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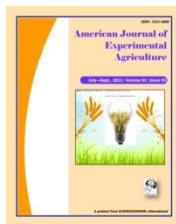
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The Impacts of Natural Disasters on Smallholder Agriculture in Rural Cameroon

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Authors' contributions:

This article was written with the full collaboration of both authors. Author RAB was involved in the data collection, based on instruments that were designed with the technical support of author GB. Initial data entry and analysis was done by author RAB and data interpretation was jointly done. Both authors were involved in revisions suggested by the anonymous reviewers, and jointly approved the manuscript for final submission.

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ABSTRACT

Problem: That climate change and subsequent natural disasters resulting from it will affect the agricultural sector is not new to anyone familiar with the disaster literature. However, the exact magnitude of such impacts remains to be estimated.

Methodology: Using empirical evidence based on a 25 year old natural disaster in rural Cameroon, we attempt to provide estimates on the immediate and long term impacts of a natural disaster on smallholder agriculture. A standardized questionnaire is applied on 301 smallholder farming households to assess the short and long term impacts of the 1986 Lake Nyos disaster on agriculture, mainly eliciting responses through a recall process. This is complemented by participatory discussions and observations.

Results: The results reveal that the disaster had significantly high negative impacts on livestock and human capital ($P=0.01$ respectively). Sampled households were found not have currently recovered even up to the levels before the 1986 disaster, after a quarter of a century.

Conclusions: The implications of such disasters on the agricultural sector and their possible effects in the short and long term include increasing efforts towards prevention, and the use of data as basis for disaster management.

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Keywords: *Natural disaster; impact; smallholder agriculture; rural Cameroon.*

ACRONYMS AND ABBREVIATIONS

CO₂: Carbon Dioxide; FCFA: Franc de la Communauté Française d'Afrique; NGO: Non Governmental Organization; SRM: Social Risk Management; USD: United States Dollar.

1. INTRODUCTION

That the globe has witnessed a rapid increase in extreme natural events in the last two decades or so has been widely acknowledged in the literature. The period between 1990 and 2005 alone is said to have accounted for more than 50% of all natural disasters witnessed globally, compared to the period up to the 1960s [1]. Although the anthropogenic effects of such disasters remain widely unknown especially on agriculture [2], there is evidence that natural disasters will become more frequent in the future [3]. Sea levels for instance rose between 10 and 20 percent in the 20th Century. Global temperatures are expected to increase between 1.4 and 5.8% by 2100. This will cause increased seasonal and inter-annual variability of climatic factors, creating favorable conditions for the occurrence of natural disasters with expected differentiated impacts especially on the agricultural sector in developed and developing countries [3,4].

The bulk of the poor lives in developing countries, where smallholder agriculture is still the major source of employment and income [5,6]. The increased (observed and expected) frequency of natural disasters will probably negatively impact agricultural production in developing countries, pushing non-poor households into poverty and poor ones deeper into a vicious cycle of poverty. In fact specific characteristics of the smallholder agricultural sector such as the entanglement of household and farm decisions, labor as the principal asset, smaller than average farm sizes, partial market integration, information asymmetry, skepticism in adopting new technologies and the existence of a moral community [6,7] suggest increased vulnerability of the sector to extreme natural events. Meanwhile, the failure of states and risk markets, deficiency of scientific data, poor understanding of the role of informal response mechanisms and information asymmetry especially on the possible impacts of such events have been identified as key factors favoring increased effects of natural disasters in developing countries in general and on agricultural production in particular [2,8,9]. It is not surprising therefore that developing countries host almost 90% of all victims of natural disasters [8,10].

Natural disaster is used here to refer to (natural) events: sudden or slow developing, that overwhelm local capacity, causing enormous damages that necessitate national and international (external) assistance. For a disaster to be declared by the United Nations Organization at least 10 people would have been killed and 100 or more affected [11]. It is generally conjectured that natural disasters will have largely negative impacts in developing countries. However, the exact magnitude of the impact remains largely unpredictable.

This research contributes to reducing this knowledge deficiency especially on the aspect of the short and long term impacts of natural disaster on the agricultural sector. Based on a 25 year old disaster, the article provides empirical evidence of the immediate effects of a natural gas explosion on livestock and human capital assets. An attempt is also made to assess the disaster recovery rate at household level, by comparing pre-disaster situation and the current situation of the household, that is 25 years later. The results are expected to improve

knowledge on the possible effects of natural disasters on the agricultural sector in developing countries. Such knowledge would be crucial to estimate possible effects and to prevent, mitigate or cope with natural disasters in developing countries in general and the smallholder agricultural sector in particular.

2. MATERIALS AND METHODS

2.1 Problem Background and the Research Area

Cameroon's geological setting and tectonic history makes her one of the most exposed countries to rapid onset natural shocks in Africa. Frequent geophysical and hydro-meteorological hazards along the so called Cameroon Volcanic Line (CVL) affect livelihood assets in the country [12]. Cameroon is exposed to natural shocks such as volcanic eruptions, toxic gas emissions, earth tremors, landslides and floods which often translate into disasters with severe impacts on the poor and the near poor.

On August 21 1986, a violent volcanic eruption at Lake Nyos in the Northwest Region of Cameroon emitted natural Carbon dioxide (CO₂) and minimal amounts of Hydrogen sulphide that asphyxiated over 1,700 inhabitants and almost all livestock in three affected villages (Nyos, Cha, Subum), located within a diameter of about 25 kilometers around the lake. Little or no damage was recorded on crops [11]. Subsequent scientific investigations on Lake Nyos confirmed huge amounts of CO₂ (300 million m³) in the deeper layers, with a high probability of further release in the future.

The Lake Nyos disaster is classified as a geological hazard as it resulted from internal, tectonic processes beneath the earth [12]. This however could not be established immediately after the disaster. While initial scientific interest was naturally tilted towards analyzing and understanding the cause of this natural shock, a high level international conference on the Lake Nyos disaster held in Yaoundé Cameroon in March 1987 proposed that surviving victims should be resettled immediately [13]. To this end, seven resettlement camps were established in Kimbi, Buabua, Yemngeh, Ipalim, Kumfutu, Esu and Upkwa villages between 1987 and 1988. The nearest camps (Buabua and Kimbi) were created some 10 Km away from the affected villages, while the furthest camps (Ipalim and Upka) spanned to about 50 Km from the disaster zone. Most households were moved immediately after construction from the affected villages into the camps where a majority still live today.

The shock-affected villages were declared disaster zone by the government and rehabilitation was legally prohibited. Nevertheless, in the last decade, a substantial number of households from the resettlement camps have been stubbornly moving back into these villages, in spite of government restriction. This research work analyzes the impact of natural disasters on agriculture for surviving households in six of the seven resettlement camps (with the exception of Ipalim) and the three affected villages with households that illegally moved back into the disaster zone. Ipalim was excluded because of difficulties to access the community by road. The analysis will focus on the impacts of the disaster on livestock and human capital. As there is scientific evidence that very little to no damage occurred on crops [11] the impact on crops was kept out of our analysis.

2.2 Methodology and Sampling Procedures

Based on a cross sectional survey design, primary data was collected only from victimized households of the 1986 Lake Nyos disaster. The sampling unit was the household. Unique primary data were collected with a standardized questionnaire. Almost all victimized households (100% of all those former Lake Nyos disaster households who had illegally returned into the potential disaster zone and over 80% of all those households that are still living in the resettlement camps) responded to the questionnaire. A total of 301 households (71 illegally resettled and 230 in camps) were surveyed. Those who were not interviewed either refused or were not available during the survey period. The pre-tested standardized questionnaire adapted from [14] included modules for risk management analysis based on the World Bank's Social Risk Management (SRM) Framework¹ [9,15]. Through a recall process, households provided information on the number and values of livestock, and human lives owned one day before and after the disaster. This data allows us to assess in a unique way, the actual impact of the disaster on agriculture. Data was also collected on current numbers and values of livestock, to allow for a comparison with the situation before the 1986 disaster as a proxy for household level of recovery from the disaster.

The quantitative survey was complemented with participatory methods like participatory discussions, participant observation, and focused group discussions. Field data collection took place between November 2009 and February 2010.

The t-test for equality of means is generally applied in analyzing the data and to relate the results to theory, as this straight-forward statistical approach best suits the issue under discussion in this paper. Within the t-test for equality of means, household level data is compared before and after the disaster to capture any variances in means that facilitate interpretation and discussions, with regard to the impact of the disaster on agriculture. This is done for livestock as well as for human capital. A similar analysis is done to estimate the rate of recovery by comparing 1986 figures before the disaster and the current situation. The results will be presented in the next section.

3. RESULTS AND DISCUSSION

In this section the empirical results will be presented and discussed. The socioeconomic characteristics of the sampled smallholder farming households who are victims of the 1986 lake Nyos disaster in rural Cameroon will be presented. This will be closely followed by the short term impact of the natural disaster on agriculture. Results and discussion on the long term impacts proxied by the recovery rate will conclude this section

¹The SRM Framework was developed by the World Bank's Social Protection Department in the late 20th and early 21st century. Following the Asian financial crisis of the 1990s, it became evident that economic growth alone is not a sufficient condition for long term poverty reduction. SRM emerged as the first comprehensive framework including social dimensions in risk management. It effectively links social protection to the broader agenda of poverty reduction by shifting the focus from risk coping to assessing risk reduction and vulnerability, therefore raising more interest on the potential role of informal instruments in managing risks. For a comprehensive overview of the framework, see for instance [9,15]. This framework was adopted in the study, with a focus on the agricultural sector. A modification of this framework is also provided by [16].

3.1 Socioeconomic Characteristics of the Sampled Disaster Affected Households

The literacy rate in the sample (47.8%) is over 20 percentage points lower than the national average for Cameroon [17]. Moreover, 82% of the population depends solely on smallholder, subsistence agriculture for their livelihoods. The rest is engaged in some form of waged farm labor (8.7%), in nonfarm enterprise activities (4.3%), or simply unemployed or unable to work (4.9%). The average age of the household heads is 48.6 years. Most household heads (66.8%) are married and living with their spouses together. Only 7.4% of all household heads in the sample are single. The rest (25.8%) are either divorced, separated or widow(er)s. This suggests that marriage is an important traditional institution in the research area.

Most households (91.2%) own the houses in which they live, even if almost 70% of all the houses were constructed by the government as part of its resettlement program after the 1986 disaster. Government support therefore contributed to the social welfare of victims. It however seemed to have created a dependency syndrome. For instance although victimized households own the government-constructed houses, they seem to depend on the government for assistance even in maintaining the houses. This was revealed through participatory discussions with victims. We also observed that 10.1% of all the houses were seriously dilapidated and 50.7% needed major repairs. The bulk of the houses were therefore in bad shape. Only 39.2% of houses were observed to be in good housing condition. There is no national electricity connection in the research villages. The mean household size of seven is significantly higher than the mean for the region observed in other studies, which is around five [2]. Perhaps household heads prefer to have more children than the average households to compensate for the losses of 1986. It is also possible that the threats of another disaster can motivate household heads to opt for more children, in order at least to maintain their lineage, in case of another catastrophe. The larger the family size, the greater the chances that some members will survive another disaster.

Mean per capita expenditures on clothing and footwear of FCFA 18920 (USD 42) are less than for other households in the region. That per capita expenditure on clothing and footwear increases with increasing income [14] suggests that the victimized households are poorer than the average households in the North West region of Cameroon. Households own an average of 2 plots, with a mean surface area of slightly above 3 hectares. The average land size per capita of 0.43 hectares suggests that the households are engaged in smallholder, subsistence agriculture. No household had a land certificate for its pieces of lands. Using land as collateral for obtaining bank financing is therefore impossible.

The annual cash expenses on farm inputs were very low. For instance the mean annual cash expenditures on seeds was FCFA 9440 (USD 20) per household. Farming in the research region depends therefore not only on smallholdings pivoted by family labor, but also operates on a low external input basis. Until now, it is contributing significantly to the food security of the concerned households, as only 15.2% of all households interviewed complained of short term food security (that is sporadic food shortages within the last 30 days) and 34.3% of long term food security (shortages within the last 12 months). Food shortage on an annual basis was traced to the 'hunger period' from March to May annually, when crops are still growing in the fields. Generally high levels of food security can be attributed to other factors such as favorable climate and high soil fertility rather than to any form of intensification.

3.2 Short Term Impacts of Natural Disaster on Agriculture

Two aspects are analyzed to capture the immediate (short term) impacts of the 1986 lake Nyos disaster on smallholder agriculture: livestock assets and human capital. Numbers and values of livestock assets were chosen for the analyzing the impact of the disaster on livestock. Livestock is an important asset in smallholder agricultural systems and households often keep livestock to buffer shocks [8,18]. Therefore it is very likely that victimized households will more reliably remember the exact numbers and values in a recall process, even if it dates back to 25 years. This gives more reliability to the data. Human capital was captured mainly based on the human lives lost to the disaster and the household size. This is done within the conviction that smallholder farming households not only own family labor as their principal asset, but also strongly depend on it for agricultural production, as farm and household objectives are basically inseparable [2,8,19]. In fact under smallholder agriculture, the household provides labor to the farm and expects the farm to provide for the basic needs of the household [12].

Table 1 presents the results of the number of livestock holdings before and after the disaster. For all the categories of livestock, a mean of one livestock survived the disaster, irrespective of the number owned before the disaster. For instance for about 20 small livestock owned per household (chicken, guinea pigs, rabbits), only one survived the asphyxiation. These results confirm earlier statements that almost all livestock were killed by the gas explosion [13,14]. As long as the threat of another disaster exists, it is very likely that households may be reluctant to re-invest in livestock production, due to the psychosocial and economic impacts of the 1986 disaster. This behavior may have long term effects on the smallholder agricultural sector in the disaster region.

Table 1. The impact of the 1986 Lake Nyos natural disaster on Livestock

Variable	Time frame	Mean	Std. deviation	P – Value
Number of large ruminants owned	Before disaster	7.71	25.90	0.02
	After disaster	0.59	3.97	
Number of small ruminants & pigs owned	Before disaster	11.46	19.66	0.01
	After disaster	0.77	4.31	
Number of other small livestock	Before disaster	19.85	23.94	0.02
	After disaster	0.82	5.12	

Source: Field data analysis

Note: That Standard Deviation exceeds the mean is an indication that the data is skewed.

Table 2 presents the analysis of the impact of the concerned disaster on human capital. From participatory discussions in the disaster villages, it was established that family members below 16 years are considered as children. As such, they supply labor on the family farms and in turn expect their needs to be met, mainly from the farm, at the discretion of the household head. At 16 years and above, they are ready for marriage (the female child) or to live independently (the male child). After 16, they can take decisions independently of the parents. To capture the dynamics of the impact of the disaster on labor supply, we divided the household members into the two categories: those below 16 years and those from 16 years and above. On average, only three household members survived the disaster within each analyzed category. This amounted to 33 percent of children and 27 percent of adults respectively. Interestingly, the impact was stronger on adults (16 years and above) than on children (below 16 years). This means that the number of survivors were significantly lower than the number of household members before the disaster ($P=0.01$). An

explanation for this rather unusual result captured through participatory discussions was that the parents/adults made tremendous efforts to help the children (by serving them with palm oil) during the disaster as an informal strategy to mitigate the asphyxiation. Other adult household members were expected to take care of themselves. This supports the conviction raised elsewhere that informal response mechanisms can be helpful in mitigating covariate natural shocks (see for instance, 4). In any case these huge labor losses have impacted tremendously on labor supply in the smallholder agricultural sector in the researched region. The psychological impacts persist till date. Field evidence for instance emanates from the fact that many households members wept after recalling the number of household members lost to the 1986 disaster.

Table 2. The impact of the 1986 Lake Nyos disaster on human capital

Variable	Time frame	Mean	Std. deviation	P – Value
Number of relatives below 16 years old	Before disaster	8.46	11.31	0.00
	After disaster	2.74	4.78	
Number of relatives 16 years & above	Before disaster	11.06	13.46	0.00
	After disaster	3.12	4.48	

Source: Field data analysis

Note: That Standard Deviation exceeds the mean is an indication that the data is skewed.

3.3 Long Term Effects of the Disaster on Agriculture: The Rate of Recovery

In an attempt to assess the long term effects of the disaster on smallholder agriculture in disaster affected rural Cameroon, we compare current livestock holdings as well as the household size to the situation one day before the 1986 disaster. A coded variable was also included in the questionnaire to capture households' perceived rate of recovery compared to the situation in 1986.

The results of the long term effects on livestock are presented in Table 3. At all levels, current mean values of livestock holdings are significantly less than the 1986 levels ($P=0.01$). Nevertheless, the recovery rate is different for different categories of livestock after 25 years: 39% for large ruminants (cattle and horses); 11% for small ruminants (sheep and goat) and pigs; and 33% for other small livestock (poultry, rabbits, and guinea pigs). The average recovery rate for all livestock is slightly above 27%. At current (linear) rates, it can be projected that while it would additionally require about a half of a century for households to fully recover their large and small ruminant holdings back to 1986 levels, it might take over 200 years for other small livestock, assuming that all other conditions (e.g. no livestock epidemics) remain constant. This trends can however be rapidly influenced by more intensive livestock production systems that provide much more heads per household, than has been the case in the past of one or two livestock promoted for instance by Heifer International non-governmental organization (NGO) in the research region as recalled by the respondents.

The recovery rate for human capital at the time of interview – captured as household size (Fig. 1.) is less than half, as the current household size of around seven represents only 35% of the size (around 20) in 1986. In other words, the current household size is significantly less than that of 1986 ($P=0.01$).

The above mentioned results somewhat mirror the negative perceptions of victimized households as to the level of recovery from the 1986 disaster. Only slightly above 20% of all respondents agreed to a full recovery from the disaster, as presented in Fig. 2. The rest (around 80%) have not recovered at all or have recovered only partially.

Table 3. Rate of recovery of livestock assets

Variable	Time frame	Mean FCFA	Std. Deviation	P – Value
Value of large ruminants owned	Before disaster	1927400	6475030	0.00
	Currently	749160	2545300	
Value of small ruminants & pigs owned	Before disaster	458290	786305	0.00
	Currently	51150	96425	
Value of other small livestock	Before disaster	49625	59840	0.00
	Currently	16510	36840	

Source: Own data analysis

Notes: 1 USD = FCFA 450

2. That Standard Deviation exceeds the mean is an indication that the data is skewed.

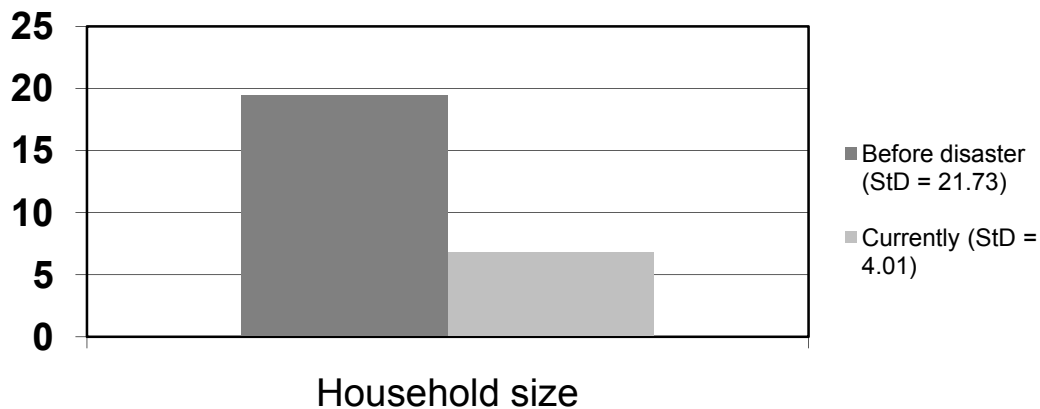


Fig. 1. Rate of recovery: An analysis of human capital

Source: Field data analysis

Notes: 1. $P=0.01$

2. That Standard Deviation exceeds the mean is an indication that the data is skewed.

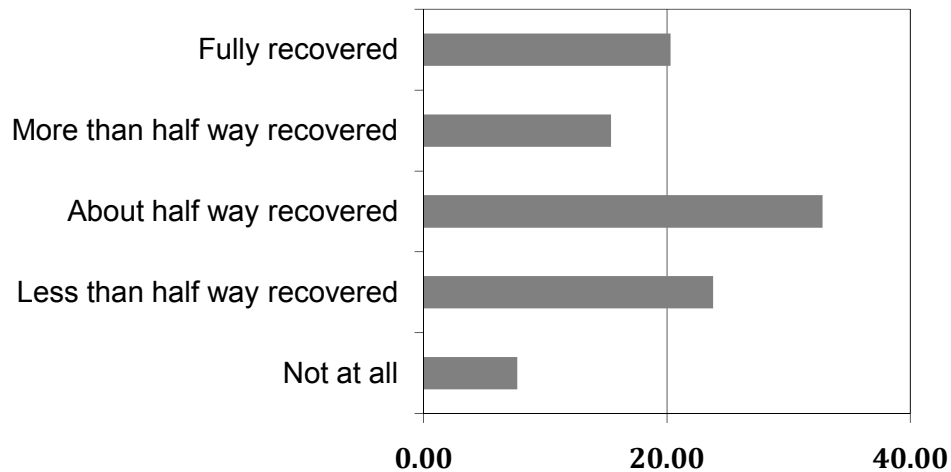


Fig. 2. Self assessment of recovery rate from the 1986 disaster at household level, in %

Source: Field data analysis

4. CONCLUSION

Scientific evidence that the globe is witnessing climate change is overwhelming. While it is generally accepted that these changes might have much more of negative impacts in developing countries where institutional frameworks for risk management are absent or function only partially, the exact magnitude of the impacts remain widely unknown.

This paper has attempted from an empirical perspective to estimate the short and long term impacts of the 1986 natural disaster on smallholder agriculture. Using livestock assets and human capital as proxies for impact on smallholder agriculture, we have demonstrated that the analyzed natural disaster had very strong short and long term negative impacts on the agricultural sector. Victimized households lost significant numbers and values of livestock. Significant losses on human lives were also registered as a result of the disaster.

After a quarter of a century, victims had not recovered back to the period before the disaster.

Our research findings have a number of implications for research and policy, within the framework of the impact of natural disasters on smallholder agriculture in developing countries. First, it is crucial to make tremendous efforts to prevent disasters before they occur. In the example discussed here, if science had the opportunity of identifying the threat before hand, a simple evacuation of the population together with their livestock would have significantly reduced the short and long term impact of the disaster on agriculture and livelihoods. Much more efforts should therefore be invested in identifying potential disaster risks and in putting in place early warning systems in order to prevent or mitigate the impacts of natural disasters, especially in very poor communities.

Secondly, it is vital to assess the impact of natural catastrophes and to use emanating data as a basis for short and long term disaster management. Enormous resources have been devoted by the Cameroon government and non-governmental organizations towards post disaster management in the research region. However, our judgment based on the data

analysis leads us to conclude that very little efforts were made at the very beginning and even over the last 25 years to restore the livelihoods assets back to the pre-disaster period. In fact the situational analysis at the beginning of interventions might not have been done, as we could not find any evidence in this direction. This is common, as external actors often content themselves with mitigating and coping efforts immediately a disaster strikes, and often pay very little attention to data collection. Good will or benevolence on the part of these external actors was not necessarily translated into any significant impact in the short and long term, on the smallholder agricultural sector on which most households depend. It is very likely that resources could have been wasted on issues of less importance to the victims. Increasing the level of participation before, during and after a disaster can significantly improve prevention, mitigation or coping.

In our particular case, assessing the actual livestock losses and using this as a basis for intervention could have had a better impact on livelihood restoration and would have rapidly improved the long term recovery rate. This is important especially for developing countries where institutional conditions generally disfavor effective disaster management and where very scarce resources often have to be invested in coping with disasters.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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