda, 2000a, 2000b). Added to these – or perhaps first on the list – is that agricultural production in Uganda is highly reliant on natural weather conditions. This implies that smallholder farm production in particular is faced with a lot of risk and uncertainty arising from weather vagaries and natural calamities. Other sources of risk to smallholder farmers come from sickness and fluctuations in prices.

As noted in the foregoing, rain-fed agriculture continues to dominate overall production and employment in the country. Availability of information on weather/rainfall patterns in Uganda from weather stations distributed countrywide and the socioeconomic data from household surveys allow for examination of this important exogenous factor of risk to farmers' income and consumption and welfare in general. Thus the importance of focusing on the impact of weather-related shocks on household income and consumption in the Uganda context cannot be overemphasized. Rainfall variability has also very big impacts on total output and prices in the economy (Republic of Uganda, 2005).

## The research problem

Uganda's agricultural practices, relying as they do on natural weather conditions, imply that farmers face considerable risks and uncertainty in their farm output, income and general wellbeing. Fluctuations in weather patterns and commodity prices translate into income shocks faced by rural households (Morduch, 1995). These risks and uncertainties are especially important where they result in consumption fluctuations (Dercon, 1996), as would be expected in the rural areas where credit and insurance markets are incomplete or totally nonexistent. Fluctuations in agricultural incomes can lead to significant changes in consumption and welfare losses, particularly where households' savings behaviour does not offset the fluctuations in income (Paxson, 1992) or if there exist no social/public security safeguards to protect the farmers. For example, a household may have a bumper harvest when the weather conditions are good or very low output in the event of extended drought. This can result in serious negative consequences for the welfare of the households. While rainfall variability is not the only exogenous factor affecting farm output and income, it is the factor contributing to income variability that is most likely to influence welfare (Rosenzweig and Binswanger, 1993).

Coping with such risks can occur at two stages. First, households can smooth income by, for example, making conservative production or employment choices and/or diversifying economic activities. In this way, households can protect themselves from adverse income shocks before they occur. Second, households can smooth consumption by borrowing and saving, depleting and accumulating non-financial assets, adjusting labour supply, and employing formal and informal insurance arrangements. Recent attention has mainly focused on this last mode of coping (see, for example, Mpuga and Okwi, 2002; Dercon, 1996; Morduch, 1995; Townsend, 1995; Paxson, 1992). However, evidence is large that because of asymmetry of information between lenders and borrowers, and the problems of moral hazard and adverse selection, there is limited scope for trading of risks (Dercon, 1996). In addition, the covariance of risks such as rainfall shocks means that community-based informal insurance coping mechanisms may not be very helpful.

On the other hand, a great deal of risk can be averted in the course of income generation using spatial planting arrangements and/or diversification of crops/economic activities. Therefore, this study examined the importance of rainfall shocks to household income and consumption, the type of response, and the implications of such response for welfare. We examined how income and consumption (of both consumer and productive goods) vary across farmers with different levels of wealth and farmers in different districts/ regions, thus facing different exposure to risk. The availability of household surveys and local area data allowed us to examine the implications of quarterly deviations from long-term trends. The major constraint is that there are only 13 weather stations in Uganda, thus we allocate several households covering large areas to the same station. Further, since not all households in the same geographical area are interviewed at the same time, even when households are allocated to the same station, they do not necessarily have the same rainfall data.

## Objectives

The major objectives of this study were to:

- Examine the importance of rainfall shocks on agricultural households, and their implications for income and expenditure.
- Identify the coping mechanisms available to farm households. Here we largely use descriptive evidence to explore available mechanisms for coping with shocks.

## Hypothesis

The following hypotheses are tested:

- Rainfall shocks have adverse implications for farm output: lower than average rainfall is expected to result in a decline in output and income, and thus consumption by farm households. However, the response to higher than average rainfall cannot be predicted a priori.
- Rainfall shocks affect households in different districts/regions differently; that is, households located in districts/regions with high rainfall variability have different coping mechanisms than those with lower rainfall variability.

## Scope and significance of the study

The study focuses on the implications of rainfall shocks for household income and expenditure, with emphasis on those households that are dependent on agriculture as their major source of income. The study comes as a follow-up to earlier work by Mpuga and Okwi (2002) to further explore the impact of changes in rainfall conditions in Uganda on farm incomes and welfare. Given the importance of the agricultural sector in Uganda's economy, the findings of the study provide an important link to policy on how to cushion farmers against rainfall fluctuations. In addition, the study provides a good basis for further research on the impact of rainfall fluctuations on total GDP and the general price level in Uganda, as well as in other countries that are reliant on agriculture.

# 2. Literature survey

Attention to the importance of shocks might be said to have started with the works of Easterly et al. (1993), who first explored the impact of shocks, particularly those due to terms of trade, and noted that these play a large role in explaining the variance of GDP. More recently and more relevant to our study, Raddatz (2005) has explored the implications of shocks on output growth in both low- and high-income countries. His work reveals the importance of weather shocks to overall GDP performance in low-income countries. He finds that climatic changes including floods, droughts, extreme temperatures and wind storms, and humanitarian disasters such as famines and epidemics, have adverse implications for GDP growth although these are not as important for overall variance in real GDP. Climatic changes and humanitarian disasters result in, respectively, 2% and 4% of GDP declines, but account for only about 11% of overall GDP variance. The remaining 89% variance is accounted for by factors outside the broad set of exogenous factors.

## Risk and coping strategies

Because of the low level and often high variability of agricultural incomes, weather and other shocks present farm households with substantial, even catastrophic, risk. The fact that agricultural production exhibits a great deal of correlation across farms implies that bad weather may leave an entire village or group of villages clamouring for assistance (Ray, 1998). For a poor household, potential sources of risk include rainfall shocks, incidence of human illness, sickness or death of animals, and crop pests and diseases (Townsend, 1995). Farm households use a number of strategies to cope with the adverse effects of income shortfalls and entitlement failures (Dercon, 1996) arising from shocks.

Among the approaches described in the literature is the *risk-coping strategy*, which aims to cushion the impact of income risk on consumption through inter-temporal saving and through mutual support networks as a risk-sharing device. If farmers have access to appropriate schemes, they are likely to save a large proportion of transitory income increases in order to cushion themselves against unanticipated falls in income in the future (Deaton, 1992, 1997; Paxson, 1992). In most developing countries, however, the lack of robust financial markets in the rural areas – and thus the limited scope for formal credit, savings and insurance services (Dercon, 1996; Morduch, 1995) – renders this coping strategy largely impractical. Similarly, problems of asymmetry of information, moral hazard and adverse selection, and covariance of risks make it difficult for households to smooth consumption through borrowing and self-help insurance schemes, depleting/accumulating non-financial assets, and employing formal and informal insurance arrangements (Dercon, 1996; Morduch, 1995; Townsend, 1995).

The other important strategy is the *risk-management strategy*. This aims at helping farmers to reduce the impact of the risk directly – before it occurs – for example by staggering planting and other operations, scattering crops over available plots, and instituting irrigation schemes and moisture conservation techniques such as mulching (Dercon, 1996). Two of these – irrigation and moisture conservation – are not commonly used in rural Uganda. Other traditional ways of risk management include holding multiple parcels of land, diversification of income sources, the extended family system, and reliance on transfers from relatives and friends (who may or may not be living in the same village). Such direct income smoothing mechanisms are more likely to occur when households anticipate being unable to borrow or insure (Morduch, 1995). This study examines the importance of risk management strategies in response to rainfall shocks among farm households and their likely impact on overall household income and welfare.

## Implications of weather shocks for welfare

For household level production and income, external shocks can play a very important role in determining both overall output and fluctuations in the output. This is particularly important for farmers who rely on natural weather conditions for production, with minimal irrigation and use of fertilizers, as is the case in Uganda. As noted by Rosenzweig and Binswanger (1993), while several other factors contribute to household income variability, rainfall variability is likely to influence welfare the most, particularly because it is spatially covariant. Unlike idiosyncratic risks such as sickness or death of a household member, farmers in a given community are less likely to insure themselves against rainfall variability, which affects all of them at the same time.

The impact of rainfall shocks in relation to savings has been examined by Paxson (1992) for Thailand and Mpuga and Okwi (2002) for Uganda, with very strong results. Paxson finds that the propensities to save out of transitory income range between 0.73 and 0.83, close to 1 as expected. Rainfall shocks in the planting season have a large and positive impact on household income. With respect to impact on income, Mpuga and Okwi (2002) reject the hypothesis that the rainfall variables are jointly insignificant, suggesting that rainfall shocks do affect income among agricultural households. In terms of savings propensities, Mpuga and Okwi show that Ugandan farmers are forward looking; that is, they save a big fraction of their transitory income – with estimates of 0.28, 0.37, 0.18 and 0.06 for income less consumption, income less expenditure on durables, change in assets and making cash savings, respectively. With respect to implications for consumption in Ethiopia, Dercon (2004) reports that rainfall shocks and the famine crisis of the 1980s have long-term adverse implications for consumption growth so that in the absence of insurance and other protection measures, farmers are bound to experience prolonged welfare losses. There also appears to be a significant, persistent growth impact from the large-scale famine in the 1980s, as well as substantial externalities from the presence of road infrastructure.

# 3. Theoretical framework and methodology

In most less developed countries, over 80% of the population depends on agriculture for a living and yet lacks access to credit and insurance markets. Because of the likely fluctuations in incomes arising from changes in weather conditions and other natural disasters, it is important to estimate this response for an agricultural country like Uganda. In this study, we analyse the implications of rainfall shocks for household income and consumption.

## Theoretical development of the model

The underdevelopment, or even absence, of credit and insurance markets in the rural areas of most African countries means that households have to use different strategies to mitigate income risk and its consequences (Dercon, 1996). In this study, we explore the implications of rainfall shocks for agricultural households. We follow the theoretical framework developed by the works of Dercon (1996) and Rosenzweig and Binswanger (1993). In the framework, a household with total assets (A) representing its wealth stock is assumed to allocate a share of the assets (n) in order to produce output that maximizes its consumption needs prior to the realization of a random weather outcome (w). Presenting the household's expected utility rankings for consumption in terms of its preference ordering over moments of the distribution of consumption, it is possible to test for this condition.[1] The household maximizes its utility following:

$$U = V(\mu_c, \sigma_c);\ V_\mu > 0,\ V_\sigma < 0 \qquad (1)$$

where $\mu_c$, and $\sigma_c$ are the mean and standard deviation of consumption. The quasi-concavity of (1) is sufficient to guarantee convexity of preferences so that

$$V_{\mu\mu},\ V_{\sigma\sigma} < 0 \ and\ V_{\mu\mu}V_{\sigma\sigma} - V^2_{\sigma\mu} \geq 0$$

The household can maximize its utility as defined in Equation 1 by choosing an appropriate combination of production investments. We assume a constant returns to scale (CRS) profit function in the inputs. The relationship between the mean $(\mu_\pi)$ and standard deviation $(\sigma_\pi)$ of the household profits, the productive investment portfolio vector[2] $S_i$ and the mean and standard deviation of the stochastic weather distribution $\mu_\omega$ and $\sigma_\omega$, respectively, can be represented as:

$$\mu_\omega = Af(S_i)\mu_\omega \text{ and} \tag{2}$$

$$\sigma_\omega = A\tau(S_i)\sigma_{\omega,} f_{ss,} \tau_{ss} < 0 \tag{3}$$

It is important to note that in equations 2 and 3, the mean and standard deviation of profits per unit of wealth are homogeneous of degree 0(1) in total assets A, reflecting the CRS assumption (in the first two moments, respectively, of the weather distribution). For simplicity, we assume one source of stochastic variability in household output. The mean consumption is thus given by:

$$\mu_c = \mu_\pi \tag{4}$$

Mapping the standard deviation in profits to that of consumption depends on the assumptions about the capital market constraints. If assets cannot be sold and borrowing is not possible, then the standard deviation of consumption will equal that of profits, i.e., $\sigma_c = \sigma_\pi$, as assumed in farm risk studies. However, if households are able to insure against income fluctuations, the standard deviation of consumption will be zero ($\sigma_c = 0$), as is assumed in studies of savings based on the permanent income hypothesis (e.g., Paxson, 1992; Mpuga and Okwi, 2002). In practice, the situation will lie somewhere in between. In any case, the sensitivity of consumption variability to ex post profit variability may depend on the total assets held, for which there may be limited market and which may serve as collateral for loans. Thus, the relationship between consumption and profit variability is expressed as influenced by total assets as:

$$\sigma_c = \kappa(A)\sigma_\pi \tag{5}$$

with $\kappa'(A) < 0$.

The set of first-order conditions are given by:

$$V_\mu f_{si} = -V_\sigma \tau_{si} \sigma_\omega \kappa,\ i = 1, 2, \ldots, n-1 \tag{6}$$

where $f_{si} = f_i - f_n$ and $\tau_{si} = \tau_i - \tau_n$, with $f_i$ and $\tau_i$ being the marginal contributions of the *jth* production capital to the mean and standard deviation of profits, respectively. From (6) we can test the implication of the investment equilibrium characterized by risk aversion, i.e., the existence of a positive association across all production assets between marginal contributions to the mean and to the variability of profits for any two assets – *i* and *k*,

$$f_{si}/f_{sk} = \tau_{si}/\tau_{sk} \tag{7}$$

Implications for the wealth-differentiated effects of the weather shock on the riskiness of household portfolios and profitability can be derived. As shown by Rosenzweig and Binswanger, the effects of a mean-preserving change (positive change) in the standard deviation of the weather distribution leads to a reduction in $\tau$, portfolio riskiness, and therefore in farm profitability. The magnitude of the effect of increased risks due to weather changes is expected to decline with the household's total wealth, if there is some post consumption smoothing. Thus, wealthier households are likely to be more efficient than poor ones (which have more variable incomes) in areas where weather risk is sufficiently high, even if risk aversion does not depend on wealth. This assumes that wealthier households are better able to smooth consumption than the less wealthy, as they have diversified sources of income and larger stocks of savings/assets. Conversely, poor households that are reliant on agriculture are more likely to suffer the impacts of rainfall shocks.

## Econometric implementation

In order to provide evidence of the impact of rainfall shocks on household income and expenditure, we estimate a general model of household total income, agricultural production and consumption expenditure with household characteristics, production assets, village-level characteristics and deviations in rainfall from the long-term average as the right-hand variables. It is hypothesized that negative rainfall shocks would result in lower yields and therefore lower household income and consumption. On the other hand, the impact of positive rainfall shocks cannot be determined a priori since higher than average rainfall can result in higher or lower yields, depending on the intensity of the shock and crop types.

$$Q_{it} = \alpha_0 + \alpha_1 H_{it} + \alpha_2 AT_{it} + \alpha_3 VX_{it} + \alpha_4 K_{it} + \theta_{it} \qquad (8)$$

where $Q_{it}$ is the value of agricultural output. In addition, household consumption expenditure $(C_{it})$ and income $(Y_{it})$ are used as left-hand variables. $H_{it}$ is a vector of household social characteristics (age, sex and education of head), $AT_{it}$ is a vector of household production characteristics (total land owned/cultivated and value of farm equipment owned), $VX_{it}$ is a vector of village level characteristics such as access to roads, markets, etc., and $K_{it}$ is a variable to capture shock experienced (rainfall deviation from long-term average). $\theta_{it}$ is the random error term assumed to be normally distributed with constant variance.

## The data

Data used in this study were obtained from the 1992/93, 1999/2000 and 2002/03 household surveys for Uganda. The surveys provide a rich source of data on household characteristics, including number of household members, who are then described by gender, age, educational level and marital status. They also provide information on employment, income, expenditure, savings, assets and other general welfare indicators.

### Socioeconomic data

Pooled cross sections of household socioeconomic characteristics are compiled from these surveys. We are able to do this because our interest is in households with similar characteristics – farm households. It is possible to construct a panel of households from surveys that do not necessarily follow up the same households over the years (Deaton, 1997; Wooldridge, 2000). Wooldridge (2000) explains that apart from increasing the sample size, pooled cross sections help to achieve more precise estimators and test statistics with more power. If random samples are drawn during each survey period, pooling the resulting random samples gives us an independently pooled cross section.

While the target numbers of respondent households for each of the surveys was 10,000, actual outcomes varied somewhat: the 1992/93 survey had about 9,900 households, the 1999/2000 edition had 10,696 households and the 2002/03 survey recorded 9,711 households. Differences between the target and actual number of households included in the surveys are attributed to cost and insecurity in some areas that hindered access at the time of the exercise. However, the data remain consistent and comparable across the surveys. The descriptive evidence of the main socioeconomic characteristics from the 1992/93, 1999/2000 and 2002/03 surveys is summarized in Appendix A. The data show consistency in the socio-characteristics such as household size (about five members) and age of the household head (on average about 40 years). Over time, female-headed households have tended to decline from about 28% in 1992/93 to about 25% in 2002/03. Marked improvements are noted among the socio-economic characteristics such as education, household expenditure and dwelling characteristics.

In addition to the socioeconomic characteristics derived from interviews at household level, the surveys provide information at community level. The evidence shows that there have been improvements in access to markets, financial services and electricity. Average distance to the nearest all-weather road declined to 87 km in 2002 from over 112 km in 1999. Communities with markets increased to about 76% in 2002 from under 50% in 1999; those with financial services increased to 60% from 42% and electricity to 38% from 17%. These and other community level characteristics are summarized in Table A1 and household characteristics are presented in Table A2.

### Rainfall data

Data on regional rainfall were obtained from the *Statistical Abstracts* for Uganda and the Background to the Budget. These two documents publish monthly rainfall data for 13 centres, two in Central region (Entebbe and Kampala), four in Eastern (Jinja, Mbale, Tororo and Soroti), four in Western (Kabale, Kasese, Masindi and Mbarara,) and three in Northern (Arua, Gulu and Lira). Monthly rainfall figures for the period 1992 to 2002 were gathered and used to construct four variables representing the four major seasons in Uganda – these generally cut across the whole country. The first planting season, stretching over the months of March to May, is a season of medium rains. The first harvest season runs from June to August; this is a dry season that also corresponds to preparation of the fields for the second crop. The second planting season starts in September and goes on until November. The second harvest season covers the months of December to February. This also corresponds to ploughing and preparation of the fields for the next crop cycle. The four seasons prevail across much of the country except for the generally drier North East, where the rains are concentrated in the September–November season. While these are averages, there are periodic fluctuations whereby rains can start early or delay for some time. There is very limited use of irrigation in Uganda and therefore farmers rely on the rains to start planting. Thus the crop cycle depends on when the rains start.

To merge the household data and the rainfall data, we use the dates (month and year) in which the household was interviewed and then attach the rainfall data for that locality (six months before). This is done in order to capture the lag impact of rains on crop output. We use the rainfall data from the weather centre nearest to the respective household. Because not all households in the same district are interviewed at the same time, there is additional variability in the rainfall level attached to each household in the same area.

In the analysis, we examine the impact of rainfall shocks in each of these seasons on total household output, agricultural output and income. Long-term average rainfall data are based on the observed rainfall patterns and data provided in the statistical abstract.[3] Rainfall variability is measured as the ratio of the difference between current seasonal rains and the long-term average rainfall.

## 4. Shocks and coping strategies in Uganda

Regional patterns of rainfall shocks in Uganda represent deviations of seasonal rainfall from the long-term average rains. The regional quarterly rainfall figures and deviations from the long term average for 1992/03, 1999/2000 and 2002/03 (reported in Appendix C) show that March to May (first planting) and September to November (second planting) receive large amounts of rainfall and larger deviations. This period is associated with planting and weeding. On the other hand, June to August (first harvest) and December to February (second harvest) are generally dry across most of the country, corresponding to harvesting and preparation of fields for the next crop. The seasonal deviations from long-term average rainfall do not depict any clear pattern, but it can be adduced from the information that the first planting season (March–May) has, on the average, large positive rainfall shocks while the second planting season tends to have large negative rainfall shocks – meaning that there is more rain than usual in the first and less in the second. At the regional level, the North and West tend to have large negative rainfall shocks compared with the national level and the Central and East.

As for other types of shocks, information from the first Uganda National Household Survey (UNHS1) data set included a module on shocks experienced by households in the previous seven years and the kind of coping strategies employed. In the first part of this section we summarize the evidence on household experience with shocks and available mitigation mechanisms. Table 2 shows that the existence of shocks is a problem facing a large number of households in the country. Such risks range from illness/injury, separation and loss of employment to the loss of productive assets. Up to 37% of all households included in the survey had faced one form of shock or another in the previous seven years, the most common of which is illness/injury.

**Table 2: Idiosyncratic shocks experienced by households in Uganda**

| Variable | All Uganda | Central | East | North | West |
|---|---|---|---|---|---|
| Occurrence of shocks (per cent) | | | | | |
| Household experienced shock | 36.9 | 35.9 | 40.1 | 33.3 | 37.1 |
| Illness/injury of 1 month or longer | 64.0 | 58.0 | 63.1 | 62.2 | 72.1 |
| Separation/Abandonment | 9.4 | 9.2 | 11.7 | 8.5 | 7.5 |
| Loss of permanent job | 6.1 | 8.4 | 6.0 | 4.3 | 4.8 |
| Loss of productive assets[1] | 23.8 | 24.4 | 24.7 | 22.8 | 22.7 |
| Other shock | 7.8 | 10.2 | 6.4 | 11.3 | 4.9 |
| Time since shock was experienced (years) | 3.5 | 3.5 | 3.4 | 3.6 | 3.6 |
| Observations | 10,696 | 3,110 | 2,865 | 1,802 | 2,919 |

[1] Includes land, livestock and machinery.
Source: Authors' analysis based on 1999/2000 survey.

For up to 64% of the households that had experienced some shock, the shock had taken the form of illness or injury lasting one month or longer. About 24% had lost productive assets, about 9% had suffered separation or abandonment, and 6% had lost a permanent job. At the regional level, the highest incidence of shocks is reported in the East (40%), followed by the West (37%) and Central 36%. The lowest of all is in the North at 33%. This is rather surprising given that the North is the region that has been experiencing civil strife since 1987.

## Coping strategies

The most important form of assistance for households that experienced shocks is help from friends and relatives (32%), followed by sale of assets (8%) and informal borrowing (4%). Use of formal credit is reported by only 0.8% of households facing shocks (Table 3). On other hand, more than half of all households that had experienced shocks are reported to have received no help at all. This large proportion of households that do not get any help indicates that there is an urgent need for insurance services to help to cushion households against shocks and the attendant implications for welfare decline.

**Table 3: Coping strategies available to households**

| Most important coping strategy (percent) | All Uganda | Central | East | North | West |
|---|---|---|---|---|---|
| Received help | 32.5 | 31.8 | 39.7 | 36.3 | 23.3 |
| Received gifts | 0.9 | 0.8 | 0.5 | 1.3 | 1.1 |
| Borrowed informally | 4.4 | 2.5 | 3.0 | 1.5 | 9.6 |
| Formal credit | 0.8 | 0.5 | 0.5 | 0.7 | 1.6 |
| Sale of assets | 8.3 | 6.3 | 8.7 | 9.3 | 9.2 |
| Other form of help | 0.8 | 0.6 | 1.4 | 0.3 | 0.7 |
| No help at all | 56.9 | 60.4 | 52.1 | 54.7 | 59.6 |
| Observations | 10,696 | 3,110 | 2,865 | 1,802 | 2,919 |

Source: Authors' calculations from the 1999/2000 household survey.

In addition to the limited scope for coping with shocks, household participation in savings groups (voluntary or otherwise) is very low. Evidence from the 1999/2000 survey shows voluntary participation of only about 4% and conditional participation of about 6% (Table 4). The lack of popularity for this form of coping mechanism could be stemming from the failed cooperative arrangements following the many years of civil strife and economic mismanagement the country faced in the 1970s and 1980s.

**Table 4: Household participation in savings groups**

| Level of participation | All Uganda | Central | East | North | West |
|---|---|---|---|---|---|
| Never (per cent) | 90.70 | 94.02 | 91.38 | 91.90 | 85.75 |
| Only when required (per cent) | 5.46 | 3.70 | 5.55 | 1.89 | 9.46 |
| Voluntarily (per cent) | 3.66 | 2.25 | 2.65 | 6.10 | 4.62 |
| Observations | 10,696 | 3,110 | 2,865 | 1,802 | 2,919 |

Source: Authors' calculations from the 1999/2000 household survey.

As noted before, to the extent that household income/assets can be used to mitigate the impact of shocks, then the discussion of shocks cannot be complete without considering poverty trends and living conditions, as these have strong implications for the ability of households to cope with such shocks. In the next section, we summarize results of earlier studies on poverty trends in Uganda since 1992/93.

## Poverty and living conditions

Since 1992/93, Uganda has reported impressive progress in the fight against poverty and general improvement in living conditions of the population. Evolving from long periods of neglect and economic mismanagement, poverty trends were first comprehensively estimated using evidence from the 1992/93 Integrated Household Survey (IHS). The results indicated that about 56% of the population were living below the poverty line of US$1 per day (Table 5; information is also consistent with findings by Appleton, 2001, and Appleton and Ssewanyana, 2003). Following this revelation, other monitoring surveys were conducted to continuously measure poverty and the impact of policy reforms that were being undertaken.

**Table 5: Head count poverty trends in Uganda, 1992/93–2002/03**

| *Proportion of population below poverty line* | 1992/93 | 1999/2000 | 2002/03 |
|---|---|---|---|
| All Uganda | 55.5 | 35.2 | 38.8 |
| Rural | 59.4 | 39.1 | 42.7 |
| Urban | 28.2 | 10.3 | 14.4 |
| *Poverty status by region* | | | |
| Central | 45.5 | 20.3 | 22.3 |
| Eastern | 59.2 | 36.5 | 46.0 |
| Northern | 71.3 | 65.8 | 63.6 |
| Western | 52.8 | 28.1 | 32.9 |
| Observations | 9,920 | 10,696 | 9,711 |

Source: Appleton (2001) and Appleton and Ssewanyana (2003).

By 1997 when the first Poverty Eradication Action Plan (PEAP)[4] was implemented, poverty levels had declined to about 44%, and to a further 35% by 1999. However, results of the 2002/03 survey indicated a slight, albeit not statistically significant, increase in poverty to 38%, which is rather inconsistent with other welfare trends. The reported increase in poverty was mainly explained by the slowdown in economic growth and declining terms of trade. Most importantly, the results show that monetary poverty increased in all quintiles expect the topmost, thus resulting in increased inequality (the Gini coefficient rose from 0.36 in 1992 to 0.43 in 2002) and vulnerability. Between 1999/2000 and 2002/03, poverty increased in both urban and rural areas and in all regions, except the North (although this region still has the highest proportion of the poor). The most recent household survey (2005/06) reported poverty to have declined to 31%, but these results are not reported here.

Over the entire period (1992/93–2002/03), however, other measures of wellbeing – including total value of assets owned by the household, ownership of specific assets and access to social services – registered strong improvements. In both rural and urban areas (and in all regions), households in the bottom two quintiles reported increased ownership of radios, bicycles or television sets. Housing conditions also improved, with more households (in all quintiles) reporting owning/living in a house with an iron-sheet roof or with walls made of some permanent material (e.g., bricks or concrete). Table 6 summarizes for the most recent survey.

**Table 6: Ownership of assets and dwelling characteristics**

| | 1999/00 | | 2002/03 | |
|---|---|---|---|---|
| | **Rural** | **Urban** | **Rural** | **Urban** |
| Ownership of specific assets | | | | |
| Electronics | 43.1 | 76.8 | 59.9 | 76.9 |
| Radio | 47.9 | 77.2 | 61.7 | 77.2 |
| Bicycle | 44.4 | 21.7 | 47.7 | 19.7 |
| *Type of dwelling* | | | | |
| House | 63.6 | 38.4 | 61.0 | 38.6 |
| Tenement (*Muzigo*)[1] | 5.5 | 57.0 | 10.5 | 57.3 |
| Hut | 30.8 | 4.6 | 28.5 | 4.1 |
| Permanent wall | 34.9 | 76.6 | 45.3 | 81.2 |

[1] This refers to one- or two-roomed semi-detached housing units, locally known as *Muzigo*. These are common in urban localities and generally occupied by low-income households.

Similarly, access to education, health care services, safe drinking water and agricultural extension services continued to improve. For example, in 1992 only about 60% (63% boys and 59% girls) of children aged 6–12 years were attending primary school, but by 2003 over 84% were in school (Table 7). While only about 61% of individuals who fell sick in 1992 visited any health care facility, about 78% did so in 2003. On the other hand, less than 7% of households in Uganda had access to piped water in 1992 but the ratio had almost doubled to 13% in 2003. Although data are not available for 2003, we find that the proportion of agricultural households accessing extension services in 1999 was 17%, an improvement over the 12% reported in 1992.[5] This suggests that in spite of the increase in monetary poverty (between 1999/2000 and 2002/03) noted in the foregoing discussion, living conditions of Ugandans continued to improve, perhaps implying strong resilience to shocks.

**Table 7: Access to social services**

| | 1992 | | 1999 | | 2002 | |
|---|---|---|---|---|---|---|
| | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** |
| *Net enrolment at primary level (age 6–12)* | | | | | | |
| Lowest quintile | 51.1 | 40.4 | 73.6 | 69.4 | 76.7 | 76.5 |
| Highest quintile | 79.5 | 75.1 | 84.7 | 83.0 | 88.4 | 89.6 |
| Urban | 76.6 | 69.7 | 84.1 | 82.8 | 88.0 | 87.8 |
| Rural | 61.9 | 57.2 | 82.1 | 81.2 | 83.5 | 84.4 |
| Total | 63.4 | 58.7 | 82.3 | 81.4 | 84.0 | 84.8 |
| *Visited hospital when sick (per cent)* | | | | | | |
| Lowest quintile | 57.3 | 51.2 | 58.1 | 53.3 | 70.4 | 70.1 |
| Highest quintile | 67.9 | 71.3 | 78.6 | 79.8 | 86.1 | 82.8 |

*Continued*

**Table 7, continued**

| | 1992 | | 1999 | | 2002 | |
|---|---|---|---|---|---|---|
| | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** |
| Urban | 72.3 | 72.7 | 75.2 | 74.3 | 84.5 | 81.4 |
| Rural | 60.5 | 60.2 | 68.4 | 66.8 | 77.9 | 77.8 |
| Total | 62.2 | 61.9 | 69.3 | 67.9 | 78.8 | 78.3 |
| *Households with access to piped water (per cent)* | | | | | | |
| Lowest quintile | 1.0 | | 1.5 | | 2.5 | |
| Highest quintile | 20.4 | | 36.0 | | 38.8 | |
| Urban | 35.2 | | 55.5 | | 57.0 | |
| Rural | 1.9 | | 2.8 | | 4.0 | |
| Total | 6.7 | | 11.1 | | 13.0 | |
| *Agricultural households using extension services (percent)* | | | | | | |
| Lowest quintile | 9.3 | | 12.6 | | Data not available | |
| Highest quintile | 18.1 | | 24.5 | | | |
| Urban | 15.0 | | 18.0 | | | |
| Rural | 12.3 | | 17.3 | | | |
| Total | 12.3 | | 17.3 | | | |

Source: Authors' own data analysis based on the 1992/93, 1999/2000 and 2002/03 UNHS.

# 5. Quantitative analysis of household response to shocks

Results of the quantitative analysis examining the link between rainfall shocks and household consumption, income and agricultural profitability are reported here. Because Uganda is a predominantly agricultural economy, this examination is critical to the understanding of the importance of such shocks to household welfare. Limited comparability and absence of some of the variables in the 1992/93 survey restricted the analysis to the 1999/2000 and 2002/03 surveys. With its detailed crop module, the 1999/2000 survey provides a much richer data set for examining agricultural production and implications of rainfall shocks.

The evidence, summarized in Appendix C, tables C1–C6, shows that rainfall shocks play an important role in the determination of total household income, agricultural income and consumption, and thus welfare. In all the tables, columns 1–2 present regression results for all households and columns 3–4 present results of households whose main activity is agriculture. In each set of tables C1–C2, C3–C4 and C5–C6, the dependent variable is total income, agriculture income and household consumption, respectively. The next sections discuss the results, first for the impact on total household income and agricultural income, and then for household consumption.

## Impact of rainfall shocks on total and agricultural income

In Table C1, we note that the impact of rainfall shocks on household income is mixed, but generally has negative implications for household income. In the first planting season (March–May), positive rainfall shocks (higher than long-term average rains) negatively affect total household income (columns 1–2). Table C3 presents a similar impact of positive rainfall shocks in the first planting season on agricultural incomes. We also note that higher than average rainfall in the second harvest season negatively affects total household income.

Tables C2 and C4 present results of the same regressions with interactive dummies. Here we see that rainfall shocks during planting seasons result in lower incomes, but shocks during harvest periods result in higher incomes, an indication that agricultural output is more prone to shocks that occur during the planting period. The results are robust to the regressions using the entire data set and the agricultural households as a group (but the coefficients and level of significance are smaller in the latter case). Large rainfall variability during the planting season damages crops, thus leading to lower output and incomes, but during the harvest seasons, which are generally the dry seasons, the impact on crop yield and incomes is positive. Overall, the variability of output and incomes arising from rainfall fluctuations implies that farmers who are dependent on natural weather conditions need protection through, for example, irrigation schemes and storage services for dry produce, which can help farmers in times of low rains and output. The other control variables included in the model behave largely as expected. Education of the household head and the number of members in the household have an important role in determining total household income, with women aged 15–64 years contributing more to income than men in the same age group. On the other hand, female headship of a household is associated with lower agricultural income. As expected, rural households have lower incomes than urban ones, but are more likely to have higher agricultural incomes. Again, households in the north, east and west have lower incomes and receive less from agriculture compared with those in the central region (excluded category).

As expected, total land owned by a household plays an important role in the determination of the income of the household, particularly agricultural households. The elasticity of total household income to an increase in cultivated land area is 0.2; that is, a 100% increase in land owned increases total household income by around 20% and agricultural income by over 50%. The impact is even stronger when the size of cultivated land is used as the explanatory variable. We find that an increase in the size of cultivated land by 100% results in an increase in total income of close to 40% while agricultural income increases by about 65%. For agricultural households, the elasticities for total and agricultural income are 0.41 and 0.60, respectively (results not presented but available on request).

These findings are not surprising, given that Uganda's agricultural production depends on the natural weather conditions and land area cultivated – our agriculture is based on land-intensive production practices. However, the findings have important implications for agricultural growth. They imply that unless steps are taken to promote the use of scientific methods of production (e.g., use of irrigation and application of fertilizers), increased agricultural output in the future (to meet domestic consumption and export needs) will only occur from expanded acreage.[6]

## Impact of rainfall shocks on household consumption

In terms of consumption, holding other factors constant, the impact of rainfall shocks is significant in the first and second planting seasons (March–May and September–November), where higher than long-term average rains result in lower household consumption expenditure, suggesting that positive rainfall shocks in this season can be detrimental to household welfare (Table C5). On the other hand, higher than long-term average rainfall during the second harvest season (December–February) results in higher household consumption. Table C6 presents results of the same regressions with interactive dummies, in which we note that for rural households, positive rainfall shocks during the first planting season have a positive effect on household consumption, but the reverse is true in the case of the second planting season. However, most of the rainfall shock coefficients in the consumption equations are smaller or even insignificant compared with those in the income and agricultural income equations, suggesting that households are engaged in consumption smoothing to mitigate the impact of shocks on welfare.

Other factors that play an important role in household total consumption expenditure include education, gender of the household head and total number of household members. Holding other factors constant, an additional year of education of the household head increases household total consumption by about 6 percentage points, something that suggests the need for increased attention to education. Extending the free universal primary education programme to secondary and tertiary level would be very helpful in this regard. The results show that female-headed households tend to have consumption expenditure nearly 5% higher than male-headed households, although this finding does not hold for agricultural households. Consumption expenditure is found to decline as the head of the household advances in age, but when we use age dummies we find that this negative relationship is restricted to age group 46–64 years, with the other categories insignificant. Overall, household consumption expenditure declines with household size (result not reported) and using dummies we find that this is accounted for by children aged 0–14 years. Females aged 15–64 years contribute positively to household consumption, while the contribution by their male age mates (and that of both women and men over 64 years) is insignificant.

Total land owned by the household plays an important role in its consumption determination. If land owned is increased by 100%, consumption expenditure would increase by over 10%. Community characteristics, including availability of electricity, markets, all-weather roads and financial services, have a significant and positive impact on overall household income and consumption. Holding other factors constant, consumption expenditures for households in communities with electricity are about 20% higher than those without. The existence of commodity markets within the community is very important for agricultural households, while markets in the next community are important for all. For agricultural households, the existence of all-weather roads within the community is very important.

With respect to locational variables, the results show that consumption expenditure of rural households is lower than that of urban households by about 23%. For the agricultural households, this effect is about half. This is not surprising, given that rural households in Uganda account for a larger proportion of the poor. Similarly, households in East, North and West spend less on consumption than those in Central (the excluded category). The results show that consumption spending for households in the North (a war-ravaged region) is about 50% lower than in Central, followed by East (20 percentage points lower) and West (12 percentage points lower). These findings are supported by the general trends in poverty in Uganda, which show the North as the poorest region followed by the East and West (Appleton and Ssewanyana, 2003). On the other hand, Central and West have lower proportions of people living in poverty.

# 6. Conclusions

Rainfall shocks play a very important role in the welfare of households in Uganda, according to the quantitative results of this study. In particular, positive rainfall shocks in the first planting season are found to result in substantially lower incomes but limited or no impact on consumption, suggesting some levels of consumption smoothing. Positive rainfall shocks in the second planting season and the second harvest season result in higher incomes. Given that agriculture contributes up to 40% of Uganda's GDP and over 70% of employment, the fluctuations in household income associated with rainfall shocks could mean large impacts on the overall economy. Government therefore needs to put in place programmes to protect households against rainfall shocks. Irrigation schemes, storage facilities for dry produce, staggered planting and crop diversification could provide helpful avenues in this regard.

In addition, other household characteristics – including age, sex and education of the household head – are important determinants of overall household consumption. These findings suggest that in order to reduce welfare variability and poverty in general, there is need to continue the focus on education and targeting of poor and vulnerable households in terms of access to education, health care and other welfare programmes. Access to land has strong implications for both income and consumption – households with access to larger land areas are likely to have higher incomes and higher consumption expenditures. This suggests that land policies to improve access are in order so as to enhance incomes of agricultural households.

One of the shortcomings of the study is that the number of weather stations is limited, and so the data are not always as refined as they could be. It would thus be helpful for government to expand the coverage of weather stations in the country, not only for providing reliable information to farmers but also to facilitate deeper examination of the country-wide impact of weather changes on output and incomes. This study focused on the impact of rainfall shocks on the incomes and consumption at the household level using survey data. In the future, it will be useful to examine the impact of rainfall shocks on national output and prices using national output data. It would also be interesting to examine the implications of other shocks such as loss of markets, regional disturbances and credit constraints on household incomes and expenditures.

# Notes

1. It is possible to map changes in the moments of the observed stochastic variable (weather) into changes in the moments of the consumption distribution since the two sets of ranking are consistent when the stochastic payoff variables differ from each only by location and scale (Meyer, 1987). On this basis, several functional forms of expected utility models are consistent with models incorporating mean-standard deviation rankings (Rosenzweig and Binswanger, 1993).

2. Each element $(s_i)$ of the vector $\boldsymbol{S}_i$ is equal to the share of the *ith* investment in total wealth.

3. The rainfall statistics report long-term average rainfall for each month at each weather station. These are based on the rainfall data observations stretching as far back as the 1960s.

4. Currently, government is finalizing the second revision of the PEAP in order to keep up-to-date with trends in poverty and policy focus. Preparation and revision of the PEAP are highly participatory exercises, involving key central government ministries, local governments, parliament, civil society organizations and the development partners.

5. Data limitations do not permit us to examine the proportion of households with access to irrigation facilities, which would have been very useful in the context of this study. It is important to note that the current government policy focus, as contained in the Poverty Eradication Action Plan of 2004 and the National Budget Framework Paper (2005/06), is to improve agricultural productivity through the renovation of irrigation and the revival of cooperative schemes.

6. This has adverse implications for the environment, however, and calls for urgent attention from the authorities.

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# Appendix A: Survey data

**Table A1: Community characteristics**

| | All Uganda | Central | East | North | West |
|---|---|---|---|---|---|
| ***2002*** | | | | | |
| Distance to all-weather road (km) | 87.4 | 86.1 | 84.2 | 89.0 | 91.2 |
| Share of communities with electricity (per cent) | 38.1 | 50.4 | 36.7 | 29.9 | 31.3 |
| Communities with markets (per cent) | 75.7 | 87.7 | 68.3 | 66.5 | 77.0 |
| Markets in next community (per cent) | 70.0 | 75.6 | 57.1 | 80.5 | 69.6 |
| Access to financial services (per cent) | 60.9 | 65.9 | 49.6 | 58.5 | 69.1 |
| Observations | 970 | 284 | 267 | 173 | 246 |
| ***1999*** | | | | | |
| Distance to all-weather road (km) | 112.5 | 56.6 | 97.1 | 261.9 | 68.2 |
| Share of communities with electricity (percent) | 16.5 | 34.0 | 17.5 | 3.3 | 8.8 |
| Communities with markets (per cent) | 49.5 | 53.0 | 51.8 | 21.5 | 64.4 |
| Markets in next community (per cent) | 82.7 | 71.1 | 81.9 | 84.9 | 92.6 |
| Access to financial services (per cent) | 41.7 | 48.9 | 27.5 | 55.8 | 36.3 |
| Observations | 1,086 | 316 | 291 | 194 | 295 |

Source: Authors' calculations from 1999/2000 and 2002/03 household surveys.

**Table A2: Household characteristics**

| Variable | 1992/93 | | | | | 1999/2000 | | | | | 2002/03 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Uganda | Central | East | North | West | All Uganda | Central | East | North | West | All Uganda | Central | East | North | West |
| Age of head (years) | 40.1 | 39.8 | 40.9 | 40.4 | 39.4 | 43.3 | 42.6 | 43.5 | 43.0 | 44.1 | 39.1 | 38.7 | 39.4 | 39.4 | 39.1 |
| Female head (per cent) | 27.5 | 29.2 | 25.6 | 31.4 | 24.3 | 26.1 | 30.1 | 24.3 | 30.4 | 22.7 | 24.5 | 27.1 | 21.3 | 30.2 | 20.4 |
| Education of head (years) | 5.3 | 5.9 | 5.3 | 4.8 | 4.8 | 5.3 | 5.8 | 5.4 | 4.7 | 5.0 | 6.1 | 7.2 | 5.7 | 5.1 | 5.9 |
| Household size | 4.9 | 4.6 | 5.0 | 5.3 | 4.8 | 5.4 | 5.0 | 5.4 | 5.3 | 5.7 | 5.2 | 4.9 | 5.6 | 5.2 | 5.4 |
| Number of children aged 0–5 years | 1.1 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 | 1.0 | 1.2 | 1.1 | 1.1 | 1.2 | 1.0 | 1.4 | 1.2 | 1.1 |
| Males aged 6–14 years | 0.6 | 0.6 | 0.6 | 0.8 | 0.6 | 0.9 | 0.8 | 0.8 | 0.8 | 0.9 | 0.8 | 0.7 | 0.8 | 0.8 | 0.8 |
| Males aged 15–64 years | 1.1 | 1.1 | 1.2 | 1.2 | 1.1 | 1.2 | 1.1 | 1.2 | 1.2 | 1.3 | 1.2 | 1.1 | 1.2 | 1.1 | 1.2 |
| Males aged 65+ years | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Females aged 6–14 years | 0.6 | 0.6 | 0.6 | 0.8 | 0.6 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Females aged 15–64 years | 1.3 | 1.2 | 1.3 | 1.4 | 1.2 | 1.3 | 1.2 | 1.3 | 1.3 | 1.4 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| Females aged 65+ years | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Total income (1992 $) | 50.9 | 60.6 | 50.5 | 43.4 | 46.6 | 80.4 | 101.6 | 72.5 | 49.3 | 84.8 | Not included | | | | |
| Consumption expenditure (1992 $) | 48.4 | 60.2 | 46.7 | 37.5 | 46.1 | 78.5 | 95.3 | 75.1 | 49.0 | 82.2 | 85.3 | 123.6 | 71.8 | 46.8 | 79.4 |
| Main activity agriculture (%) | 62.6 | 55.8 | 62.4 | 71.4 | 63.0 | 70.3 | 66.1 | 68.5 | 74.9 | 73.8 | | | | | |
| House with iron sheet roof or better (%) | 47.1 | 67.1 | 44.6 | 20.0 | 49.8 | 61.5 | 83.1 | 53.6 | 15.2 | 75.0 | 64.4 | 88.4 | 54.7 | 14.1 | 81.8 |
| House with toilet facility (%) | 79.0 | 91.5 | 74.2 | 54.8 | 90.1 | 68.1 | 76.5 | 56.9 | 47.9 | 82.7 | 75.0 | 80.6 | 65.0 | 58.3 | 90.6 |
| Located in rural location (%) | 64.5 | 58.9 | 65.7 | 68.8 | 65.9 | 78.0 | 69.9 | 79.4 | 80.7 | 83.6 | 83.3 | 66.9 | 90.0 | 92.1 | 90.4 |
| Observations | 9,920 | 2,818 | 2,512 | 2,106 | 2,484 | 10,696 | 3,110 | 2,865 | 1,802 | 2,919 | 9,711 | 2,831 | 2,675 | 1,730 | 2,475 |

Source: Authors' calculations from 1992/93, 1999/2000 and 2002/03 household surveys.

# Appendix B: Seasonal average rainfall and deviations

| Season* | Average rainfall (mm) | | | | | Deviation from long-term average | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All Uganda | Central | East | North | West | All Uganda | Central | East | North | West |
| ***1992/93*** | | | | | | | | | | |
| First planting(March–May) | 149.4 | 163.6 | 165.3 | 191.4 | 98.9 | 32.0 | 33.7 | 32.7 | 26.0 | 31.9 |
| First harvest(June–August) | 85.1 | 97.6 | 90.2 | 106.4 | 53.3 | 8.4 | 10.0 | 17.9 | 1.0 | 2.9 |
| Second planting(September–November) | 134.4 | 126.3 | 122.9 | 150.2 | 133.9 | -23.9 | -13.0 | -10.2 | -37.6 | -29.4 |
| Second harvest(December-February) | 56.6 | 56.3 | 59.3 | 55.5 | 55.1 | 7.6 | 6.9 | 6.0 | 13.3 | 4.1 |
| ***1999/2000*** | | | | | | | | | | |
| First planting(March–May) | 119.3 | 139.0 | 112.8 | 90.6 | 126.2 | 30.2 | 22.4 | 60.8 | 56.1 | -10.4 |
| First harvest(June–August) | 83.5 | 83.5 | 104.7 | 151.0 | 41.8 | 1.0 | -4.7 | 11.7 | -3.1 | 3.2 |
| Second planting(September–November) | 141.3 | 149.2 | 123.4 | 166.0 | 130.1 | -19.8 | -35.7 | -0.8 | -24.8 | -17.4 |
| Second harvest(December–February) | 51.3 | 64.3 | 63.0 | 13.2 | 43.9 | 12.6 | 5.3 | -1.4 | 37.9 | 23.0 |
| ***2002/03*** | | | | | | | | | | |
| First planting(March–May) | 150.2 | 178.0 | 188.8 | 139.0 | 115.8 | 5.1 | -12.7 | 52.0 | -18.1 | -3.8 |
| First harvest(June–August) | 82.6 | 59.5 | 59.9 | 177.3 | 40.3 | -10.6 | 17.7 | -42.4 | 37.7 | -19.3 |
| Second planting(September–November) | 141.7 | 176.7 | 153.8 | 146.6 | 111.5 | 28.8 | 63.8 | 58.7 | 13.1 | 0.7 |
| Second harvest(December–February) | 73.1 | 144.3 | 83.6 | 28.1 | 63.3 | 13.9 | 58.5 | 30.3 | -20.1 | 4.8 |

* Seasons are defined according to the country's rainfall and crop patterns. The first planting season covers the rainy months of March–May and the first harvest season follows in the dry months of June to August. The second planting season is the September to November quarter followed by the second harvest season of December to February. It is important to note that the weather patterns depict long-term averages. In any given year/season rains may come earlier or later, which may have implications for crop output and quality.

Source: Authors' calculations based on data from the *Statistical Abstracts* and the *Background to the Budget*, various issues.

# Appendix C: Results for response to rainfall shocks

**Table C1: Impact of rainfall shocks on total household income**

| Dependent variable is log total household income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Female head* | -0.042 | -0.042 | -0.041 | -0.041 |
| | (1.69) | (1.72) | (1.50) | (1.54) |
| Age of head (log) | -0.076 | -0.076 | -0.086 | -0.087 |
| | (2.27)* | (2.27)* | (2.30)* | (2.35)* |
| Education of head, years | 0.048 | 0.048 | 0.041 | 0.040 |
| | (18.23)** | (18.16)** | (12.96)** | (12.84)** |
| Children under 5 | 0.061 | 0.061 | 0.049 | 0.048 |
| | (7.13)** | (7.13)** | (5.00)** | (4.99)** |
| Males 15–64 years | 0.139 | 0.138 | 0.128 | 0.127 |
| | (13.03)** | (13.03)** | (10.61)** | (10.60)** |
| Females 15–64 years | 0.169 | 0.169 | 0.187 | 0.187 |
| | (15.27)** | (15.34)** | (14.64)** | (14.68)** |
| Males 6–14 years | 0.106 | 0.105 | 0.103 | 0.103 |
| | (12.43)** | (12.43)** | (10.86)** | (10.83)** |
| Males over 64 years | 0.102 | 0.101 | 0.122 | 0.121 |
| | (3.00)** | (2.96)** | (3.27)** | (3.25)** |
| Females 6–14 years | 0.111 | 0.110 | 0.111 | 0.111 |
| | (12.38)** | (12.29)** | (11.00)** | (10.95)** |
| Females over 64 years | 0.180 | 0.181 | 0.227 | 0.228 |
| | (5.55)** | (5.57)** | (6.40)** | (6.45)** |
| Total land owned (log) | 0.196 | 0.195 | 0.187 | 0.187 |
| | (16.65)** | (16.67)** | (13.81)** | (13.86)** |
| Rural household | -0.287 | -0.283 | -0.230 | -0.223 |
| | (7.03)** | (6.94)** | (4.24)** | (4.11)** |
| All-weather road | 0.000 | 0.000 | 0.000 | 0.000 |
| | (4.48)** | (4.52)** | (4.93)** | (5.03)** |
| Electricity | 0.027 | 0.031 | 0.018 | 0.021 |
| | (0.89) | (1.01) | (0.47) | (0.58) |
| Market within | -0.017 | -0.017 | -0.032 | -0.032 |
| | (0.89) | (0.88) | (1.51) | (1.51) |
| Market outside | 0.014 | 0.017 | 0.020 | 0.020 |
| | (0.53) | (0.63) | (0.65) | (0.66) |
| Financial inst within | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.60) | (1.74) | (1.78) | (1.91) |
| Year dummy, 2002 =1 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.00)** | (0.00)** | (0.00)** | (0.00)** |

*Continued*

**Table C1, continued**

| Dependent variable is log total household income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| East | -0.413 | -0.415 | -0.476 | -0.481 |
| | (16.32)** | (16.41)** | (16.74)** | (16.92)** |
| North | -0.725 | -0.734 | -0.755 | -0.762 |
| | (23.76)** | (24.09)** | (22.53)** | (22.75)** |
| West | -0.140 | -0.136 | -0.159 | -0.156 |
| | (5.68)** | (5.54)** | (5.79)** | (5.73)** |
| ***Seasonal rainfall shock:*** | | | | |
| First planting (P1) | -0.679 | | -0.517 | |
| | (3.05)** | | (1.97)* | |
| Second planting (P2) | -0.259 | | -0.013 | |
| | (1.62) | | (0.07) | |
| First harvest (H1) | 0.191 | | 0.121 | |
| | (0.86) | | (0.48) | |
| Second harvest (H2) | -0.177 | | -0.380 | |
| | (0.75) | | (1.41) | |
| Positive shock, P1 | | -0.459 | | -0.459 |
| | | (4.69)** | | (3.92)** |
| Positive shock, P2 | | 0.000 | | 0.000 |
| | | (0.00)** | | (0.00)** |
| Positive shock, H1 | | 0.071 | | 0.043 |
| | | (1.10) | | (0.59) |
| Positive shock, H2 | | -0.151 | | -0.163 |
| | | (2.04)* | | (1.99)* |
| Constant | 13.523 | 14.003 | 13.604 | 14.052 |
| | (90.88)** | (78.87)** | (79.37)** | (68.23)** |
| Observations | 7,217 | 7,217 | 5,794 | 5,794 |
| Adjusted R-squared | 0.40 | 0.40 | 0.37 | 0.38 |
| t-test P1 = P2 = P3 = P4 = 0 [prob >F] | 0.011 | 0.000 | 0.188 | 0.000 |

Absolute value of t-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

**Table C2: Rainfall shocks and total household income, with interactive dummies**

| Dependent variable is log total household income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female head | 0.404 | 0.313 | 0.415 | 0.230 |
| | (2.25)* | (1.78) | (2.01)* | (1.16) |
| Age of head (log) | -0.074 | -0.074 | -0.085 | -0.088 |
| | (2.20)* | (2.21)* | (2.28)* | (2.37)* |
| Education of head, years | 0.048 | 0.048 | 0.041 | 0.041 |
| | (18.18)** | (18.15)** | (12.95)** | (12.92)** |
| Children under 5 | 0.062 | 0.063 | 0.051 | 0.051 |
| | (7.21)** | (7.33)** | (5.21)** | (5.28)** |
| Males 15–64 years | 0.138 | 0.138 | 0.130 | 0.129 |
| | (12.96)** | (13.04)** | (10.81)** | (10.78)** |
| Females 15–64 years | 0.166 | 0.166 | 0.184 | 0.184 |
| | (15.03)** | (15.08)** | (14.42)** | (14.47)** |
| Males 6–14 years | 0.106 | 0.105 | 0.103 | 0.102 |
| | (12.46)** | (12.44)** | (10.87)** | (10.80)** |
| Males over 64 years | 0.100 | 0.101 | 0.119 | 0.121 |
| | (2.94)** | (2.98)** | (3.22)** | (3.28)** |
| Females 6–14 years | 0.110 | 0.109 | 0.110 | 0.109 |
| | (12.33)** | (12.23)** | (10.95)** | (10.86)** |
| Females over 64 years | 0.178 | 0.178 | 0.232 | 0.232 |
| | (5.50)** | (5.48)** | (6.56)** | (6.58)** |
| Total land owned (log) | 0.092 | 0.017 | 0.225 | 0.116 |
| | (1.04) | (0.21) | (1.98)* | (1.07) |
| Rural household | 0.005 | -0.184 | 0.232 | 0.134 |
| | (0.01) | (0.61) | (0.33) | (0.34) |
| All-weather road | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.46) | (1.08) | (1.09) | (0.23) |
| Electricity | 0.023 | 0.026 | 0.002 | 0.002 |
| | (0.76) | (0.87) | (0.06) | (0.04) |
| Market within | 0.084 | 0.065 | 0.227 | 0.178 |
| | (0.51) | (0.40) | (1.22) | (0.96) |
| Market outside | -0.132 | -0.271 | -0.572 | -0.780 |
| | (0.47) | (0.99) | (1.58) | (2.18)* |
| Financial inst within | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.46) | (1.62) | (1.63) | (1.73) |
| Year dummy, 2002 =1 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.00)** | (0.00)** | (0.00)** | (0.00)** |
| East | -0.401 | -0.409 | -0.462 | -0.469 |
| | (15.75)** | (16.02)** | (16.22)** | (16.41)** |
| North | -0.728 | -0.741 | -0.749 | -0.764 |
| | (23.67)** | (23.94)** | (22.25)** | (22.47)** |
| West | -0.132 | -0.125 | -0.148 | -0.143 |
| | (5.34)** | (5.04)** | (5.38)** | (5.21)** |
| ***Seasonal rainfall shock:*** | | | | |
| First planting (P1) | -0.620 | | 1.659 | |
| | (0.80) | | (1.30) | |
| Second planting (P2) | 0.337 | | 2.365 | |
| | (0.30) | | (1.24) | |

*Continued*

**Table C2, continued**

| Dependent variable is log total household income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| First harvest (H1) | 3.618 | | 3.671 | |
| | (0.72) | | (0.53) | |
| Second harvest (H2) | 3.158 | | 3.538 | |
| | (2.74)** | | (1.99)* | |
| Land size*P1 rain shock | -0.198 | 0.211 | -0.484 | -0.136 |
| | (0.74) | (0.91) | (1.41) | (0.44) |
| Land size*P2 rain shock | 0.075 | 0.023 | 0.113 | 0.071 |
| | (0.21) | (0.06) | (0.27) | (0.17) |
| Land size*H1 rain shock | -0.080 | 0.015 | -0.530 | -0.188 |
| | (0.35) | (0.07) | (1.85) | (0.70) |
| Land size*H2 rain shock | -0.568 | -0.544 | -0.570 | -0.505 |
| | (2.60)** | (2.55)* | (1.96)* | (1.76) |
| Rural*P1 rain shock | -3.401 | -0.996 | -3.143 | 0.131 |
| | (3.21)** | (1.14) | (1.95) | (0.12) |
| Rural*P2 rain shock | -5.550 | -2.803 | -5.598 | -2.704 |
| | (1.10) | (1.99)* | (0.81) | (1.61) |
| Rural*H1 rain shock | 2.547 | 2.680 | 2.238 | 3.494 |
| | (2.31)* | (2.70)** | (1.44) | (2.74)** |
| Rural*H2 rain shock | 2.411 | 2.634 | 3.056 | 5.012 |
| | (2.55)* | (5.14)** | (1.75) | (6.54)** |
| Positive shock, P1 | | -0.633 | | -0.632 |
| | | (3.80)** | | (3.03)** |
| Positive shock, P2 | | 0.000 | | 0.000 |
| | | (0.00)** | | (0.00)** |
| Positive shock, H1 | | 0.175 | | 0.146 |
| | | (1.16) | | (0.84) |
| Positive shock, H2 | | -0.264 | | -0.381 |
| | | (1.61) | | (1.94) |
| Constant | 13.329 | 14.275 | 13.334 | 14.439 |
| | (28.89)** | (52.81)** | (18.36)** | (44.13)** |
| Observations | 7,217 | 7,217 | 5,794 | 5,794 |
| Adjusted R-squared | 0.40 | 0.40 | 0.38 | 0.38 |
| t-test P1 = P2 = P3 = P4 = 0 [prob >F] | 0.071 | 0.000 | 0.111 | 0.004 |

Absolute value of t-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

**Table C3: Impact of rainfall shocks on agricultural income**

| Dependent variable is log of agricultural income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female head | -0.356 | -0.359 | -0.306 | -0.308 |
| | (5.86)** | (5.91)** | (5.39)** | (5.43)** |
| Age of head (log) | 0.041 | 0.045 | -0.056 | -0.053 |
| | (0.50) | (0.55) | (0.71) | (0.68) |
| Education of head, years | 0.037 | 0.037 | 0.049 | 0.049 |
| | (5.71)** | (5.66)** | (7.41)** | (7.36)** |
| Children under 5 | 0.047 | 0.046 | 0.020 | 0.019 |
| | (2.25)* | (2.17)* | (0.99) | (0.93) |
| Males 15–64 years | 0.137 | 0.134 | 0.115 | 0.114 |
| | (5.23)** | (5.14)** | (4.53)** | (4.49)** |
| Females 15–64 years | 0.165 | 0.166 | 0.204 | 0.205 |
| | (6.05)** | (6.12)** | (7.56)** | (7.61)** |
| Males 6–14 years | 0.094 | 0.095 | 0.093 | 0.093 |
| | (4.52)** | (4.54)** | (4.64)** | (4.64)** |
| Males over 64 years | 0.016 | 0.011 | 0.056 | 0.053 |
| | (0.19) | (0.13) | (0.72) | (0.68) |
| Females 6–14 years | 0.054 | 0.052 | 0.094 | 0.093 |
| | (2.43)* | (2.35)* | (4.42)** | (4.35)** |
| Females over 64 years | 0.215 | 0.216 | 0.226 | 0.228 |
| | (2.69)** | (2.71)** | (3.03)** | (3.06)** |
| Total land owned (log) | 0.509 | 0.508 | 0.410 | 0.409 |
| | (17.60)** | (17.61)** | (14.39)** | (14.39)** |
| Rural household | 0.767 | 0.768 | 0.327 | 0.331 |
| | (7.64)** | (7.67)** | (2.86)** | (2.89)** |
| All-weather road | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.66) | (0.67) | (1.36) | (1.37) |
| Electricity | 0.050 | 0.049 | 0.092 | 0.094 |
| | (0.67) | (0.65) | (1.18) | (1.20) |
| Market within | 0.093 | 0.091 | 0.056 | 0.054 |
| | (1.98)* | (1.95) | (1.26) | (1.21) |
| Market outside | 0.339 | 0.341 | 0.244 | 0.247 |
| | (5.12)** | (5.16)** | (3.71)** | (3.76)** |
| Financial inst within | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.45) | (1.58) | (0.12) | (0.23) |
| Year dummy, 2002 =1 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.00)** | (0.00)** | (0.00)** | (0.00)** |
| East | -0.663 | -0.657 | -0.736 | -0.736 |
| | (10.65)** | (10.54)** | (12.29)** | (12.28)** |
| North | -1.340 | -1.357 | -1.144 | -1.158 |
| | (17.87)** | (18.11)** | (16.20)** | (16.40)** |
| West | -0.064 | -0.058 | -0.132 | -0.130 |
| | (1.05) | (0.97) | (2.28)* | (2.27)* |
| ***Seasonal rainfall shock:*** | | | | |
| First planting | 0.097 | | 0.104 | |
| | (0.18) | | (0.19) | |
| Second planting | -0.578 | | -0.374 | |
| | (1.47) | | (0.97) | |

*Continued*

**Table C3, continued**

| Dependent variable is log of agricultural income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| First harvest | 0.238 | | 0.430 | |
| | (0.43) | | (0.80) | |
| Second harvest | -0.835 | | -0.621 | |
| | (1.44) | | (1.10) | |
| Positive shock, P1 | | -0.255 | | -0.246 |
| | | (1.05) | | (0.98) |
| Positive shock, P2 | | 0.000 | | 0.000 |
| | | (0.00)** | | (0.00)** |
| Positive shock, H1 | | 0.005 | | 0.079 |
| | | (0.03) | | (0.52) |
| Positive shock, H2 | | -0.594 | | -0.400 |
| | | (3.26)** | | (2.33)* |
| Constant | 10.624 | 11.502 | 11.689 | 12.338 |
| | (29.00)** | (26.26)** | (32.29)** | (28.27)** |
| Observations | 7,209 | 7,209 | 5,788 | 5,788 |
| Adjusted R-squared | 0.21 | 0.21 | 0.21 | 0.21 |
| t-test P1 = P2 = P3 = P4 = 0 [prob >F] | 0.349 | 0.008 | 0.587 | 0.084 |

Absolute value of t-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

**Table C4: Rainfall shocks and agricultural income with interactive dummies**

| Dependent variable is log of agricultural income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female head | -0.381 | -0.738 | -0.726 | -1.165 |
| | (0.85) | (1.68) | (1.65) | (2.74)** |
| Age of head (log) | 0.039 | 0.041 | -0.057 | -0.063 |
| | (0.48) | (0.49) | (0.73) | (0.80) |
| Education of head, years | 0.038 | 0.037 | 0.049 | 0.049 |
| | (5.76)** | (5.66)** | (7.43)** | (7.36)** |
| Children under 5 | 0.044 | 0.045 | 0.017 | 0.017 |
| | (2.07)* | (2.12)* | (0.81) | (0.83) |
| Males 15–64 years | 0.134 | 0.131 | 0.114 | 0.111 |
| | (5.13)** | (5.00)** | (4.50)** | (4.39)** |
| Females 15–64 years | 0.162 | 0.164 | 0.201 | 0.202 |
| | (5.95)** | (6.03)** | (7.45)** | (7.50)** |
| Males 6–14 years | 0.094 | 0.095 | 0.092 | 0.092 |
| | (4.48)** | (4.54)** | (4.60)** | (4.60)** |
| Males over 64 years | 0.010 | 0.011 | 0.049 | 0.052 |
| | (0.12) | (0.13) | (0.62) | (0.67) |
| Females 6–14 years | 0.054 | 0.053 | 0.094 | 0.093 |
| | (2.44)* | (2.39)* | (4.39)** | (4.37)** |
| Females over 64 years | 0.217 | 0.213 | 0.228 | 0.228 |
| | (2.71)** | (2.67)** | (3.06)** | (3.05)** |
| Total land owned (log) | 0.223 | -0.012 | 0.166 | -0.075 |
| | (1.02) | (0.06) | (0.69) | (0.33) |
| Rural household | 2.776 | 0.115 | 2.679 | 0.484 |
| | (2.49)* | (0.15) | (1.79) | (0.57) |
| All-weather road | 0.002 | 0.001 | 0.002 | 0.001 |
| | (2.61)** | (2.12)* | (2.46)* | (1.77) |
| Electricity | 0.052 | 0.049 | 0.097 | 0.089 |
| | (0.69) | (0.65) | (1.23) | (1.13) |
| Market within | 0.408 | 0.192 | 0.300 | 0.110 |
| | (1.02) | (0.48) | (0.76) | (0.28) |
| Market outside | 1.637 | 1.161 | 0.813 | 0.309 |
| | (2.33)* | (1.71) | (1.04) | (0.40) |
| Financial inst within | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.55) | (1.68) | (0.25) | (0.35) |
| Year dummy, 2002 =1 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.00)** | (0.00)** | (0.00)** | (0.00)** |
| North | -0.659 | -0.663 | -0.733 | -0.738 |
| | (10.50)** | (10.52)** | (12.16)** | (12.19)** |
| East | -1.346 | -1.367 | -1.146 | -1.165 |
| | (17.77)** | (17.90)** | (16.08)** | (16.18)** |
| West | -0.052 | -0.054 | -0.131 | -0.133 |
| | (0.85) | (0.89) | (2.25)* | (2.28)* |
| First planting | 4.793 | | 7.551 | |
| | (2.51)* | | (2.75)** | |
| Second planting | -1.157 | | -1.100 | |
| | (0.42) | | (0.27) | |
| First harvest | -24.520 | | -3.284 | |
| | (1.97)* | | (0.23) | |

*Continued*

**Table C4, continued**

| Dependent variable is log of agricultural income | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Second harvest | 3.857 | | 3.407 | |
| | (1.36) | | (0.91) | |
| Positive shock, P1 | | -0.317 | | -0.521 |
| | | (0.77) | | (1.18) |
| Positive shock, P2 | | 0.000 | | 0.000 |
| | | (0.00)** | | (0.00)** |
| Positive shock, H1 | | -0.282 | | -0.121 |
| | | (0.76) | | (0.33) |
| Positive shock, H2 | | -1.058 | | -0.929 |
| | | (2.61)** | | (2.23)* |
| Land size*P1 rain shock | -0.812 | -0.191 | -0.456 | -0.054 |
| | (1.23) | (0.33) | (0.63) | (0.08) |
| Land size*P2 rain shock | -0.126 | -0.126 | -0.431 | -0.408 |
| | (0.14) | (0.14) | (0.49) | (0.46) |
| Land size*H1 rain shock | 0.696 | 1.310 | 0.133 | 0.936 |
| | (1.22) | (2.43)* | (0.22) | (1.63) |
| Land size*H2 rain shock | -0.904 | -0.947 | -0.984 | -1.007 |
| | (1.68) | (1.80) | (1.59) | (1.65) |
| Rural*P1 rain shock | -3.426 | 0.997 | -3.042 | 1.233 |
| | (1.31) | (0.46) | (0.89) | (0.55) |
| Rural*P2 rain shock | 20.571 | -1.844 | 4.203 | 1.650 |
| | (1.66) | (0.53) | (0.29) | (0.46) |
| Rural*H1 rain shock | -0.886 | 2.551 | -4.032 | 1.449 |
| | (0.32) | (1.04) | (1.21) | (0.54) |
| Rural*H2 rain shock | 1.407 | 0.612 | 3.129 | 2.290 |
| | (0.60) | (0.47) | (0.85) | (1.33) |
| Constant | 7.609 | 12.055 | 9.081 | 13.192 |
| | (6.67)** | (18.06)** | (5.87)** | (19.01)** |
| Observations | 7,209 | 7,209 | 5,788 | 5,788 |
| Adjusted R-squared | 0.21 | 0.21 | 0.21 | 0.21 |
| t-test P1 = P2 = P3 = P4 = 0 [prob >F] | 0.016 | 0.046 | 0.073 | 0.093 |

Absolute value of t-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

**Table C5: Impact of rainfall shocks on consumption expenditure**

| Dependent variable is log of consumption expenditure | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female head | 0.049 | 0.048 | 0.012 | 0.013 |
| | (4.08)** | (4.04)** | (0.75) | (0.82) |
| Age of head (log) | -0.056 | -0.056 | -0.037 | -0.037 |
| | (3.33)** | (3.34)** | (1.75) | (1.74) |
| Education of head, years | 0.056 | 0.056 | 0.036 | 0.036 |
| | (43.82)** | (43.78)** | (20.22)** | (20.24)** |
| Children under 5 | -0.101 | -0.101 | -0.078 | -0.077 |
| | (23.60)** | (23.67)** | (14.46)** | (14.45)** |
| Males 15–64 years | -0.014 | -0.014 | -0.038 | -0.038 |
| | (2.69)** | (2.74)** | (5.59)** | (5.63)** |
| Females 15–64 years | 0.007 | 0.007 | -0.008 | -0.008 |
| | (1.30) | (1.29) | (1.17) | (1.19) |
| Males 6–14 years | -0.089 | -0.089 | -0.088 | -0.087 |
| | (19.72)** | (19.75)** | (16.22)** | (16.16)** |
| Males over 64 years | -0.024 | -0.024 | -0.032 | -0.031 |
| | (1.23) | (1.24) | (1.49) | (1.46) |
| Females 6–14 years | -0.054 | -0.054 | -0.047 | -0.047 |
| | (11.85)** | (11.88)** | (8.34)** | (8.32)** |
| Females over 64 years | 0.006 | 0.007 | 0.014 | 0.015 |
| | (0.34) | (0.36) | (0.69) | (0.70) |
| Total land owned (log) | 0.107 | 0.108 | 0.112 | 0.111 |
| | (12.66)** | (12.77)** | (12.43)** | (12.40)** |
| Rural household | -0.229 | -0.233 | -0.111 | -0.105 |
| | (16.42)** | (16.77)** | (4.64)** | (4.41)** |
| All-weather road | 0.000 | 0.000 | 0.000 | 0.000 |
| | (5.00)** | (5.09)** | (5.58)** | (5.72)** |
| Electricity in community | 0.206 | 0.205 | 0.136 | 0.138 |
| | (15.39)** | (15.36)** | (6.73)** | (6.87)** |
| Market within | 0.014 | 0.014 | 0.028 | 0.030 |
| | (1.37) | (1.37) | (2.35)* | (2.48)* |
| Market outside | 0.083 | 0.082 | 0.049 | 0.047 |
| | (7.66)** | (7.54)** | (3.41)** | (3.29)** |
| Financial inst within | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.94) | (1.78) | (2.37)* | (2.19)* |
| Year dummy, 2002 =1 | 0.097 | 0.117 | -0.001 | 0.135 |
| | (2.04)* | (2.04)* | (0.01) | (2.08)* |
| East | -0.201 | -0.205 | -0.228 | -0.235 |
| | (16.41)** | (16.76)** | (14.28)** | (14.72)** |
| North | -0.506 | -0.513 | -0.570 | -0.568 |
| | (35.05)** | (36.05)** | (31.41)** | (31.78)** |
| West | -0.118 | -0.124 | -0.134 | -0.139 |
| | (9.69)** | (10.20)** | (8.77)** | (9.08)** |
| ***Seasonal rainfall shock:*** | | | | |
| First planting | 0.000 | | 0.000 | |
| | (0.15) | | (0.13) | |
| Second planting | -0.004 | | -0.005 | |
| | (2.35)* | | (1.72) | |

*Continued*

**Table C5, continued**

| Dependent variable is log of consumption expenditure | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| First harvest | -0.001 | | -0.003 | |
| | (0.89) | | (1.63) | |
| Second harvest | -0.002 | | 0.012 | |
| | (1.13) | | (2.92)** | |
| Positive shock, P1 | | -0.228 | | -0.228 |
| | | (6.86)** | | (4.64)** |
| Positive shock, P2 | | -0.255 | | -0.205 |
| | | (3.15)** | | (1.81) |
| Positive shock, H1 | | 0.028 | | 0.008 |
| | | (0.57) | | (0.15) |
| Positive shock, H2 | | 0.053 | | 0.090 |
| | | (1.81) | | (2.18)* |
| Constant | 10.557 | 10.741 | 10.502 | 10.639 |
| | (164.27)** | (138.92)** | (126.81)** | (102.92)** |
| Observations | 16,773 | 16,773 | 8,673 | 8,673 |
| Adjusted R-squared | 0.37 | 0.37 | 0.25 | 0.25 |
| t-test P1 = P2 = P3 = P4 = 0 [prob >F] | 0.108 | 0.000 | 0.008 | 0.000 |

Absolute value of t-statistics in parentheses; * significant at 5% level; ** significant at 1% level.

**Table C6: Rainfall shocks and consumption expenditure with interactive dummies**

| Dependent variable is log of consumption expenditure | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female head | 0.017 | 0.019 | 0.007 | 0.009 |
| | (1.02) | (1.12) | (0.41) | (0.51) |
| Age of head (log) | -0.064 | -0.065 | -0.043 | -0.044 |
| | (3.84)** | (3.89)** | (2.05)* | (2.08)* |
| Education of head, years | 0.055 | 0.055 | 0.035 | 0.035 |
| | (43.30)** | (43.28)** | (19.87)** | (19.75)** |
| Children under 5 | -0.101 | -0.101 | -0.076 | -0.076 |
| | (23.69)** | (23.82)** | (14.24)** | (14.26)** |
| Males 15–64 years | -0.019 | -0.019 | -0.042 | -0.042 |
| | (3.60)** | (3.60)** | (6.24)** | (6.28)** |
| Females 15–64 years | 0.003 | 0.003 | -0.013 | -0.013 |
| | (0.54) | (0.53) | (1.88) | (1.87) |
| Males 6–14 years | -0.089 | -0.089 | -0.088 | -0.088 |
| | (20.03)** | (20.02)** | (16.38)** | (16.42)** |
| Males over 64 years | -0.032 | -0.031 | -0.036 | -0.035 |
| | (1.69) | (1.63) | (1.68) | (1.64) |
| Females 6–14 years | -0.056 | -0.055 | -0.048 | -0.048 |
| | (12.26)** | (12.22)** | (8.65)** | (8.60)** |
| Females over 64 years | -0.001 | 0.000 | 0.004 | 0.004 |
| | (0.04) | (0.02) | (0.17) | (0.21) |
| Total land owned (log) | 0.100 | 0.098 | 0.097 | 0.100 |
| | (6.75)** | (6.67)** | (4.75)** | (4.84)** |
| Rural household | -0.265 | -0.256 | -0.202 | -0.185 |
| | (9.48)** | (9.25)** | (5.57)** | (5.25)** |
| All-weather road | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.99) | (2.13)* | (1.29) | (0.80) |
| Electricity | 0.205 | 0.204 | 0.127 | 0.127 |
| | (15.29)** | (15.29)** | (6.31)** | (6.29)** |
| Market within | 0.048 | 0.051 | 0.040 | 0.040 |
| | (3.44)** | (3.73)** | (2.78)** | (2.73)** |
| Market outside | 0.031 | 0.035 | 0.000 | 0.003 |
| | (1.55) | (1.79) | (0.00) | (0.14) |
| Financial inst within | 0.000 | 0.000 | 0.000 | 0.000 |
| | (1.88) | (1.80) | (2.20)* | (2.20)* |
| Year dummy, 2002 =1 | 0.025 | 0.019 | -0.094 | -0.215 |
| | (0.48) | (0.27) | (1.04) | (2.32)* |
| East | -0.197 | -0.200 | -0.220 | -0.219 |
| | (16.03)** | (16.27)** | (13.85)** | (13.76)** |
| North | -0.512 | -0.513 | -0.575 | -0.580 |
| | (35.22)** | (35.54)** | (31.44)** | (31.72)** |
| West | -0.119 | -0.125 | -0.127 | -0.131 |
| | (9.79)** | (10.20)** | (8.34)** | (8.52)** |
| ***Seasonal rainfall shock:*** | | | | |
| First planting | 0.005 | | -0.029 | |
| | (1.67) | | (2.74)** | |
| Second planting | 0.001 | | 0.013 | |
| | (0.26) | | (1.19) | |

*Continued*

**Table C6, continued**

| Dependent variable is log of consumption expenditure | All households | | Agricultural households only | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| First harvest | -0.002 | | 0.006 | |
| | (0.54) | | (0.93) | |
| Second harvest | -0.005 | | -0.005 | |
| | (0.76) | | (0.36) | |
| Positive shock, P1 | | -0.286 | | -0.247 |
| | | (7.33)** | | (4.58)** |
| Positive shock, P2 | | -0.071 | | 0.277 |
| | | (0.67) | | (1.33) |
| Positive shock, H1 | | -0.003 | | -0.037 |
| | | (0.06) | | (0.72) |
| Positive shock, H2 | | 0.042 | | -0.036 |
| | | (1.14) | | (0.61) |
| Land size*P1 rain shock | -0.034 | -0.037 | 0.101 | 0.128 |
| | (2.66)** | (2.90)** | (1.14) | (1.25) |
| Land size*P2 rain shock | 0.030 | 0.028 | 0.016 | 0.021 |
| | (1.78) | (1.66) | (0.65) | (0.83) |
| Land size*H1 rain shock | 0.003 | 0.003 | -0.012 | -0.013 |
| | (0.33) | (0.31) | (0.70) | (0.79) |
| Land size*H2 rain shock | -0.018 | -0.024 | -0.013 | 0.011 |
| | (0.43) | (0.57) | (0.21) | (0.18) |
| Rural*P1 rain shock | 0.016 | 0.014 | 0.039 | 0.041 |
| | (3.67)** | (3.18)** | (3.21)** | (4.18)** |
| Rural*P2 rain shock | -0.005 | -0.005 | -0.012 | -0.008 |
| | (2.79)** | (3.82)** | (2.74)** | (3.11)** |
| Rural*H1 rain shock | 0.000 | 0.002 | 0.028 | 0.004 |
| | (0.16) | (1.06) | (2.80)** | (1.38) |
| Rural*H2 rain shock | -0.008 | -0.008 | -0.015 | -0.009 |
| | (1.92) | (2.57)* | (1.47) | (1.71) |
| Constant | 10.682 | 10.915 | 10.658 | 10.924 |
| | (157.73)** | (127.04)** | (123.81)** | (93.70)** |
| Observations | 16,773 | 16,773 | 8,673 | 8,673 |
| Adjusted R-squared | 0.38 | 0.38 | 0.27 | 0.27 |
| t-test P1 = P2 = P3 = P4 = 0 [prob >F] | 0.255 | 0.000 | 0.017 | 0.000 |

Absolute value of t-statistics in parentheses: * Significant at 5% level; ** significant at 1% level.

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**ISBN 9966-778-13-6**