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Can Rwandan Rural Households Manage?*

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Abstract

During the nineties Rwandan households faced severe shocks of war and genocide. In addition, the structural problem of land scarcity remains unsolved. How did Rwandan households manage? This is an important question from a development perspective, but also from a security perspective, because uneven development raises the risk of renewed conflict. To find an answer, we study welfare gains and losses in a sample of 189 rural households in two Rwandan provinces over the period 1990-2002. In our sample, many households were severely affected by the genocide. In addition, poverty and inequality increased. Moreover, we observe a lot of income mobility. Only one quarter of the households remained in the same income quintile over time. Especially the households headed by widows and prisoner's wives moved downward in the income distribution. Households who reduced their dependence on subsistence agriculture moved upward.

1. Introduction

In this paper we study income mobility of rural household in Rwanda between 1990 and 2002. Rwanda is special in Sub Saharan Africa because it faces acute problems of land scarcity and declining soil fertility. In addition, the period we cover was characterized by war and genocide. Unrest started in Rwanda at the end of 1990, when the RPF (Rwandan Patriotic Front) started launching attacks from Uganda. Intermittent hostilities and negotiations resulted in a power sharing agreement between the government and the RPF. But on April 6, 1994 the plane carrying President Habyarimana was shot down. Thereafter, Rwanda sunk away in chaos. Within hours, the military, administrators, the Interahamwe militia and ordinary people started to kill Tutsi, moderate Hutu and Hutu leaders from political parties rival to the president's party, the MRDN. Simultaneously the war between the Rwandan army and the RPF was restarted. An important fraction of the population took refuge in neighboring countries. Late in May the killing and the war came to an end. The balance made up after the events was shocking: an estimated 800,000 Tutsi killed, two million people displaced and more than 100,000 prisoners suspected of participation in the genocide (Des Forges, 1999) [1]. There have been multiple conflicts in Africa, but the scale of the violence in Rwanda was unprecedented.

One of the causes of the civil war and a structural problem typical for Rwanda and neighboring Burundi was the alarming increase in population density and land scarcity[2]. According to population censuses in 1978 Rwanda's population stood at 4,85 million people, while by 1991 it had risen to 7,17 million. This means that within a time span of 13 years the population density had increased from 192 to 283 people per square km. As a consequence of war and genocide, the World Bank (2002) estimated that by the end of 1994 the Rwandan population density had dropped to 247 habitants per square km. However, in the aftermath of the genocide population increased again at a fast pace. The population census of 2002 reports a density of 322 inhabitants per square km (Government of Rwanda, 2003)[3]. Since an estimated 90% of Rwanda's population depends on agriculture, increasing land scarcity implies a decrease of economic opportunities, especially so as demographic pressure did not lead to a wide adoption of agricultural innovations (Clay, 1996; Platteau, 2000)[4].

Against the background of these structural problems and of the violence of the nineties, we raise the question how Rwandan rural households manage. Studies comparing the pre-war with the

post-war situation in Rwanda are still scarce and do not agree on the trend of poverty[5]. The trend of increasing inequality is less contested (Government of Rwanda, 2002a; Piron and McKay 2004). But, despite the overall trend of poverty and inequality, some households must do better than others. It is interesting to know which households have managed to improve their income position and which ones have remained poor or fell into poverty. Specific questions we try to answer are: How did the shocks of genocide, civil war and their aftermath affect the income position of households? What were the strategies of households who improved their income? And what were the characteristics of households who fell (deeper) into poverty?

We try to answer these questions using a panel data set of 189 rural Rwandan households for the years 1990 and 2002. The data set starts from a survey carried out by Rwanda's Ministry of Agriculture and Livestock (MINAGRI) in 1989-1990. Our colleague Philip Verwimp (2003) was able to trace most households in that survey in three Rwandan provinces ('prefectures'). Data on the economic activities of these households in two of these provinces were collected in 2002. The panel data make it possible to analyze income mobility over a period covering the civil war and the genocide. Although income mobility studies are still in their infancy, there are some interesting country studies that illustrate the potential richness of economic mobility analysis[6]. In a nutshell, the analysis allows us to quantify the movement of the households through the income distribution and to relate households' mobility experiences to various determinants.

We structure our analysis as follows. In section two we present our data sources. We describe the data collection process, highlight the advantages and disadvantages of our data set, discuss attrition bias in our sample and explain how we measure household welfare. In addition we present summary measures of some of our data. In section three, we use two approaches to describe income mobility, the ordinary (Pearson) correlation coefficient and the inter-temporal transition matrix. Based on these measures, we offer insight in the extent of income movement of Rwandan peasant households between 1990 and 2002. In section four we present some preliminary hypotheses on the relation between variables linked to violence, land scarcity, household strategies and income gains and losses. We illustrate these hypotheses by statistics describing the relation between these variables and the change in income ranking of households. In section five we use regression analysis to analyze systematically the factors that had an impact on income mobility between 1990 and 2002. We find that shocks mattered and that strategies to overcome land scarcity were of paramount importance. The final section concludes.

2. Data

2.1. The data set

In principle, the panel data set for this analysis covers 256 rural households. We have two time observations, the first spanning the crop season from October 1989 through March 1990, the second spanning the same crop season 12 years later, from October 2001 through March 2002[7]. From now onwards, we refer to the two periods as 1990 and 2002. The 1990 data come from a national farm survey carried out by the Division of Agricultural Statistics (DSA) of Rwanda's Ministry of Agriculture and Livestock (MINAGRI)[8]. This survey was based on a nationwide random sample of approximately 1,248 farm households and it was geographically stratified in clusters of 16 households. It provided data on output, area and yields and information on topics such as livestock, non-farm income, household composition and schooling.

In 1999 and 2000, Philip Verwimp (2003) tried to track the same households of the 1990 survey in three provinces ('prefectures') of central and southwest Rwanda: Gitarama, Kibuye and Gikongoro, with 160 households (10 clusters) in the first and 96 (6 clusters) in each of the latter two provinces[9]. At the time he collected mainly demographic data. He was able to trace 155 out of 160 households in Gitarama, all 96 households in Gikongoro and 89 out of 96 households in Kibuye. "Tracking" did not mean that all households still existed. Information on some households was obtained indirectly, e.g. from neighbors.

The data on economic activities were collected in February and March of 2002 as part of a study for the Belgian Department for Development Cooperation (DGOS) under the Policy Research Program. Because of financial constraints, the collection of economic data was limited to Gikongoro and Gitarama provinces. In these two provinces, the faith of 251 out of 256 households is known, though only 212 of the 256 households could be physically located. Therefore the 2002 survey covered 212 out of the 256 households in the 1990 survey. These households were located in 16 different clusters in the two provinces. Each of these clusters was located in a different administrative sector. Annex 1 shows the sectors' location.

Our data set is unique as it is the only available household panel data set on Rwanda that includes information for the same households relating to the period before and after the highly turbulent years of civil war and genocide. In 2000-2001 the Department of Statistics of the

Ministry of Finance and Economic Planning, MINECOFIN, in collaboration with the World Bank, UNDP, UNICEF, DFID and ADB, implemented the Integrated Household Living Conditions Survey (IHLCS). This survey has a much wider coverage than ours (6450 households countrywide against 212 in two provinces in our survey). The main aim of the IHLCS was to obtain a detailed poverty profile as a base for policy measures, later formulated in the PRSP (Government of Rwanda, 2002a). But this survey did not include (retrospective) questions on the extent of shocks suffered during war and genocide[10]. Therefore it does not contain information on the shocks suffered by households as a result of war, genocide and their aftermath and does not permit an analysis of their impact which is one of the purposes of this paper.

2.2. Attrition

From the 256 households in the survey in Gikongoro and Gitarama provinces, 44 (17%) had dropped out by 2002[11]. Important reasons for the high dropout were the genocide of 1994 and the subsequent displacement of the population[12]. Of the 212 remaining households, 13 could not be considered as "the same" households, because the household changed fundamentally, being replaced by distant family or neighbours. For ten of the remaining 1999 households, some crucial variables were missing in the 1990 data set. The panel data set we eventually use comprises complete data on 189 households that could be identified in both years.

An attrition level of 23% (57 out of 246 households with complete information in 1990) may seem high, but it is in line with expectations when taking into consideration the turbulent history of Rwanda between 1990 and 2002. Nevertheless the omission of 57 households may cause attrition bias. Attrition bias occurs when “lost” households differ systematically from remaining ones.

Table 1 compares some household characteristics of the 189 households included in our panel data set with those of the 57 households that had dropped out. We tested the difference between these characteristics by regressing them on an attrition dummy variable and a constant. We found that households that had dropped out, had on average in 1990 a smaller household size, an older household head, a lower value of livestock, a smaller contribution of income from livestock to household income and a somewhat smaller farm size than the households in our panel data set. Other characteristics did not differ significantly.

Table 1: Data of households in panel data set and households that had dropped out, 1990

	189 households of the PCRHS	57 = 44 not traced + 13 not "the same"
Average household size	5.4	4.4**
Average adult equivalent[a]	4.8	4.0
Average age of household head	46	51**
% female-headed households	17.5%	23.6%
Average dependency ratio[b]	1.09	1.10
Average number of TLU [c]	0.95	0.58
Average land ownership (hectare)	0.96 ha	0.78 ha*
Average income per adult equivalent (1990 prices)	10,797 RWF	9,634 RWF
Average income per capita	9,584 RWF	7,706 RWF
Average share of subsistence crops in income	58.5%	61.9%
Average share of cash crops in income	6.6%	6.7%
Average share of livestock in income	8.1%	4.1%**
Average share of beer brewing in income	7.6%	11.3%
Average share of off-farm work in income	19.2%	16.0%

The difference is *significant at 10%, **significant at 5%
RWF=Rwandan Franc

[a] The adult equivalent is based on the calorie needs of household members, depending on their age and sex. The reference is an adult, aged 20-39 years. We took the same values as those used in the IHLCS (Government of Rwanda, 2002b).

[b]Dependency ratio=(number of dependent/ number of active household members). In the case were there were no active, the ratio equals 1.

[c] Tropical Livestock Unit

It is not straightforward to predict how the attrition in our sample influences the results of our income mobility analysis. We attempt to make one prediction. It is probable that a large proportion of the households that dropped out of the sample did not end up in an enviable situation, as they could well have been affected by the massacre of 1994 or by the subsequent displacement of population. The sudden loss of household members or the forced migration probably reduced their welfare in a broad sense. It is also likely to have reduced their income[13]. Therefore, we suspect that the dropout of households results in an upward bias of average income in the 2002 sample. It probably also biases downwards the number of households that suffered sharp income losses. This may affect our analysis of the determinants of income mobility. Indeed, leaving out households that had to cope with severe income reducing shocks is expected to bias downwards the estimated effect of shocks on income. When discussing our results of income mobility, we should keep this in mind.

2.3. Nonrandom household division

Besides attrition, another caveat of many panel data sets is the split-off of individuals from households. If the division of households is nonrandom, estimates of economic mobility may be biased. Foster and Rosenzweig (2002) illustrate this for a panel survey from Bangladesh. They develop a model in which a household member stops co-residing with the household as soon as

his utility of leaving becomes larger than his utility of co-residing. When testing the model empirically, Rosenzweig (2003) finds that the decision to leave a household is determined by household characteristics, i.e. household division is not random. For example, higher income households are more likely to divide. Since the Bangladesh survey gathered information on individuals who left the household, the data allow assessing the effect of leaving out split-off individuals. It was found that the effect of household income on mobility was overstated in the incomplete sample, the reason being that less able men leave the relatively wealthy households.

Since we do not have sufficient follow-up information on individuals leaving our sample, we cannot compare the results of our incomplete with a complete sample that includes split-off individuals. The best we can do to find out whether household division affects our results, is to verify to what extent household division is nonrandom in our sample. Therefore, we perform similar empirical tests as Rosenzweig (2003), first only for men leaving, than also including women[14]. The regression results can be found in annex 2. Column 1 of the table in annex 2 presents the results of a tobit regression for 172 households out of the 189 in our sample that had at least one co-resident men older than 14 years in 1990. The dependent variable is the number of men who left between 1990 and 2002. Column 2 repeats this exercise for the number of adults leaving. Only the estimated coefficient of the total number of men in 1990 and household size in 1990 are significant in respectively column 1 and 2. Therefore, when interpreting the coefficient of household size as an explanatory variable in our analysis of income mobility, we should be aware of a possible bias due to nonrandom household division. For example, if adults who leave large households are less able than those who stay, the positive effect of household size on income mobility - a result we find in section five of this paper - is overestimated. Column 3 and 4 present probit regressions for respectively 202 men and 425 adults, the dependent variable being leaving or staying in the household during the period 1990-2002. Again, we find only scarce evidence for nonrandomness of household division. This makes us confident that the bias caused by leaving out departed individuals is small in our sample.

However, a more serious bias may be caused by nonrandom mortality. Among others, Kanbur and Mukherjee (2003) put it to our attention that if a poor person dies, head-count poverty decreases. We will treat this so-called mortality paradox as a special case of nonrandom household division. In so far the probability of dying is related to household characteristics, the results of our income mobility study may be biased. But how will they be biased? This is difficult to tell without knowing what income we should ascribe to those who died prematurely. Kanbur

and Mukherjee (2003) argue that we should project what the individual would have had if still alive. This would imply for example that if the risk of premature mortality is highest for the least productive individuals of the poorest households, upward income mobility for the poorest households will be overestimated. This is a variation on the mortality paradox: the premature death of a poor individual increases the upward income mobility of the poorest.

Quantifying the bias caused by nonrandom premature mortality would require sufficient information on the productivity of individual household members, which we do not have. It is however very plausible to argue that the weakest individuals are most prone to premature mortality and are at the same time the least productive. It is also reasonable to assume that these individuals are at an especially high risk in the poorest households since there are fewer goods to share. Besides making these assumptions, the best we can do is study the extent of randomness of premature mortality across households. The results of four different regressions are reported in annex 3. The first two regressions are tobit estimates of the total number of household members who died and the number of household members who died from violence for the 189 households in our sample. The next two regressions are probit estimates for the 1347 individuals who were part of the 189 households in 1990. We find that income is an important determinant of premature mortality. Therefore, assuming that the least productive individuals die first, the upward mobility of poor households may partly be due to the mortality paradox.

Besides income, ethnicity is also a pronounced determinant of premature mortality. Tutsi-headed households were far more likely to have lost members due to violence. However there is no mortality paradox in this case. Even though also women and children were targeted, assailants especially killed strong able men. If we would then apply the above reasoning of projecting their income, we should say that since the most productive individuals died the downward mobility of the household in question is overestimated. This does not make sense. Thinking of welfare as a broad concept, leaving out dead members can bias mobility upward but should never bias it downward. We will not elaborate here on philosophical and conceptual questions, but let's keep the following three points in mind when discussing the results of the mobility equation later on.

First, households with a larger size are more likely to divide. If (more) less able individuals leave large households the positive coefficient of household size is (under)overestimated in the regressions explaining income mobility. Second, members of poorer households are more prone to premature mortality. These members probably are among the least productive in the

household. Therefore the upward income mobility of the poor households is overestimated. Third, Tutsi-headed household were much more likely to have lost members due to violence. Keeping in mind the broad concept of welfare, we can however not conclude that the downward mobility of the household (due to the loss of a relatively productive member) is overestimated. Rather, the narrow concept of income underestimates the welfare loss of Tutsi-headed households because of its incapacity to value the welfare loss of on the one hand high premature mortality of members of Tutsi-headed households and on the other the complete extermination of eight Tutsi-headed households in our sample.

2.4. Measuring income

The scope of this paper is material welfare. Changes in material welfare over time can be measured by income or expenditures. Expenditures are the preferred measure of material welfare. But because of lack of data on expenditures we use income as a measure of household welfare. The use of income rather than expenditures as a welfare measure is likely to overstate the extent of economic mobility. There are two reasons for this. First, households try to smooth consumption over time. To the extent that households succeed in this attempt, the use of income overstates economic mobility. The ability of households to smooth consumption - and thus the extent of the overstatement - depends on the presence of well functioning credit and insurance systems (Ravallion, 1988) [15]. Second, income tends also to be more volatile than consumption because of measurement error. The difficulty lies in accounting correctly for the value of production for subsistence. This causes measurement error, which may bias the measurement of income mobility in our sample upwards. For a thorough discussion of the effect of measurement error in income mobility studies, we refer to McCulloch and Baulch (2000). In addition, the fact that we work with income of the season from October till March of the following year instead of yearly income is also likely to inflate observed income mobility. For example, Dercon and Krishnan (2000) find high seasonal variability in income and poverty in rural Ethiopia.

To measure income, we asked questions on five different income sources: subsistence agriculture, crop sales, beer brewing, livestock production and off-farm earnings. On average, in our survey subsistence agriculture was good for 41% of total income in 2002, compared to 59% in 1990. The income from crop sales increased from 7% to 18%. A large part of the rise was probably the result of the favorable weather conditions in 2002 that resulted in a good harvest. This stands in sharp contrast with 1990, a poor crop year in which the southern part of Rwanda

(Gikongoro foremost) was recovering from a crop failure[16]. The harvest was so poor that few crops could be marketed. In 2002, harvests were very good[17]. Besides land, the most important asset for Rwandan rural households is livestock. Both in 1990 and in 2002 31% of the households possessed cattle. Including small livestock, the percentage of households owning livestock was about 60% in both years. The contribution of livestock to income increased from 8 to 10%[18]. Both in a social and an economic sense, beer brewing is an important activity in rural Rwanda. A part of the beer is consumed by the household members or offered as a gift on social occasions, another part is sold. The share of beer brewing in income remained at about 7%.

Rural households increasingly add to their livestock and agricultural income by off-farm labor. Earnings from off-farm labor amounted to 19% of total income in 1990 and 25% in 2002. Within this category we distinguish between agricultural wage labor, low-skilled non-farm labor (e.g. construction work) and high-skilled non-farm labor (e.g. public servant)[19]. Almost all of the 6%-increase is explained by the increased contribution of low-skilled non-farm earnings. In the face of increased land scarcity, the access to non-farm jobs is expected to be an important determinant of income mobility.

We calculated gross income by taking the sum of the monetary value of subsistence agriculture, crop sales, beer brewing, livestock holdings and off-farm work. To obtain net income, we substracted the cost of hiring casual labor and of the inputs needed for beer brewing[20]. We did not have satisfactory data on the use of farm inputs such as seeds and fertilizer. However, we believe our net income to be a good approximation since farming in Rwanda is labor intensive, depends primarily on household labor, uses almost no modern inputs and only a few rudimentary tools. To calculate monetary values of subsistence agriculture and livestock, we used prices at the provincial level. For beer and crop sales, we could use the prices reported by the household[21]. Between 1990 and 2002, the general price level rose by a factor of three. Thus, to obtain income in prices of 2002, we multiplied the income of 1990 by three.

2.5. Comparison of survey data for 1990 and 2002

Table 2 summarizes some of our panel data. We observe that the average net income per adult equivalent increased. The increase was mainly accounted for by one administrative sector (Kigoma) that suffered from a poor crop year in 1990, but profited from an extraordinary banana harvest in 2002.

Table 2: Summary statistics for season A, 1990 and 2002

	1990	2002
Household net income (RWF)	45,221	51,539
Household net income per adult equivalent	10,797	11,810
Household size	5.4	5.0
Adult equivalent[a]	4.8	4.6
Dependency ratio[b]	1,09	1,27
Age of the household's head	45.9	50.9
Female-headed household	17.5%	42.3%
Share of agricultural subsistence production	58.5%	40.8%
Share of crop sale	6.6%	17.7%
Share of beer brewing	7.6%	6.7%
Share of livestock income	8.1%	9.8%
Share of off-farm employment	19.2%	25.0%
Casual labor	9.5%	9.1%
Low-skilled non-farm	2.5%	8.2%
High-skilled non-farm	7.1%	7.7%
Land size (hectare)	0.96	0.86
Tropical Livestock Unit owned [c]	0.95	0.91
Cattle owned	0.71	0.68
Poverty head count [d]	66%	71%
Gini coefficient of HH net income/ ae	0.40	0.47

[a] The adult equivalent is based on the calorie needs of household members, depending on their age and sex. The reference is an adult, aged 20-39 years. We took the same values as those used in the IHLCS (Government of Rwanda, 2002b).

[b]Dependency ratio=(number of dependent/ number of active household members). In the case were there were no active, the ratio equals 1.

[c] Tropical Livestock Unit

[d] We used the food poverty line which equaled 45,000 RWF (108$) per adult equivalent in 2001 (Government of Rwanda, 2002b)

Note: these descriptive statistics include 7 observations that we excluded from the regression analysis. See annex 7 for details. Without these observations the summary statistics change hardly: Income per adult equivalent becomes 10871 in 1990 and 11247 in 2002, and the Gini coefficient of inequality increases from 0.40 in 1990 to 0.44 in 2002.

Between 1990 and 2002 the dependency ratio increased considerably. This is partly due to the fact that 10% of the households have a member in prison. Although the prisoners are adults, we counted them as dependent rather than active. In Rwanda it is common that family members and friends of a prisoner bring food on a weekly or two-daily basis. For the prisoner's household this implies a cost not only in terms of expenditure, but also in terms of time, especially when the prison is far from the household's residence.

One of the most striking evolutions is the increased number of female-headed households. Their proportion rose from 18% to 42%. This is explained by the fact that prisoners' wives have become household heads, but foremost by the high number of male casualties during war and genocide[22].

We also note the increase of the Gini coefficient between 1990 and 2002. The income distribution has become more skewed. Concurrently the proportion of households below the poverty line in our sample increased from 66% to 71%. However these figures are instantaneous

measures. They offer no information on the movement of households through the income distribution. The analysis of income mobility to which we now proceed does so.

3. Income mobility measurement

Income mobility studies have two advantages compared with a static analysis of poverty and inequality. First, a static analysis does not provide information on the mechanisms behind a change in household relative or absolute income. For example, if poverty incidence is observed to increase, this might be due to new poor having joined the existing poor, or it might be the net outcome of a dynamic process whereby some people escaped poverty and others - a larger number - have become poor. In contrast, a dynamic analysis can distinguish between transient and permanent poverty. Second, income mobility studies enable an analysis of characteristics that differentiate households that escape from poverty from those that remain poor.

Income mobility can be measured in different ways. Overviews of income mobility measures can be found in Maasoumi (1998), Atkinson, Bourguignon and Morrison (1992), Fields (2001) and Amiel and Bishop (2003). In this section we present measures that quantify time dependence in our sample, i.e. they measure how a household's current economic position is determined by its position in the past. This will give us a grasp of the occurrence of transient and permanent poverty in our sample. The more households move through the income distribution, the lower the time dependence and the higher the proportion of transient in total poverty. The measures we present in this section are all based on income per adult equivalent[23].

The simplest measure of time dependence is the ordinary (Pearson) coefficient of correlation between base period income and final period income. The closer the value of the correlation coefficient is to +1, the higher the positive time dependence; the closer it is to -1, the higher the negative time dependence there is. Perfect time-independence arises when a household's final period income is independent of its base period income. This corresponds to a correlation coefficient of zero. In our sample we find a coefficient of 0.04, which is very close to zero, indicating almost perfect time-independence.

Another very common instrument to analyze time dependence is the inter-temporal transition matrix. In table 3, the rows of the 5 by 5 matrix correspond to the income quintiles of the base period and the columns to the corresponding income quintiles of the final period. The entries in

the transition matrix indicate the fractions of households in the base period income quintile that ended up in a final period income quintile. Between brackets we give the absolute numbers.

Table 3: Inter-temporal income quintile transition matrix (income/ adult equivalent)

		Income quintiles in 2002				
		1	2	3	4	5
Income	1	14% (5)	16% (6)	19% (7)	19% (7)	32% (12)
quintiles	2	16% (6)	29% (11)	26% (10)	18% (7)	11% (4)
in 1989	3	32% (12)	21% (8)	18% (7)	16% (6)	13% (5)
	4	24% (9)	16% (6)	18% (7)	29% (11)	13% (5)
	5	13% (5)	18% (7)	18% (7)	18% (7)	32% (12)

Number of households between brackets

For example, element (1; 1) of the matrix indicates that 14% of households that belonged to the lowest income quintile in 1990 remained in that quintile in 2002. Element (1;5) shows that 32% of the poorest households in 1990 managed to climb up to the highest quintile in 2002. This suggests a lot of mobility among the poorest households.

More generally, in the case of perfect time independence - or, "perfect mobility" - every entry in the matrix would be equal to 20%. If perfect time dependence - "perfect immobility" - prevailed, each element on the principal diagonal would equal 100%. The percentages in the cells of the matrix are rather close to 20%, which suggests a high degree of time independence in our data set. From the transition matrix we can calculate the immobility ratio. This is the fraction of households that remain in the same quintile, i.e. the average of the elements on the diagonal. We obtain an immobility ratio of 24.4%, which is comparable with other findings that used income quintiles for the transition matrix. For example, Lanjouw and Stern (1993) used income quintiles for India and found an immobility ratio of 26%, also over a 12-year period. For ease of comparison, annex 4 provides an overview of the results of eight mobility studies. We added our results to a table taken from Baulch and Hoddinott (2000). All studies that use income as mobility measure, report immobility ratios within the range of 23% and 26%[24]. The result of our study fits within this range. However, the mobility within our lowest quintile of 1990 is considerable higher than what is found in other studies. We provide an explanation for this fact.

In subsection 2.4 we gave three reasons why our measure of income mobility may overstate the actual economic mobility in our sample. These reasons were related to consumption smoothing, measurement error and the use of seasonal instead of yearly data. Other causes of the high mobility of poor households are attrition and the mortality paradox. Indeed, if especially the

poorest households or the least productive individuals of the poorest households dropped out of the sample, the transition matrix may overstate the degree of upward mobility of the poor.

On the other hand, we have very good reasons to expect that actual economic mobility is high in our sample. We offer three reasons. First, the time span is fairly long. The longer the time span, the lower the correlation of income in the base and the final period. Second, the chaos of war and genocide disrupted the economic situation and might have offered chances to some households while destroying the opportunities of others. Finally, in developing countries in general and specifically in Rwanda, the contribution of agriculture to income is very high and agricultural output depends on varying weather conditions[25]. Agricultural output and weather conditions differ across the different locations in our sample. To the extent that weather conditions are region specific, inter-regional income mobility may explain an important part of total income mobility in the sample.

The importance of weather conditions in our data set is reflected e.g. by the fact that six out of the 12 households that made the remarkable upward climb from the lowest to the highest income quintile lived in one particular sector, Kigoma. This sector suffered from famine in 1990, but had an extraordinary banana harvest in 2002[26]. We argue that attrition and the particular change for Kigoma largely explains the high mobility for households of the lowest quintile in 1990.

To strengthen the finding of much income mobility, we repeated the above analysis using an asset index. This index was constructed on the basis of the two most important assets of Rwandan rural households, livestock and land[27]. The correlation of the change in income with the change in the asset index is 0.28. Therefore we do not expect the inter-temporal asset mobility matrix to perfectly match the inter-temporal income mobility matrix[28]. However, they are expected to match to some degree.

Table 4: Inter-temporal asset quintile transition matrix (a weighted sum of livestock and land per adult equivalent)

		Asset quintiles in 2002				
		1	2	3	4	5
Asset quintiles in 1990	1	41% (15)	27% (10)	19% (7)	3% (1)	11% (4)
	2	16% (6)	21% (8)	26% (10)	18% (7)	18% (7)
	3	24% (9)	34% (13)	11% (4)	21% (8)	11% (4)
	4	16% (6)	11% (4)	24% (9)	34% (13)	16% (6)
	5	3% (1)	8% (3)	21% (8)	24% (9)	45% (17)

Number of households between brackets

Table 4 shows the results of the mobility analysis for the asset index. Note that the position of 40% of the households in the lowest and highest quintiles of 1990 was unchanged in 2002 (elements (1; 1) and (5; 5) in the matrix). So, time dependence for the first and fifth asset quintiles is much higher than for the corresponding income quintiles. But for the other three quintiles the diagonal cells are closer to 20%. As a consequence, the immobility ratio of asset mobility remains fairly low, at 30.2%, compared to 24.4% for income mobility.

To sum up, both the correlation coefficient of household incomes in 1990 and 2002 and the income quintile transition matrix for those years reveal very low time dependence in our sample. The analysis of the asset quintile transition matrix confirms this finding. We can therefore safely conclude that there was considerable income mobility between the period before and after the war and the genocide in Rwanda. The poor did not necessarily remain poor, and a number of non-poor fell into poverty: 34 of the households originally below the poverty line succeeded in escaping poverty, while 44 households that in 1990 were above the poverty line had become poor by 2002[29].

4. Drivers of income mobility: preliminary analysis

We argued that Rwanda stands out in Africa because of its high population density and its turbulent history. Before analyzing the determinants of income mobility using regression analysis in the next section, this section provides a preliminary analysis with respect to these two specific features of Rwanda. We provide data on a number of variables linked to the shocks of war, genocide and their aftermath as experienced by individual households, and land scarcity as well as strategies to overcome this. We then study the relationship between income movement during the period 1990-2002 and each of these variables.

For this purpose, we use the change in income ranking, i.e. positional income movement. We started out by ranking households in 1990 and in 2002 according to their income (per adult equivalent), starting by the household with the lowest income. We then computed the positional income movement, i.e. the difference between a household's income rank in 2002 and in 1990. For example, a household with rank ten in 1990 (i.e. the tenth poorest household) that climbed up to rank 40 in 2002, had an upward positional income movement of 30 places. In this section we use this positional movement as our measure of income mobility. In section 5 we will also consider absolute income changes between the two years under consideration.

4.1. Shocks

Our 2002 survey contains several indicators of shocks related to war and genocide. In table 5, we list human losses and violent deaths for all households and according to ethnicity. In table 6 we give summary data on other shocks. Table 7 then relates these shocks to our measure of positional income movement.

Between 1990 and 2002 the households in our sample lost 181 family members, on average almost one member per household. Of these human losses, 34% occurred in 1994, 27% died a violent death, and 86% of these violent human losses occurred in 1994. The data in table 5 show the well-known fact that especially the Tutsi population was the target of violence. On average, in 1994 a Tutsi headed household in our sample lost more than one member due to violence.

Table 5: Average number of human losses per household (absolute number between brackets)

	All Households (189)	Hutu-headed HHs (173)	Tutsi-headed HHs (12)
Human losses, 1990-2002	0.96 (181)	0.88 (152)	1.75 (21)
Human losses in 1994	0.33 (62)	0.25 (44)	1.25 (15)
Violent human losses , 1990-2002	0.26 (49)	0.18 (32)	1.25 (15)
Violent human losses in 1994	0.22 (42)	0.14 (25)	1.25 (15)

Note: The observations of the second and third column do not add up to 189 because we have 4 Twa households in our sample.

When evaluating these shocks, it is essential to be aware of the consequences of attrition in our sample. Attrition for Tutsi-headed households amounts to 45% compared to 20% for Hutu-headed households. Consequently, the extent of human losses is biased downwards and that this bias is more pronounced for Tutsi-headed households.

In addition to human losses, households lost physical capital during the war and the genocide. Table 6 shows that more than 50% of all cattle lost between 1991 and 2002 were lost in 1994. One out of twenty households in the sample lost their house in 1994 due to destruction by assailants. These losses of physical capital were again more severe for Tutsi-headed households[30]. For example, more than half of Tutsi-headed households in our sample lost their house in 1994.

Two shocks were more common among Hutu-headed households: taking refuge abroad and imprisonment. Over the period 1994-2002 16% of sample households had taken refuge for one or several months, sometimes even for years. Almost 10% of households had a member in prison in 2002. All households in our sample that had taken refuge abroad or that had a member in prison were Hutu-headed

Table 6: Other shocks related to war and genocide (absolute number between brackets)

	All Households (189)	Hutu-headed HHs (173)	Tutsi-headed HHs (12)
Cattle lost, 1990-2002	0.72 (136)	0.64 (111)	2.08 (25)
Cattle lost in 1994	0.37 (70)	0.32 (55)	1.25 (15)
Violent cattle loss, 1990-2002	0.41 (78)	0.36 (63)	1.25 (15)
Violent cattle loss, 1994	0.31 (59)	0.28 (48)	0.92 (11)
% Destruction of house, 1994	5.8% (11)	2.3% (4)	58.3% (7)
% Prisoner (2002)	9.5% (18)	9.8% (17)	0
% Refuge abroad (1994-2002)	15.9% (30)	17.3% (30)	0

Note: the observations of the second and third column do not add up to 189 because we have 4 Twa households in our sample.

We now relate shocks experienced by households to positional income movement. In table 7 we provide data on the average rank change for households that experienced a specific shock and for households that did not. To test whether the link between the shock and the change in rank was statistically significant, we constructed a dummy variable for each shock and regressed the change of income rank separately on each dummy variable. Of course the shortcoming of this procedure is that it does not take into account simultaneously all shocks as well as other variables that could have had an impact on income rank changes. We will do this in section 5.

Table 7: Shocks and positional movement (income/ adult equivalent)

Event (between brackets: the number of observations)	Average change in rank		Difference
	Yes	No	
Lost more than 1 member in '94 (11)	-10	+1	-11
The HH became female-headed between '90-'02 (54)	-26	+10	-36***
The HH's house was destroyed between '90-'02 (36)	-18	+4	-22
The head of the HH in prison after '94 (17)	-41	+4	-45**
HH took refuge for more than 3 months (20)	-4	0	-4
Moved to another administrative sector after '94 (10)	-11	+1	-12

The difference is significant *at 10%, **at 5%, *** at 1%
Between brackets the number of households affected by the shock

Note: these descriptive statistics include 7 observations that we excluded from the regression analysis. See annex 7 for details. Without these observations the summary statistics change considerably for the first and third row. The difference of the rank change for the first row becomes –28 instead of –11, though it remains insignificant. The difference for the third row becomes –26 and significant at the 10% level.

Table 7 summarizes our results. All shocks included in table 7 are negatively related to income rank movement. The largest difference in rank change is found for households whose head was in prison and for households that became female-headed between 1990 and 2002, as many as 28.6% of households in the 2002 survey became female-headed. For Tutsi-headed households the percentage was 67.7% and for Hutu-headed households 25.4%.

4.2. Land scarcity and strategies to overcome it

Rwanda is struggling with two major structural problems: land scarcity and land degradation. We argue that Rwandan peasant households have two options to deal with land scarcity and land degradation. First, they can increase land productivity, either by using better or more inputs, either by turning to the market. This latter option supposes that farmers cultivate a limited range of crops with a high yield and exchange these on the market for other crops they like to consume. Second, households may increasingly rely on non-farm earnings to complement for their decreasing farm incomes. Table 8 shows the average positional movement of households that did (or did not) experience a substantial amount of land loss and of households that did (or did not) adopt specific strategies to raise their income. It also indicates whether the difference between their positional movements was statistically significant, using the same test as was used for table 7.

Table 8: Strategies to overcome land scarcity and positional movement (income/ adult equivalent) (for 189)

Event	Average change in rank		Difference
	Yes	No	
Substantial loss of land, 1990-2002 (47)[a]	-17	+5	-22*
Use of fertilizer, 2002 (18)	+15	-1	+16
Migration, 2002 (35)[b]	+35	-7	+43***
Increased contribution of high-skilled non-farm labor, 1990-2002 (28)	+50	-9	+59***
Increased contribution of low-skilled non-farm labor, 1990-2002 (38)	+36	-9	+45***
Increased contribution of agricultural wage labor, 1990-2002 (43)	+14	-4	+18
Increased contribution of beer brewing, 1990-2002 (71)	-6	+4	-10
Increased contribution of livestock, 1990-2002 (82)	-7	+4	-13
Increased contribution of crop sale, 1990-2002 (127)	+2	-5	+7
Increased contribution of subsistence, 1990-2002 (49)	-42	+14	-56***

The difference is significant *at 10%, **at 5%, ***at 1%
Between brackets the number of households concerned.
[a] A household is said to have lost a substantial area of land if the households is part of the quartile of households that lost most land.
[b] Migration is a dummy that equals 1 when at least one member of the households migrated in order to find employment.

Table 8 shows that households with a substantial loss of land had a statistically significant negative positional income movement. Households using fertilizer moved on average 15 places up, compared to an average loss of one place for the other households, but the difference is not statistically significant. Households with one or more migrants (mostly to Kigali) experienced on average upward mobility. The difference with non-migrant households is significant. However we cannot draw conclusions from this finding on the impact of migration since the causality is not clear: migration may be a successful coping strategy leading to upward mobility but upward mobility may also produce the necessary means for migration. Table 8 also shows that increases

in non-farm high-skilled and low-skilled labor were associated with positive changes in income ranking. With respect to income composition, it appears that households that substituted subsistence agriculture with other income sources experienced upward income movement. Again, the causal link is not a priori clear; causality may be from change in income ranking to change in the contribution of subsistence agriculture to household income. Therefore in the regression analysis in section 5, we instrument for the income strategies.

In the previous section, we briefly mentioned that many households from Kigoma sector managed to escape from poverty. There are other sectors that stand out with an exceptionally good or poor record of positional movement. We provide some detail on the location specific pattern of income positional movement in annex 5.

5. Drivers of income mobility: regression analysis

This section studies the factors that drive the income movement of households in our panel data set. The dependent variable is the change of log real income[31]. Subsequently we also use the change of income rank as defined in the previous section, since it provides a nice way of interpreting the results. We present eight regression equations.

The first two equations, (I) and (II), explain income movement as determined by household capital in the base year income, the change of capital between 1990 and 2002, shocks at the household level, the altitude of the administrative sector and its distance to the market in 1990[32]. The explanatory variables are described in detail in table 9. Annex 6 lists the mean and standard deviation of all variables.

I. $DlogY_i = f(capital90_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$
II. $DrankY_i = f(capital90_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$

Regressions (III) and (IV) analyse the effect of the same determinants on the change of two specific sources of income, income from crop sale and income from non-farm employment (respectively $DlogYCS_i$ and $DlogYNF_i$).

III. $DlogYCS_i = f(capital90_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$

$$IV.\quad DlogYNF_i = f(capital90_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$$

In section 4, we argued that households can deal with land scarcity in two ways: increasing land productivity and turning to non-farm employment. Increasing land productivity can be realized by using more or better inputs, or by producing the crops with the highest yield and exchanging them on the market for other crops. Not many Rwandan farmers use modern inputs and for the few farmers in our sample who do, we lack good quantitative data. Therefore, we use crop sales by the household to account for the second possibility. To make sure we are not just capturing the marketing of occasionally agricultural surpluses, we use $altitude_i$ to control for varying weather conditions across the 16 different locations in our sample[33].

Table 9: Description of explanatory variables

Explanatory variables		
Category	Symbol.	Description
$Capital90_i$	HHSIZE90	Household size, 1990
	DEPRAT90	Dependency ratio, 1990 (dependent/ active members)[a]
	AGEH90	Age of head, 1990
	YEDUCH90	Years of education head, 1990 [b]
	FEMH90	Dummy female-headed, 1990
	TUTSIH	Tutsi-headed household
	LLANDS90	Log of Land size, 1990 (ha)
$Dcapital_i$	DHHSIZE	Δ Household size
	DDEPRAT	Δ Dependency ratio
	DAGEH	Δ Age of head [c]
	DYEDUCH	Δ years of education head [c]
	DFEMH	Δ to male (-1) or female head (+1) [c]
	DLANDS	Δ Land size [d]
$Shocks_i$	VIOLENTL90-02	Number of members lost due to violence, 1990-2002
	HHMOVED94-02	Household moved to another sector after 1994
	HDESTR90-02	House destroyed, 1990-2002
	PRISON02	Household member in prison, 2002
	NMREFUGE94-02	Number of months the household took refuge, 1994-2002
$Altitude_i$	ALT	Altitude (meter), at the sectoral level
$DistM_i$	DISTM90	Distance to market (km) in 1990, at the sectoral level

[a] Prisoners are counted as dependents

[b] We converted the answers on no, completed or in-completed primary, secondary or tertiary education into years of education

[c] In 53 cases, the household head changed over time. Instead of taking a dummy for the change of the household head, we chose to include three characteristics that changed, the household head's age, education and sex.

[d] For the change in land size to be exogenous, we left out changes due to market transactions such as land sold or purchased, and rented land. Important remaining causes of land size changes are inheritance and land loss due to erosion.

While these latter two equations do provide a nice comparison with equations (I) and (II), they may fail to detect an income strategy change. Indeed, a household may experience a simultaneous rise or fall of all its income sources. Therefore, we perform a similar regression explaining the changing contribution of respectively crop sale and non-farm earnings to income.

$$V.\quad DshareCS_i = f(capital90_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$$

$$VI.\quad DshareNF_i = f(capital90_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$$

In a final stage, we want to assess the effect of an income strategy change on the household's income movement. Since the income strategy change is endogenous, we use an instrumental variable estimation (IVE). Equations (V) and (VI) are used as the equations of the first-stage instrumental variable regressions. The base-period variables ($capital90_i$) are the excluded instruments. Equations (VII) and (VIII) below represent the second-stage IV regressions, with the changing contribution of crop sale and non-farm earnings instrumented.

$$VII.\quad DlogY_i = f(IDshareCS_i, IDshareNF_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$$

$$VIII.\quad DrankY_i = f(IDshareCS_i, IDshareNF_i, Dcapital_i, shocks_i, altitude_i, distM90_i)$$

If the base period variables ($capital90_i$) are important in determining income change, (VII) and (VIII) are misspecifications. Therefore we report in annex 9 results that include instrumented base period income, $IlogY90_i$ and $IrankY90_i$, arguing that base period income should effectively substitute for leaving out $capital90_i$. Comparing table 11 with annex 9, we find very similar[34].

In a small data set like ours, a single observation that is substantially different from all other observations can make a large difference in the results of the regression analysis. That is why we looked for unusual and influential observations in our data. We used five criteria and excluded observations that were recognized as unusual or very influential according to three out of the five criteria. Annex 7 lists more details on the criteria and results. At the end of this exercise, we dropped seven out of the 189 observations. Consequently, the regression results are based on 182 observations[35].

For equations (I) to (VI) we used the Breush-Pagan and the White test for heteroskedasticity in the error distribution (Breusch, Pagan, 1979; White, 1980). When the null hypothesis of homoskedasticity was rejected, we based our inferences on the Hubert/ White robust standard errors. For equations (VII) and (VIII) we used the test of Pagan and Hall (1983), designed for detecting heteroskedasticity in the case of instrumental variable estimation. To test the validity of our instruments, we performed the Sargan test for overidentifying restrictions (Sargan, 1958). In addition, for several variables for which there are reasons to suspect that they are simultaneously determined with income growth, we used the C- or "difference-in-Sargan" test to assure that the

condition of orthogonality with the error term is fulfilled (Baum et al., 2003). A comprehensive discussion of tests in the IV framework is provided by Baum et al. (2003). Our results are reported in tables 10 and 11.

Table 10: Explaining income movement

Dependent variable	Change of log income	Change of income rank	Change of log income from crop sale	Change of log income from non-farm
Explanatory variables	(I)	(II)	(III)	(IV)
HHSIZE90	0.121 (3.01)***	4.653 (1.77)*	0.236 (1.15)	0.411 (1.47)
DHHSIZE	0.084 (2.38)**	3.541 (1.53)	-0.015 (-0.08)	0.012 (0.05)
DEPRAT90	-0.219 (-2.42)**	-11.176 (-1.89)*	0.178 (0.38)	-0.162 (-0.26)
DDEPRAT	-0.147 (-3.23)***	-10.461 (-3.51)***	-0.047 (-0.20)	-0.146 (-0.46)
AGEH90	-0.002 (-0.37)	-0.131 (-0.31)	0.005 (0.16)	-0.033 (-0.75)
DAGEH	-0.007 (-1.25)	-0.180 (-0.48)	-0.007 (-0.24)	-0.007 (-0.18)
YEDUCH90	0.007 (0.23)	-0.294 (-0.14)	-0.083 (-0.50)	-0.250 (-1.11)
DYEDUCH	0.087 (2.58)**	3.781 (1.71)*	-0.128 (-0.74)	-0.147 (-0.62)
FEMH90	-0.273 (-1.35)	-5.903 (-0.45)	1.273 (1.23)	-2.584 (-1.83)*
DFEMH	-0.367 (-2.33)**	-20.878 (-2.03)**	-0.342 (-0.42)	-1.877 (-1.70)*
LLANDS90	-0.238 (-2.77)***	-17.809 (-3.17)***	0.203 (0.46)	-1.125 (-1.87)*
DLANDS	0.113 (1.14)	3.703 (0.57)	0.049 (0.10)	0.863 (1.24)
TUTSIH	-0.074 (-0.25)	-14.746 (-0.74)	-1.974 (-1.27)	3.602 (1.70)*
HHMOVED94-02	-0.344 (-1.03)	-39.435 (-1.81)*	-3.397 (-1.99)**	-0.712 (-0.30)
HDESTR90-02	-0.380 (-2.25)**	-21.985 (-1.98)**	-0.847 (-0.98)	-1.209 (-1.02)
PRISON02	-0.717 (-3.20)***	-43.004 (-2.94)***	-1.853 (-0.74)	-4.255 (-2.72)***
VIOLENTL90-02	-0.187 (-1.67)*	-8.792 (-1.20)	-0.592 (-1.03)	-2.170 (-2.77)***
NMREFUGE94-02	-0.004 (-1.04)	-0.131 (-0.52)	-0.015 (-0.77)	-0.043 (-1.61)
ALT	0.001 (5.06)***	0.087 (4.68)***	0.004 (2.81)***	0.003 (1.30)
DISTM90	-0.228 (-4.51)***	-15.683 (-4.74)***	-0.812 (-3.13)***	-0.482 (-1.36)
Intercept	-1.545 (-2.48)**	-72.876 (-1.79)*	-3.336 (-1.05)	-0.707 (-0.16)
R^2	47%	45%	21%	21%
Breush-Pagan test	Chi-sq (1)	Chi-sq (1)	Chi-sq (1)	Chi-sq (1)
	P-value = 0.388	P-value = 0.331	P-value = 0.445	P-value = 0.293
Breush-Pagan test	Chi-sq (20)	Chi-sq (20)	Chi-sq (20)	Chi-sq (20)
	P-value = 0.233	P-value = 0.514	P-value = 0.257	P-value = 0.676
White test	Chi-sq (181)	Chi-sq (181)	Chi-sq (181)	Chi-sq (181)
	P-value = 0.465	P-value = 0.465	P-value = 0.465	P-value = 0.465

T-vaues between brackets
Significant at the *10% level, ** 5% level, *** 1% level

In table 10, the shocks HHMOVED94-02, HDESTR90-02, PRISON02, VIOLENTL90-02 and NMREFUGE94-02 have the expected negative sign in all equations. The estimated coefficient of NMREFUGE94-02 is not significant in any of the equations. The estimated coefficients of the other shocks are significantly negative in at least two out of the four equations. Equation (II) suggests that some of the shocks are associated with large decreases of income rank. For example, a household with a member in prison fell 43 places in the income distribution. PRISON02 and VIOLENTL90-02 had a highly significant negative effect on non-farm earnings. Many of these shocks are correlated with each other and with DFEMH and TUTSIH. We present a correlation matrix in annex 8. The coefficient on DFEMH is negative and statistically significant in three out of the four regressions. Even when controlling for other shocks,

regression (II) indicates that households that became female-headed between 1990 and 2002 lost on average 21 places in the income ranking.

Since the genocide targeted mainly Tutsi, we expect that Tutsi-headed households experienced more downward mobility than Hutu-headed households did. We find that, although the estimated coefficient for TUTSIH is negative in equations (I)-(III), it is not significant. This result cannot be explained by the fact that we control for shocks that are highly correlated with ethnicity. Indeed, even the correlation matrix in annex 8 does not show significant negative correlation between ethnicity and income movement. However, attrition bias may explain part of this result: 45% of Tutsi-headed households of the original sample dropped out compared to 20% of Hutu-headed households. Another explanation arises from equation (IV), where the coefficient for TUTSIH is positive and significant. It is plausible that some Tutsi-headed households increased their non-farm earnings in the post-war period, since after the genocide a considerable number of Tutsi were elected for positions in the local administration[36].

Besides the shocks of war and genocide, we are interested in the effect of land scarcity. Regressions (I) and (II) show a significant negative sign of LLANDS90, implying that on average households with smaller land sizes in 1990 moved upward in the income distribution. Although, both in 1990 and 2002, the land-poor were poorer in income terms than the relatively land-rich, the smaller landowners of 1990 managed to bridge part of the gap. The means to bridge this gap came from the non-farm sector. Indeed, according to the results of regression (IV), especially the smaller landowners increased their non-farm income.

Finally we mention the results for ALT and DISTM90. The altitude in our sample varies between 1400 and 2300 meters. Kigoma, the sector performing exceptionally well, lies at 2300 meter. In general, the sectors at a higher altitude profited from a good harvest in 2002 compared to 1990. This is reflected in the significantly positive coefficient of ALT in regressions (I) to (III). DISTM90 is negative and significant in the first three regressions. Households living in sectors close to a market in 1990 expanded their income from crop sale considerably more than other households. We note that only one household-level variable (HHMOVED94-02) is significant in regression (III). The change of crop sales appears to be mainly driven by favourable weather conditions and easy access to a market, while household characteristics play an insignificant role. This is hardly true for regression (IV) where several household characteristics and shocks determined the growth of non-farm income.

We find similar results for regressions (V) and (VI). The results of regression (V) show that mainly variables at the sectoral level determined the changing contribution of crop sales to income. In regressions (VI), explaining the changing contribution of non-farm earnings to income, the estimated coefficients of PRISON02 and VIOLENTL90-02 are highly negative and significant. In addition, as was also evident from table 10, we find that especially small landowners increasingly use the non-farm sector to complement their farm income.

Remark that AGEH90, YEDUCH90, FEMH90 and DFEMH have negative and significant coefficients in regression (VI). Households with older heads, female-headed households and households that became female-headed between 1990 and 2002 experienced a decreased contribution of non-farm earnings to income. Households with less educated heads may have seen an opportunity to expand the contribution of non-farm earnings to income thanks to an increased demand for low-skilled non-farm labor. Remember from table 2 that the contribution of low-skilled non-farm work to total income increased from 2.5 percent in 1990 to 8.2 percent in 2002.

We performed a similar regression to explain the changing contribution of subsistence agriculture to income. The results were opposite to what we found for regressions (V) and (VI): AGEH9, DAGEH, DFEMH, PRISON02, VIOLENL90-02, NMVLUCHT94-02 and DISTM9 have a positive significant sign, while the estimated coefficient for ALT is significantly negative.

Regression (VII) and (VIII) were designed to capture the effect of an income strategy change on the income movement of households. So far, we noted that the contribution of crop sales to income was mostly determined by ALT and DISTM90. Therefore we can hardly speak of an income strategy change at the household level with respect to crop sales. Controlling for ALT and DISTM90 in (VII) and (VIII), we do not find a significant effect of IDSCROPS on income mobility. However, when DISTM90 is part of the excluded instruments, the estimated coefficient of HDSCROPS becomes positive and significant. We reported this result in annex 9. We conclude that household characteristics play a minor role in the decision to market crops, but, given a good harvest, the access to markets is crucial for turning the agricultural surplus into a profit.

In contrast, we found that several household characteristics were important in explaining the change of income from the non-farm sector. In regression (VIII), IDSNONF has a positive and

significant effect on income movement. Increasing the contribution of non-farm earnings to income with one percent, leads on average to an upward mobility of almost two places in the income ranking. The effect of shocks on income mobility disappears when including IDSNONF as part of the explanatory variables. This suggests that shocks, such as VIOLENTL90-02, DFEMH and PRISON02 led to downard income mobility through decreased participation in the non-farm sector.

Table 11: Explaining income strategy change and assessing its effect on income movement

Dependent variable	Change of share of crop sale in total income	Change of share of non-farm in total income	Change of log income	Change of income rank
Explanatory variables	(V)	(VI)	(VII)	(VIII)
IDSCROPS			0.035 (1.19)	2.672 (1.37)
IDSNONF			0.028 (2.86)***	1.727 (2.67)***
HHSIZE90	0.331 (0.39)	1.155 (0.79)		
DHHSIZE	-0.743 (-1.08)	-2.134 (-1.53)	0.132 (2.53)**	7.966 (2.27)**
DEPRAT90	-1.544 (-0.77)	-2.613 (-0.88)		
DDEPRAT	-0.116 (-0.09)	-0.182 (-0.13)	-0.129 (-3.12)***	-9.078 (-3.27)***
AGEH90	0.006 (0.04)	-0.458 (-2.06)**		
DAGEH	0.006 (0.05)	-0.260 (-1.28)	-0.003 (-0.56)	-0.012 (-0.03)
YEDUCH90	0.606 (0.83)	-2.114 (-1.89)*		
DYEDUCH	0.095 (0.14)	-0.678 (-0.59)	0.092 (2.61)***	4.435 (1.88)*
FEMH90	9.672 (1.88)*	-17.678 (-2.34)**		
DFEMH	2.748 (0.75)	-10.581 (-2.23)**	-0.153 (-0.91)	-10.101 (-0.89)
LLANDS90	1.012 (0.68)	-7.019 (-2.47)**		
DLANDS	0.682 (0.58)	4.821 (0.90)	-0.047 (-0.38)	-5.927 (-0.71)
TUTSIH	-8.399 (-1.35)	15.986 (1.42)	-0.093 (-0.25)	-14.793 (-0.59)
HHMOVED94-02	-8.108 (-1.04)	-5.071 (-0.47)	-0.046 (-0.10)	-10.662 (-0.35)
HDESTR90-02	-0.505 (-0.15)	-6.520 (-1.18)	-0.176 (-0.86)	-8.988 (-0.65)
PRISON02	-1.010 (-0.26)	-28.873 (-4.56)***	0.124 (0.34)	9.337 (0.38)
VIOLENTL90-02	-0.870 (-0.36)	-11.081 (-3.16)***	0.195 (1.09)	13.713 (1.14)
NMREFUGE94-02	-0.122 (-1.84)*	-0.113 (-0.66)	0.004 (0.65)	0.366 (0.88)
ALT	0.040 (5.61)***	-0.000 (-0.00)	0.000 (0.00)	-0.016 (-0.21)
DISTM	-5.137 (-5.30)***	-1.084 (-0.60)	0.001 (0.01)	-0.024 (-0.00)
Intercept	-37.998 (-2.69)***	42.812 (1.96)*	-0.540 (-0.52)	-6.264 (-0.11)
R^2	34%	26%		
Breush-Pagan test	Chi-sq (1) P-value = 0.000	Chi-sq (1) P-value = 0.004		
Breush-Pagan	Chi-sq (20) P-value = 0.052	Chi-sq (20) P-value = 0.0224		
White test	Chi-sq (181) P-value = 0.465	Chi-sq (181) P-value = 0.465		
Pagan and Hall test			Chi-sq (20) P-value = 0.999	Chi-sq (20) P-value = 0.999
Sargan test			Chi-sq (4) P-value = 0.122	Ch-sq (4) P-value = 0.562
C test for DLANDS			Chi-sq (1) P-value = 0.815	Chi-sq (1) P-value = 0.660
C test for DFEMH, DYEDUCH, DAGEH			Chi-sq (3) P-value = 0.578	Chi-sq (3) P-value = 0.492

T-vaues between brackets
Significant at the *10% level, ** 5% level, *** 1% level
Note: the inferences for regression (V) and (VI) are based on robust standard errors

Note: The C-test is used to test the validity of a subset of instruments. We chose to test DLANDS because inheritance is a choice variable and could thus be endogenous. In addition we tested the combined validity of DFEMH, DYEDUCH and DAGEH since these may be highly correlated with other unobserved characteristics of the new household head.

We performed a similar regression analysis using the instrumented changed contribution of agricultural subsistence to income. The results show that an increased contribution of subsistence agriculture to income leads on average to a loss of almost two places in the income distribution.

6. Conclusion

Rwanda stands out in Africa due to two specific features. First, in 1994, the Rwandan population lived through a horrifying genocide. This resulted in human and material losses, an outflow of refugees and a high number of imprisoned presumed perpetrators of genocide. A second specific feature of Rwanda is its extremely dense population compared to African standards. Whereas most countries in Africa do by far not attain the population densities of Asian countries, Rwanda does with more than 300 inhabitants per square km. In addition to the immense challenge of reconciliation, Rwandan households have to find ways of surviving in the face of increasingly scarce natural resources.

To get an insight in the impact of the shocks of war, genocide and their aftermath and in the impact of land scarcity and strategies to cope with it, we studied income mobility in a panel data set of 189 rural Rwandan households. Our data reveal increased income poverty and inequality, decreased land sizes and severe shocks of war and genocide at the household level.

Between the years 1990 and 2002 we found considerable income mobility. As many as three out of four households had moved to another income quintile in 2002 compared to their starting position in 1990. Besides the effects of sample attrition, the mortality paradox and measurement error, we commented on other plausible reasons for the high mobility in our sample. Most importantly, rural Rwandan households are frequently confronted with agricultural setbacks. These may be very location specific, which explains why in different administrative sectors households experienced positive or negative income mobility. In addition, we studied income mobility in a turbulent period in which many households were affected by severe shocks.

The analysis time dependence of income suggested that over the period 1990-2002 one third of income poverty in our sample was transient rather than permanent. If harvest failure or other forms of temporary bad luck cause transient poverty, policymakers may implement smoothing policies to provide a safety net.

Our analysis of determinants of income mobility has shown that downward income mobility was associated with the imprisonment of household members, change in the household head from a male to a female, and the destruction of the family house. We found a weaker link between downward mobility and human losses, and no statistically significant link between downward mobility and the time interval of a household taking refuge. We found upward income mobility for households that had reduced their dependence on subsistence agriculture. The increased contribution of non-farm earnings proved to be a successful strategy. Some of the land-poor in 1990 could bridge part of the gap with the land-rich by increasing reliance on the non-farm sector.

This last result is encouraging. Given the high labor-land ratio in Rwanda and the absence of succesful land-augmenting innovations, a way to deal with land scarcity and soil degradation is the diversification of income sources. However not every household has equal opportunities in the labor market. Especially single-parent households are too time-constrained to explore alternative economic opportunities. Households headed by women and households who lost (mostly) male active members due to the war or imprisonment were facing a decrease of non-farm earnings. They failed to compensate for this loss and showed considerable downward mobility. If their situation is to be improved, specific policies targeting these groups are required.

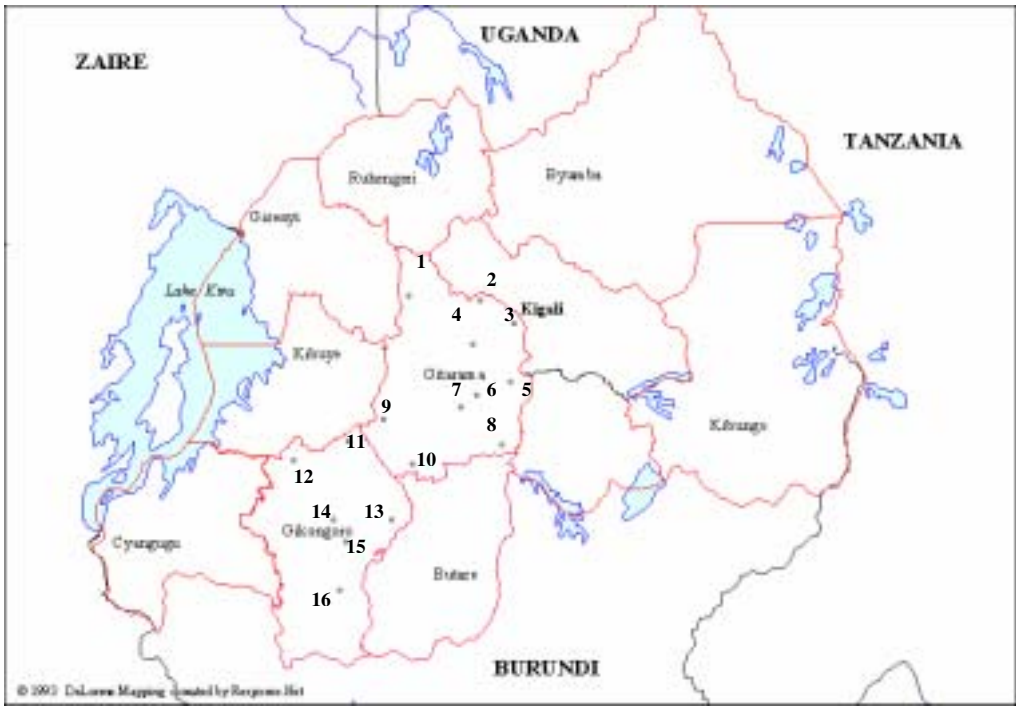
Annex 1: The location of the administrative sectors of the 2002 survey

Gitarama

1 Kagogwe
2 Ngamba
3 Ruyenzi
4 Gihembe
5 Mbati
6 Mbuye
7 Ntenyo
8 Gitovu
9 Munanira
10 Runyengando

Gikongoro

11 Kigoma
12 Bitandara
13 Nyarusange
14 Kibirizi
15 Kamegeri
16 Gorwe



Annex 2: Household division

	Break-up of household, tobit estimate		Split-off of individual, probit estimate	
	Men leaves (n=172 hhs) 48 uncensored observations	Adult leaves (n=189 hhs) 90 uncensored observations	Men Leaves (n=202 adult men)	Adult leaves (n=425 adults)
Household income 1990 ($x10^{-4}$)	0.047 (0.89)	0.068 (1.51)	0.051 (1.38)	0.026 (1.13)
Log land owned 1990	0.330 (1.36)	0.107 (0.50)	0.219 (1.61)	0.115 (1.27)
Number of males 1990	0.468 (3.07)***		0.011 (0.18)	
Household size 1990		0.230 (2.57)**		0.045 (1.13)
Maximum years of schooling of adults	0.009 (0.11)	-0.082 (-1.14)	-0.067 (-1.61)	-0.045 (-1.44)
Mean age of adult men	0.024 (1.53)		0.012 (1.73)*	
Mean age of adults		0.003 (0.13)		0.011 (0.86)
SD, age of adult men	0.004 (0.18)		0.020 (1.69)*	
SD, age of adults		0.021 (0.82)		0.019 (1.63)
Number of adult men	0.843 (0.58)		-0.764 (-1.01)	
Number of adults		0.059 (0.35)		-0.009 (-0.11)
Constant	-3.642 (-3.21)***	-1.735 (-2.04)**	-0.745 (-1.73)*	-1.153 (-3.29)***

Note: t-values are in brackets and corrected for household-level clustering in the last two columns.

Annex 3: Premature mortality

	Dead of household member, tobit estimate		Dead of individual, probit estimate	
	Number of household members died between 1990 and 2002	Number of household members died in violence between 1990 and 2002	Died between 1990 and 2002	Died in violence between 1990 and 2002
	(n=189 hhs) 112 uncensored observations	(n=189 hhs) 34 uncensored observations	(n=1347 individuals)	(n=1347 individuals)
Household income 1990 ($x10^{-4}$)	-0.077 (-1.76)*	-0.095 (-1.29)	-0.040 (-2.73)***	-0.044 (-2.13)**
Log land owned 1990	0.074 (0.43)	0.029 (0.10)	-0.017 (-0.28)	-0.087 (-0.68)
Household size 1990	0.051 (0.83)	0.104 (0.97)		
Maximum years of schooling of adults	0.052 (0.94)	0.194 (1.95)*	0.005 (0.23)	0.100 (2.26)**
Mean age of adults	0.004 (0.27)	-0.024 (-0.70)		
SD, age of adults	0.012 (0.61)	0.019 (0.46)		
Age of individual who died			0.014 (6.60)***	0.016 (5.88)***
Sex of individual who died			-0.397 (-4.26)***	-1.018 (-5.50)***
Tutsi-headed	1.293 (2.53)**	2.843 (3.78)***	0.410 (3.45)***	0.802 (3.56)***
Constant	0.039 (0.06)	-2.805 (-2.21)**	-0.745 (-1.73)*	-2.377 (-11.72)***

Note: t-values are in brackets and corrected for household-level clustering in the last two columns.

Annex 4: Summary of 10 transition matrices

Country and source	Welfare measure	Time span (years)	Percent of households that:			Percent of households in bottom quintile that:		
			Remain on diagonal	Move by one quintile	Move by two or more quintiles	Remain in bottom quintile	Move by one quintile	Move by two or more quintiles
India: Swaminathan (1991a, 1991b)	Land	8	48.2	36.5	15.3	52.9	17.6	29.5
Peru: Glewwe and Hall (1998)	Expenditure	5	36.0	37.8	26.2	40.3	23.0	36.7
South Africa: Maluccio et al. (2000)	Expenditure	5	34.6	41.2	24.2	40.9	30.2	28.9
Vietnam: World Bank, (1999)	Expenditure	5	40.4	39.8	19.8	48.6	27.2	24.2
India: Lanjouw and Stern (1991, 1993)	Income	9	23.0	31.0	46.0	17.4	21.7	60.9
	Income	12	25.7	34.3	39.0	15.8	26.3	57.9
	Income	5	25.6	44.9	24.5	26.3	26.3	47.4
Chile: Scott and Litchfield (1994)	Income	18	23.3	39.0	37.7	8.0	32.0	60.0
Rwanda: present study	Income	12	24.4	29.1	46.6	13.5	16.2	70.3
	Asset index	12	30.2	37.6	32.2	40.5	27.0	32.4

Source: Baulch and Hoddinott (2000) and our data from Rwanda for the last two rows

Annex 5: Regional diversity

Income mobility has a very pronounced location specific pattern. Table A.5 illustrates the diversity. It reports for every administrative sector: mean base period income, the sector's income rank in 1990, mean final period income, the sector's income rank in 2002 and the average change in income rank for the households of the sector. The last column of the table gives the proportion of households in the sector that experienced positive positional income movement.

Table A.5. Administrative sectors and positional movement

Sector	Mean base period Income (RWF)	The sector's income rank in 1990	Mean end period Income (RWF)	The sector's income rank in 2002	Average change in rank	% of HH in the sector experiencing positive positional movement
Nyarusange	11,067	10	6,699	2	-14	33%
Kamegeri	6,528	3	9,113	7	+30	70%
Bitandara	8,656	5	9,594	8	+20	67%
Kibirizi	5,338	2	8,399	4	+34	58%
Gorwe	16,441	15	6,187	1	-64	10%
Kigoma	5,228	1	26,829	16	+104	85%
Gihembe	8,960	6	9,683	9	-15	50%
Munanira	14,095	13	9,983	10	-17	50%
Kagogwe	14,090	12	14,012	13	-6	39%
Ngamba	13,633	11	6,734	3	-55	9%
Ruyenzi	19,465	16	21,564	15	+7	50%
Ruyengado	9,962	8	12,010	12	-22	23%
Ntenyo	7,799	4	9,077	6	-10	54%
Mbati	14,899	14	11,564	11	-28	23%
Gitovu	10,108	9	8,476	5	-5	55%
Mbuye	9,024	7	16,103	14	+27	62%

We already mentioned that six of the twelve households that made most progress in income terms came from Kigoma sector. This sector suffered from a severe crop failure in 1990, but benefited from a very good harvest in 2002. Whereas the sector had the lowest mean income in 1990, it moved to the first position in 2002. 85%, or 11 out of the 13 interviewed households in Kigoma experienced positive positional income movement.

Another eye-catching sector is Gorwe. In 1990 it was almost the richest sector (15th place); in 2002 it became the poorest. The average positional movement was -64 places, while 90% of the interviewed households in Gorwe experienced negative positional movement. What is the story behind Gorwe? Gorwe is situated in an area where the genocide was extremely severe. The shocks are evident from our data: only ten from the original 16 households remained in the sample, the 15 members of Tutsi households in the 1990 sample were all killed, four households

out of the ten interviewed had a member in prison, six out of the ten took refuge. The dependency ratio increased from 87 to 186. One of the reasons why the genocide was so severe was that the proportion of Tutsi in the population was fairly high compared to other parts of Gikongoro. It appears that the economic activities in the severely affected sector of Gorwe suffered a setback. The income source that decreased most in Gorwe is off-farm work. More information on the reasons behind the income movement of sectors can be obtained from the authors on request.

Annex 6: Mean and standard deviation of variables

Summary of dependent variables

	Description	Mean	St. Dev.
DlogY	Change in log income	-0.09	1.07
DrankY	Change in income rank	0.00	69.00
DlogYCS	Change in log income from crop sale	1.13	4.50
DlogYNF	Change in log income from non-farm	-0.12	6.14
DshareCS	Change of share of crop sale in total income	11.16	21.25
DshareNF	Change of share of non-farm in total income	5.67	31.33

Summary of continuous explanatory variables

Symbol.	Description	Mean	St. Dev
HHSIZE90	Household size, 1990	5.41	2.26
DHHSIZE	Δ Household size	-0.41	2.56
DEPRAT90	Dependency ratio, 1990 (dependent/ active)	1.09	0.88
DDEPRAT	Δ Dependency ratio	0.49	1.95
AGEH90	Age of head, 1990	45.47	14.68
DAGEH	Δ Age of head	5.77	14.62
YEDUCH90	Years of education head, 1990	1.93	2.49
DYEDUCH	Δ years of education head	0.35	2.24
LLANDS90	Log of land size, 1990 (ha)	-0.38	0.84
DLANDS	Δ Land size	-0.09	0.66
VIOLENTL90-02	Number of members lost due to violence, 90-02	0.26	0.66
NMREFUGE94-02	Number of months HH took refuge, 1994-2002	5.21	17.19
ALT	Altitude (meter)	1741	239
DISTM	Distance to market (km)	4.19	1.36

Summary of discrete explanatory variables

symbol	Description	Value= 1	Value= -1
FEMH90	Dummy female-headed, 1990	31	
DFEMH	Δ to male (-1) or female head (+1)	51	5
TUTSIH	Tutsi-headed household	12	
HHMOVED94-02	Household moved after 1994	8	
HDESTR90-02	House destroyed, 1990-2002	34	
PRISON02	Household member in prison, 2002	17	

Note: these summary statistics use the data of the 182 observations included in our regression analysis.

Annex 7: Unusual and influential observations

We used five criteria to detect unusual and influential observations:

1. Income per adult equivalent < (mean income per adult equivalent – 3* standard deviation of mean) OR income per adult equivalent > (mean income per adult equivalent + 3* standard deviation of mean)
2. | studentized residual| > 2
3. leverage > (2k+2)/ n
4. Cook's D > 4/ n
5. | DFITS| > 2*sqrt(k/ n)

(where k is the number of predictors and n the number of observations)

For more details on these criteria, we refer to
http:/ / www.ats.ucla.edu/ stat/ stata/ webbooks/ reg/ chapter2/ statareg2.htm

Table A.7 below gives the number of observations recognized as unusual or influential according these criteria.

Table A.7

Criteria	1	2	3	4	5
Number of "outliers"	8	9	13	11	13

If an observation is selected as unusual or influential in three out of five of these criteria, we left it out of the regression analysis of section 5. This is the case for seven observations. Leaving these observations out of the other sections does hardly influence the results of the descriptive statistics. For an example see the note below table 2. It does however change the results of table 7, below which we included a note for the important changes.

Annex 8: Correlation matrix of shocks, ethnicity and income movement

	TUTSIH	DFEMH	HHMOVED94-02	HDESTR90-02	PRISON02	VIOLENTL90-02	NMREFUGE942
TUTSIH	1.0						
DFEMH	0.223**	1.0					
HHMOVED94-02	-0.057	-0.001	1.0				
HDESTR90-02	0.270***	0.212**	0.035	1.0			
PRISON02	-0.085	0.142*	-0.069	0.040	1.0		
VIOLENTL90-02	0.400***	0.239**	0.120	0.090	-0.097	1.0	
NMREFUGE9402	-0.081	0.046	0.273***	-0.080	-0.005	-0.072	1.0
DlogY	-0.072	-0.283***	-0.076	-0.177**	-0.202**	-0.102	-0.061
DrankY	-0.103	-0.279***	-0.105	-0.180**	-0.190**	-0.100	-0.053

Significant at the *10% level, ** 5% level, *** 1% level

Annex 9: Assessing the effect of income strategy on income movement

Dependent variable Explanatory variables	Change of log income (IX)	Change of income rank (X)	Change of log income (XI)	Change of income rank (XII)
IDSCROPS	0.040 (1.19)	2.442 (1.32)	0.034 (3.50)***	2.676 (4.05)***
IDSNONF	0.031 (2.68)***	1.608 (2.56)***	0.027 (3.93)***	1.728 (3.67)***
ILOGY90	0.24 (0.87)			
IRANKY90		-0.122 (-0.62)		
HHSIZE90				
DHHSIZE	0.142 (2.37)**	7.967 (2.30)**	0.131 (4.12)***	7.972 (3.70)***
DEPRAT90				
DDEPRAT	-0.133 (-2.85)***	-8.769 (-3.34)***	-0.129 (-3.14)***	-9.078 (-3.28)***
AGEH90				
DAGEH	-0.004 (-0.63)	-0.001 (-0.00)	-0.003 (-0.56)	-0.012 (-0.03)
YEDUCH90				
DYEDUCH	0.104 (2.48)***	4.146 (1.85)*	0.092 (2.62)***	4.435 (1.88)*
FEMH90				
DFEMH	-0.129 (-0.67)	-10.542 (-1.00)	-0.153 (-0.94)	-10.095 (-0.92)
LLANDS90				
DLANDS	-0.071 (-0.49)	-5.183 (-0.66)	-0.047 (-0.40)	-5.933 (-0.74)
TUTSIH	-0.156 (-0.37)	-12.955 (-0.55)	-0.094 (-0.27)	-14.777 (-0.62)
HHMOVED94-02	-0.098 (-0.18)	-15.165 (-0.52)	-0.048 (-0.13)	-10.628 (-0.41)
HDESTR90-02	-0.200 (-0.86)	-8.352 (-0.65)	-0.177 (-0.89)	-8.981 (-0.67)
PRISON02	0.155 (0.37)	8.209 (0.36)	0.123 (0.39)	9.364 (0.45)
VIOLENTL90-02	0.215 (1.06)	13.087 (1.17)	0.194 (1.31)	13.727 (1.38)
NMREFUGE94-02	0.004 (0.54)	0.368 (0.96)	0.004 (0.88)	0.366 (1.20)
ALT	0.000 (0.04)	-0.016 (-0.22)	0.000 (0.03)	-0.016 (-0.50)
DISTM	-0.015 (-0.08)	0.598 (0.06)		
Intercept	-3.112 (-0.98)	5.255 (0.08)	-0.545 (-0.68)	-6.172 (-0.11)
Pagan and Hall test	Chi-sq (20)	Chi-sq (20)	Chi-sq (20)	Chi-sq (20)
	P-value = 1.000	P-value = 0.999	P-value = 0.842	P-value = 0.801
Sargan test	Chi-sq (3)	Ch-sq (3)	Chi-sq (5)	Ch-sq (5)
	P-value = 0.171	P-value = 0.377	P-value = 0.198	P-value = 0.704
C test for DLANDS	Chi-sq (1)	Chi-sq (1)	Chi-sq (1)	Chi-sq (1)
	P-value = 0.871	P-value = 0.805	P-value = 0.839	P-value = 0.708
C test for DFEMH,	Chi-sq (3)	Chi-sq (3)	Chi-sq (3)	Chi-sq (3)
DYEDUCH,	P-value = 0.171	P-value = 0.377	P-value = 0.708	P-value = 0.495
DAGEH				

T-vaues between brackets
Significant at the *10% level, ** 5% level, *** 1% level

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ENDNOTES

[1] The death toll among Tutsi remains a debated issue. In addition, tens of thousands of Hutu were killed or died from deprivation in refugee camps.

[2]On land scarcity and unequal land distribution, leading to uneven development and violence see Mamdani (2001), Prunier, (1998), Newbury (1998), Uvin (1998), Verwimp, (2003). Other determinants of the genocide are the outbreak of civil war with the RPF invasion in October 1990 and the radicalisation of Hutu power politics in response to the perceived RPF threat, the creation of opposition parties under the slow process of democratic liberalisation, and a feeling of Hutu inferiority that led to ethnic hatred and the extreme attempt to purge the 'Hutu nation' of Tutsi (Baines, 2003).

[3] The most recent census of 2002 gave a population figure of 8.16 million inhabitants. The country's surface was also re-estimated with the help of IMU/ UNDP. Instead of 24738 km² as used in the data of the World Bank, the surface was calculated to be 25314 km² (Government of Rwanda, 2003).

[4] This is in contrast to the prediction made by Boserup (1965), who argued that increased population density leads to innovations that temper to problem of land availability. It is somewhat difficult to measure land degradation. For documentation on this topic, we refer to Clay (1996) and the PRSP (Government of Rwanda, 2002a). We do have detailed data on land sizes. In our own data set, average farm size decreased from 0.96 ha in 1990 to 0.86 ha in 2002. The number of households with less than 0.7 ha, the generally accepted minimum size needed to feed a household, increased from 57% in 1990 to 62% in 2002.

[5] Using household expenditure, the Poverty Reduction Strategy Paper (Government of Rwanda, 2002a) finds that the proportion of people below the poverty line increased, from two out of five in the early 90's to three out of five persons in 2002. However, Piron and McKay (2004) suggest the opposite based on information about agricultural production, household income and child malnutrition. The trend of increasing inequality is less contested (Government of Rwanda, 2002a; Piron and McKay 2004). According to two nationwide surveys, the Gini coefficient of inequality rose from 0.29 in 1984/ 86 to 0.45 in 2000/ 2001 (MINECOFIN, 2002).

[6] For an overview of the theory and empirics of income mobility studies, see Fields (2001). Examples of country studies are: Glewwe and Hall (1998), Randolph and Trzcinski (1989), Trzcinski and Randolph (1991), Scott and Litchfield (1994), Nee (1996), Nee and Liedka (1997), Chen and Ravallion (1996), Jalan and Ravallion (1998, 1999), Grootaert and Kanbur (1996), Grootaert, Kanbur and Oh (1997), Coondoo and Dutta (1990), Drèze, Lanjouw, and Stern (1992).

[7] Rwanda has two seasons, the first, from October to March -season A- and the second from April to September - season B. Season B has a longer rainy period than season A. Season A counts 100 agricultural labor days compared to 80 for season B. Although, the 1990 data include data for season B and in 2002, we did collect data on the harvest of the preceding B season (April 2001-September 2001), we do not use them and work only with season A. The

reasons for this are twofold. First, the data collection took place in February and March 2002, during the season A harvest, but more than four months after the season B harvest. Since our season B data are based on recall, they might be less trustworthy than those for season A. The second reason for using only season A data is that for season B we did not ask questions on off-farm earnings and on income from beer brewing.

[8] The exact name of the unit changed over time from "Service des Enquêtes et Statistiques Agricoles" (SESA), to "Division des Statistiques Agricoles" (DSA), and most recently Food Security Research Project (FSRP), Division of Agricultural Statistics. The DSA and MINAGRI received assistance from the United States Agency for International Development (USAID) through a cooperative agreement with Development Alternatives Inc. (DAI) and Michigan State University.

[9] Reasons for choosing these provinces included among others the availability of information needed to locate the households, the mix of low and rather high survival rates of Tutsi during the genocide (respectively in Gikongoro and Kibuye on the one hand and Gitarama on the other), the presence of a sizable Tutsi population, an the mix of very poor and less poor administrative communes. See Verwimp (2003).

[10] Examples of such questions are whether, when and how household members were killed, and whether, when and where a household took refuge. The inclusion of such questions may have been too sensitive, as the answers would provide clues on the ethnicity of the household. In presentday Rwanda it is no longer politically correct to mention ethnicity.

[11] In 1999/ 2000 40 out of the 256 households in Gikongoro and Gitarama were not found. On 35 of these households Ph. Verwimp obtained information from neighbours. On 5 households there is no information at all. In 2002, four additional households could not be found. Thus, in 2002 we were not able to interview 44 households out of a total of 256 or 17%.

[12] We know for example that among the households who dropped out, eight had been completely exterminated during the genocide. The war-related displacements can be divided into three broad categories. The first concerns widows of the genocide who, often the sole survivor of their household, went back to their birth area. The second category comprises survivors of the genocide who moved to houses constructed by the government, so-called *imidugudu*. Thirdly, war and genocide triggered a massive outflow of Rwandans to neighbouring countries. Many refugees did not return to Rwanda, others did, but not necessarily to the same place.

[13] Further on in the text we provide a measure of the positional income movement of households and we relate this to shocks. Our data suggest that households that suffered from shocks experienced on average more negative positional income movement than other households.

[14] Rosenzweig (2003) focuses in his research only on men who leave arguing that in the context of rural Bangladesh most adult women do not participate in the labor force. In our sample of Rwandan households, the number of men and women who leave the household for working purposes are almost equal. We find that 48 men and 42 women of

the 189 households stopped co-residing. The reasons for leaving the origin household vary from marriage to never returned refugees to job searching, with women most commonly leaving to perform agricultural labor or to work as a domestic servant in town. To study the probability of household division we use the same explanatory variables as Rozenseweig: the household income and landholdings, the maximum years of schooling of anyone in the household, the number of males in the household in 1990, the mean age of adult men, the standard deviation of the ages of adult men, and the total number of adult men in 1990. The reasoning behind these variables can be found in Rosenzweig (2003), but the main idea is that they capture the household public good and its utility of this public good for the adult men. For example, since schooling is considered as a public good, the maximum schooling of the household should decrease the probability of household division. But, the more heterogeneity in the household, the less likely that the sharing of the household's public goods benefits all members and therefore the standard deviation of the ages of adult men is expected to increase the probability of household division.

[15] In our setting, household smooth consumption ex post mainly by selling assets, by taking up consumption credit and by drawing on their savings. Over the period of 12 years we found that on average annually 5% of households sold an asset to be able to reach their minimum food consumption. In the end period, 2002, 17% of households possessed some savings while 16% had taken credit. However, the strategies for income smoothing are far from perfect. As a consequence of negative shocks, many households had been forced to reduce the number of daily meals in several years between 1990 and 2002. The percentage of households in our sample reporting to have suffered food shortages fluctuated strongly across years, with a peak of 55% of households in 1994.

[16] The severe crop failure took place in season B of 1989. See P. Vewimp (2003).

[17] The larger contribution of crop sales to income may partly have resulted from an increased specialization and intensification of the agricultural activities of some farmers. We refer to Berlage, Verpoorten, and Verwimp (2003).

[18] The increased contribution of livestock was due to higher income from cattle sales, resulting from an increase of the relative price of cattle. It is not clear how best to include livestock assets and production in income. Livestock is kept largely for manure. Since the use of manure raises the revenue from cropping income, its contribution to income is already included in subsistence output and crop sales. Livestock is not kept for home consumption. Most rural Rwandans are too poor to consume sizable amounts of meat, eggs or milk (Kangasniemi, 1998). However, selling livestock, eggs or milk livestock contributes to cash income. We included the revenue from eggs, milk and livestock sales in livestock income. Data on the revenue of the sale of eggs and milk exist for 1989/ 1990, but not for 2001/ 2002. We estimated the latter on the basis of the number of chickens and cows in 2001/ 02 applying a proportionality factor for the revenue of milk and eggs derived from the 1989/ 1990 data. Including the receipts from livestock sales in revenue is problematic because the number of livestock sold over such a short time span of one season is fairly small. The estimated income would be highly dependent on whether households happened to sell livestock during the 6 months of season A. An alternative approach is to assume that the income from livestock is proportional to the value of livestock holdings (Kangesniemi, 1998). We applied this method. The proportionality factor we use is the calculated average probability in the 2002 survey of selling livestock.

[19] Off-farm jobs are jobs performed outside the family farm, be it in agricultural or non-agricultural activities. Examples are casual labor and construction work. Non-farm jobs belong to the non-agricultural sector, but can be performed on or outside the family holdings. Examples are pottery and construction work.

[20] Relying on the mid-point estimates for small beer brewers by Hagblade (1987) we assume that 3.41 kilograms of bananas and 0.11 kilograms of sorghum are needed to produce one liter of banana beer and that 0.36 kilograms of sorghum are needed to brew one liter of sorghum beer. The inputs for beer consumption are subtracted from the category "agricultural subsistence production" in so far the household itself grow bananas and sorghum. The remainder of the inputs needed to account for beer consumption and the inputs needed for beer sale are subtracted from the gross revenue of beer sale.

[21] We compared this with the use of provincial prices. With provincial prices for crop sales and beer sales, we obtained several observations with negative net income from sale. So, in our case it seems that reported prices perform better because they can capture important intra-regional price differences. These differences might be due to the quality of the produce or the time of selling.

[22] 59 widows (31%) and 6 wives of prisoners (3%) act as a household head in our sample.

[23] The same analysis for income per capita did not lead to considerably different results. We used the adult equivalent scale as reported in the IHLCS (Government of Rwanda, 2002b), the large-scale Integrated Household Living Survey implemented in Rwanda in 2000-2001.

[24] In developed countries, the immobility ratio is higher. Burkhauser, Holtz-Eakin and Rhody (1998) found an immobility ratio of 50.4% over five years for US income quintiles. Using expenditures instead of income increases the immobility ratio. In Peru, Glewwe and Hall (1998) reported that 36% of households remained in the same consumption expenditure quintile over a five-year period. Maluccio et al. (2000) found almost the same result for South Africa over the period 1993-1998.

[25] For a comprehensive overview of the climate and bio-diversity of Rwanda, we refer to Gotanegre, J. F. Prioul, C. Sirven, P. (1974)

[26] The particular situation of Kigoma is illustrated by the increased percentage of harvest sold. In 1990, only 5% of the harvest was sold compared to 84% in 2002. Anecdotal evidence is that when visiting the sector in 2002, many of the inhabitants were drunk in daytime. This was not a one-day event as our interviewer complained of night noise during her three-week stay in Kigoma. Drinking banana and sorghum beer is a popular activity in Rwanda and we suspect that people were spending their occasional surplus in feasting and drinking.

[27] We summed the tropical livestock units (TLU) and land size, both per adult equivalent. Land size was expressed in hectare and divided by 4, assuming that the value of 1 TLU corresponds to the value of 0.25 hectare. Other important assets like schooling and social capital are difficult to quantify.

[28] The positive correlation between assets and income stems from two facts. First, the more physical capital the household possesses, the larger the base for income generating activities. Second, the more income the household has, the higher its capacity to invest in physical assets. However, we are not surprised that our asset index does not match income perfectly. Many factors besides land size and livestock, such as off-farm earnings and land productivity determine the income level. Moreover, a household can invest its income also in schooling, migration or a small business. In addition, the choice to invest in the purchase of land and livestock is often constrained by the availability of land and pastureland.

[29] As stated in footnote to table 2, we used the food poverty line, which equalled 45,000 RWF (108$) per year per adult equivalent in 2001 (MINECOFIN, 2002).

[30] The higher loss of cattle of Tutsi households is somewhat misleading because in the 1990 sample Tutsi households owned more cattle (on average 1.58) than Hutu households (1.04).

[31] The reason why we chose the change of log income as dependent variable is best illustrated by an example. Imagine two households, A and B. Household A's income over time increases from 100 to 200. For B there are two scenarios. In scenario 1, household B's income increases from 1000 to 2000, while in scenario 2 it increases from 1000 to 1100. In scenario 1 the relative income change of A and B is the same and the Gini coefficient does not change over time. In scenario 2, the absolute income change of A and B' is the same and the Gini coefficient decreases over time, indicating less inequality. If you agree that in scenario 1 income inequality has not changed, you better use the change of log income to study income mobility since you value the income mobility of A and B as equal. If you rather think that inequality increased in scenario 1 and stayed the same in scenario 2, you better go along with absolute income change to measure mobility since you judge that the income movement of A and B' are equal. Because most people would agree that income inequality remained the same in scenario 1, we use relative income mobility for our analysis.

[32] We have data on the distance to the market in 2002. In two sectors the distance to the market decreased between 1990 and 2002. However, in order to avoid endogeneity we use the distance to the market in 1990. Indeed, if a sector expanded agricultural surplus and crop sales, local traders or authorities might react by constructing a market nearby.

[33] Crop selling is not the ideal measure to detect a "market strategy". Many households sell immediately after the harvest out of necessity, often purchasing the same crop some time later at a higher price. Crop selling can also occur merely as a consequence of surpluses after a good crop season. One could argue that a better measure would be the share of land on which the household grows so-called cash crops. We cannot apply this measure to Rwanda. Almost all crops in our sample can be used both for consuming and selling. The only real cash crop in our sample is coffee, but it is grown by a small fraction of farmers and it is increasingly abandoned due to price deterioration. In addition, we argue that the strategy in the face of land scarcity is not merely turning to the market, but rather cultivating the crops with the highest yield. This crop could be very different across households and locations.

[34] In annex 11 we use base year income to subsititute for base year capital as an explanatory variable. This is only a valid approach if factor prices stayed more or less the same over the period 1990-2002. To verify this we performed two regressions. The first relates income of 1990 to the base year capital in 1990 captured by the variables HHSIZE9, DEPRAT9, AGEHEAD9, FEMH9 and LLANDS9. The second regresses the income of 2002 on the capital of 2002. The estimated coefficients for most of the different forms of capital remain almost constant over time. We note a slight decrease of the estimated coefficient for the years of education of the household head and for land ownership. There is a steep increase of the absolute value of the estimated coefficient for female-headed households. The results of these regressions are available on request.

[35] Using 189 instead of 182 observations gives only minor differences for the estimated coefficients with a slight loss of significance for some shocks. The main conclusions of the paper do not change. All regression results for the sample including outliers are available on request.

[36] The appointment of Tutsi in the local administration may not only have increased the non-farm earnings of Tutsi-headed households directly, but also indirectly due to better social networks for the access to non-farm wage work. However, we do not have quantitative proof of such social networks, neither do we have extensive quantitative proof of the proportion of Tutsi in the local administration. During qualitative fieldwork in 2003 one of the authors noted that the "responsables" of the sectors she visited were "rescapés". Her translator explained that shortly after the genocide, in a climate of incrimination of many Hutu and feelings of guilt towards the Tutsi community, "rescapés" were often appointed as "responsable" at the sector level. He explained that because people were pleased with their work and integrity, they voted for them during the grassroots elections at the cell and sector levels in March 1999. Human Rights Watch (New York, February 1, 2001) however criticizes the elections of March 1999: "There were few reports of irregularities, but the system itself inhibited free choice. Political party activity was prohibited and voters did not use secret ballots, as in elections under previous governments, but instead signified their vote by lining up publicly behind the candidates."