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Do Climate Shocks Disadvantage Household Investment in Human Capital in Benin? An Approach Based on the Endogenous Treatment Regression Model

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Abstract

The increasing number of drought and flood shocks in Benin is causing considerable economic losses and social disruption. This article looks specifically at the effects of these shocks on household human capital expenditure in three climatic zones of Benin to highlight the effects specific to each zone. The data used come from the Harmonized Survey of Household Living Conditions. A linear regression model of the endogenous treatment was used for the analyses. The findings indicate that climate shocks reduce household capital expenditure and that this impact depends on the household's climatic zone of residence. Investment in resilient infrastructure, such as water drainage and anti-flood systems, is suggested. The implementation of social and health assistance measures and school subsidies to cushion the impact of climatic shocks on the human capital expenditure of disaster-stricken households. The development and maintenance of an early warning system to anticipate the occurrence of shocks, floods, and droughts would also contribute to mitigation actions.

Keywords: Climate shock, Human capital, Endogenous treatment, Climatic zones, Benin

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Introduction

Human capital is an important element in the socio-economic development process of countries, as it induces productivity gains (Kafando, 2021). Indeed, differences in investment efforts in human capital formation are generally used in the economic literature to explain disparities in wealth levels between countries. Thus, the wealthiest regions are those that have invested massively in human capital, particularly in the health and education of their populations. Investment in human capital helps to build a stock of human resources capable of innovating, adopting new technologies more quickly, taking an active part in the economic growth process, and, above all, increasing the capacity to generate income (Berthélemy, 2008; Unterhalter, 2009, 2012).

The world's economies, especially those of developing countries, are exposed to recurring climatic shocks affecting their capacity to generate income and investment (Hallegatte and Théry, 2007). According to Baez et al. (2010), climate shocks affect education and the health system through the destruction of health centers and schools. Furthermore, Caruso et al. (2023) indicate that manifestations of climate change affect economic systems, markets, and income-generating activities. These, in turn, have consequences for investment and the development of human capital. The ability of households to invest in their education or training and to adapt to climate shocks is affected by the deterioration of health infrastructures as a result of climate shocks. Caruso et al. (2023) showed that human capital plays a vital role in effective mitigation and adaptation to climate shocks. Households with low levels of human capital are more exposed to climate shocks.

Since the work of Schultz (1961), there has been a need to direct substantial resources towards investment in human capital, particularly in developing countries, to strengthen their resilience. Human capital refers to “the set of productive capabilities that an individual acquires through the accumulation of general or specific knowledge, know-how, etc.” (Becker, 1992). It is essentially acquired by investing in education and health. According to classics, individuals contribute to growth through their know-how and cultural and intellectual endowment, acquired mainly through their level of education, which makes them more productive and efficient, improving their output (Lamzihri et al., 2023). Muttarak and Lutz (2014) as well as Kafando (2021) have shown that investment in human capital, particularly in education and health, significantly reduces income inequality and poverty and can reduce vulnerability and improve resilience to natural disasters.

Benin is characterized by three climatic zones and is frequently subjected to climatic shocks. It is the 16th most vulnerable country to climate change (Banque Mondiale, 2023). The main climatic shocks identified in the

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country are drought, floods, violent winds, excessive heat and rising sea levels. Their impacts are very significant and are characterized by the degradation of natural resources, the displacement of populations, coastal erosion and the disruption of economic activities, especially farming, with increasingly heavy economic and social costs (Teka et al., 2022; MCVDD, 2021). In 2010, 620 schools throughout the country were declared flood-affected, including 577 primary and nursery schools and 43 secondary schools. With regard to the state of infrastructure, rapid assessment missions have revealed that approximately 9.8% of public school buildings (all school levels combined) have been affected by flooding (Hountondji, 2022). These various effects can influence the allocation of household economic resources and impact human capital expenditures.

The aim of this article is to assess the impact of climate shocks on household human capital expenditures in Benin. Most of these studies (Lokonon and Mbaye, 2018; Soglo and Nonvide, 2019; Akpa et al., 2024) have highlighted the vulnerability of agriculture-based livelihood systems to climate shocks (Lokonon, 2019) and the effect of climate change on agricultural productivity or yield or income (Hounnou et al., 2019) while obscuring its impact on human capital investment. To fill this gap, this article adopts a climate zone analysis approach that isolates impacts according to the specific characteristics of each zone to determine the effect of drought and flooding on household spending on education and health. To do this, he uses a methodology based on a linear regression model of endogenous treatment and concludes that drought reduces human capital expenditure in the Sudanian and Sudano-Guinean zones but increases it in the Guinean zone. Flooding reduces human capital expenditure in all three climatic zones, although the effect is not significant in the Sudanian zone.

The rest of the article is structured as follows: section 2 reviews the literature on human capital expenditure and the impact of climate shocks on households. Section 3 presents the data used and the methodological approach and section 4 presents the main results. Section 5 summarizes the policy implications of the findings.

Literature review

The concept of human capital (Schultz, 1961; Becker, 1964) postulates that the skills acquired by the individual in the course of his training distinguish him and make him a rare resource (Vignolles, 2013). Marshall (1894) explains that this scarcity is compensated for by the individual's training efforts. Becker (1964) shows that households allocate an investment to their training, making a trade-off between the expected benefits of years of education and the implicit costs: direct costs linked to the financing of training and the opportunity costs arising from the fact that years of training are as

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many years not worked and therefore not paid for the individual. According to Spence (1973), investment in human capital is in fact a way for individuals to signal their abilities to firms rather than increasing them.

Indeed, individuals with certain capabilities find it easier to acquire knowledge. As a result, only the most productive individuals will find it profitable to make this investment. This selection thus serves as a signal of people's abilities (Vignolles, 2013). Beyond being a means for each individual to improve his or her personal economic situation, it is seen as an outcome enabling societies as a whole to be able to capture and use the knowledge and know-how that circulates. As such, any shock that reduces households' ability to spend on human capital would be detrimental to them. The debate on the relationship between climate shocks and human capital has been well-founded in the literature, given the growing number of damaging extreme weather events. Two channels of effect emerge from this debate: direct and indirect.

Direct effects take into account the destruction and depletion of physical and human capital. The destruction of physical capital, such as schools, health centers and household assets, is cited, as is the destruction of human capital, in terms of death, disability, illness and injury (Caruso et al., 2023; Cuaresma, 2010; McDermott, 2011; Sellers and Gray, 2019). Indeed, the direct consequences of climate shocks include injuries and illnesses that prevent people from attending school. In addition, death translates into a loss of previous investments in human capital, and the outbreak of disease or epidemics results from the unhealthy conditions engendered by the shocks. The destruction of physical and human capital increases the marginal cost of acquiring human capital (Baez and De La Fuente, 2010), which deteriorates its future accumulation and, consequently, the social development potential of the affected regions (Amaya, 2020). Floods and droughts have a direct impact on food crops, livestock and, consequently, food security. Climate shocks can also affect people's mental health and well-being (Caruso et al., 2023).

Climate shocks have also been shown to impact the educational achievement of individuals, particularly children. Evidence of the negative impacts of climate shocks is highlighted by Cho (2017). He noted that heat waves reduce performance on university entrance exams. Goodman (2014) further showed that among different groups of students, snowfall can disrupt learning by selectively promoting absenteeism. Peet (2021) also finds in the same vein that climatic shocks affect student performance and labor market outcomes. Psacharopoulos and Patrinos (2018) have shown that schooling is important for individual well-being. The effect of climate shocks on human capital in this case is twofold. The first is schooling, which in turn has an impact on individual well-being.

The indirect effects of climate shocks on human capital are linked to decisions made by households after their occurrence (McDermott, 2012;

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Valencia Amaya, 2020). Indeed, the loss of household assets, as well as health effects (illness or death), which could reduce the time available to generate income, as well as migration and/or evacuation decisions, reduce household income (Baez and De La Fuente, 2010; Cuaresma, 2010; McDermott, 2011). The destruction of infrastructure caused by climate shocks will require investment decisions on the part of households but will be faced with a lack of financial resources. In such a situation, households will be forced to sell productive assets to cope with the shock, trapping themselves in a vicious circle. A reduction in productive assets will diminish their capacity to generate income in the future, increasing their vulnerability to future climate shocks (McDermott, 2011). Consequently, these income shocks will lead households to reduce their investment in human capital accumulation (consumption of food, health services and education) (Caruso et al., 2023; Amaya, 2020).

Drought induces an income effect whereby households with limited means to smooth consumption disinvest in their children's human capital (Joshy, 2019). Similarly, Khalili et al. (2021) showed that households affected by severe drought reduce their health spending more than less-affected households. Food expenditure is also affected by climatic shocks. Drought, for example, has been shown to reduce food consumption by affected households. This jeopardizes their food security and weakens their human capital. Carpena (2019) found that households spend 1% less per person per month on food. However, other findings suggest that people affected by drought and floods see their healthcare expenditure increase significantly due to the deterioration in their health caused by these shocks (Lohmann and Lechtenfeld, 2015).

Empirical studies provide evidence of the direct or indirect effects of climate shocks on human capital. The main point is that this evidence supports the fact that the net effect of direct and indirect impacts is strongly negative and long-lasting. It should also be noted that very few studies have directly addressed the differential effects according to the characteristics of each climatic zone. In this respect, Sherval et al. (2023) indicated that the impact of climatic shocks can vary considerably from one geographical region to another within the same country. To this end, they recommend a region-specific analysis to build resilient communities in the face of today's climatic extremes.

Methods

The data and methodological approaches used to achieve the article's objectives are presented here. The variables used are described, and the estimation technique is presented.

Data

The data used in this study were obtained from the "*Enquête Harmonisée sur les Conditions de Vie des Ménages (EHCVM)*". This is a nationally

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representative survey conducted in two waves, one in 2018 and one in 2019, with financial support from the World Bank and in collaboration with the WAEMU Commission. It is the result of harmonization within the WAEMU, with the same sampling plan being used within each country for data collection. The methodological approach consists of two-stage stratified random sampling. Each region was subdivided into urban and rural parts to form the sampling strata. It provides information on savings, consumption expenditures, food security, production, climate and income shocks, etc. The unit of analysis here is the household. In total, the analysis covered 8012 households across three climatic zones.

Definition of variables

In this article, household investment in human capital is measured by household spending on education and health. It is made up mainly of expenditures on all forms of training (schooling, apprenticeships, education services, etc.) and health care. Climate shocks are essential, in the case of this work, drought and floods, as they are the most recurrent climate shocks experienced by households. The variable is defined as follows :

$$drought = \{ 1: \ if\ the\ household\ is\ affected\ \ 0: \ If\ not$$

$$flood = \{ 1: \ if\ the\ household\ is\ affected\ \ 0: \ If\ not$$

The control variables are described in Table 1.

Table 1: Definition and measurement of control variables

Description	Modalities/Nature	Justification
Age of head of household	Continuous quantitative variable expressed in years	It can have both a positive and a negative effect on human capital expenditure. This is confirmed by the work of Cutler (1998), who shows that changes in disability and mortality trends reduce medical expenditure for elderly individuals.
Sex of head of household	0- Male 1- Female	-
Marital status of head of household	0- Single 1- Married 2- Divorced 3- Widowed	Married heads of household may spend more on human capital, as they often have more dependents.
Level of education	0- No level 1- Primary level 2- Secondary level	An individual's level of education can enhance his or her understanding of human capital issues and therefore influence human capital spending.

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	3- Higher education	Additionally, a higher level of education would require more spending and therefore increase the individual's human capital expenditure.
Household size	Quantitative variable (number of people living in the household)	It can have an impact on the household's human capital expenditure, depending on the presence of children under five (05) years of age and elderly individuals.
Salary income	Continuous quantitative variable expressed in XOF	The level of household income strongly influences household spending and coping strategies.
Place of residence	0- Urban 1- Rural	Residence (urban or rural) is also an important variable in assessing human capital expenditure. Living in an urban environment can help reduce healthcare costs, thanks to the proximity of access to healthcare or education services. Additionally, the availability of sanitary infrastructures, drinking water supply and access to electricity, etc., can reduce the risk of disease.
Well-being	Quantitative variable	Average annual per capita consumption is used to construct this indicator. It takes into account food and nonfood consumption of nondurable goods and services, the use value of durable goods and the imputed rent of owner-occupied households and those housed free of charge, thus reflecting the population's standard of living.

Source: Authors, 2024.

Empirical model and estimation strategies

To analyse the impact of climate shocks on household human capital expenditure, the model below is used in a context where households are faced with drought and/or floods. Let the equation be:

$$HCE_i = \beta_1 + \beta_2 shocks_i + \beta_3 X_i + \varepsilon_i \quad (1)$$

HCE_i denotes the human capital expenditure who includes household spending on education and health of household in a given climate zone. $shocks_i$ refers to drought and flood shocks suffered by households; X_i represents the vector of control variables, mainly household characteristics. ε_i represents the error term. Drought and floods are the most recurrent climatic shocks suffered by Benin households.

Being affected by climatic shocks is not voluntary and may be based on self-selection. In fact, it may depend on certain variables, such as living conditions, living environment, and location. These specificities may influence the probability of being affected by shocks, leading to self-selection. These specificities can influence the probability of being affected by shocks, resulting in inconsistent and biased estimates. Several techniques are used in

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the literature to correct this bias. These include the Heckman selection model (Pham and Talavera, 2018), the propensity score matching method (PSM) (Dutta and Banerjee, 2018; Liu et al., 2021), and the regime-switching model (Assouto and Houngbeme, 2023; Ifecro et al., 2022). These techniques are widely used in the empirical literature to address endogeneity issues.

In this article, we contribute to this rich literature by using a linear regression model with endogenous treatment effects or an endogenous treatment regression model. It uses a linear model for outcomes and a normal distribution and allows a specific correlation structure between unobservable variables affecting treatment and those affecting potential outcomes. Heckman (1978) introduced this model to the modern literature. Maddala (1983) also reviews some empirical applications and describes it as an endogenous switching model. Formally, the endogenous treatment regression model is composed of an equation for the outcome y_j and an equation for the endogenous treatment t_j. Variables X_j are used to model the result. When there are no interactions between t_j and X_j , we have :

$$y_j = X_j\beta + \delta t_j + \epsilon_j \qquad (2)$$

$$t_j = \{1, \quad if\ w_j\gamma + u_j > 0\ 0, \qquad if\ not$$

where w_j are the covariates used to model treatment allocation, and the error terms j and u_j are bivariate normal with zero mean. This model can be generalized to a potential outcome model with separate variance and correlation parameters for treatment and control groups. The generalized model is:

$$y_{0j} = X_j\beta_0 + \delta t_j + \epsilon_{0j}$$

$$y_{1j} = X_j\beta_1 + \delta t_j + \epsilon_{1j} \qquad (3)$$

$$t_j = \{1, \quad if\ w_j\gamma + u_j > 0\ 0, \qquad if\ not$$

where y_{0j} is the result that the household j is not affected by shocks the treatment 0, and y_{1j} if it is affected. It is not observed at the same time y_{0j} and y_{1j} but only one or the other. It is observed :

$$y_j = t_j y_{1j} + (1 - t_j) y_{0j} \qquad (4)$$

When there are no interactions between the treatment variable and the covariates, the model directly estimates the average treatment effect on the treated (ATT) and the average treatment effect (ATE). The model is estimated with the maximum likelihood estimator.

Results

Presentation and descriptive analysis of data

The first stage involved a descriptive analysis of the climate shock variables, and the second analysed the central and dispersion trends in human capital expenditure. The following tables and figures illustrate the results.

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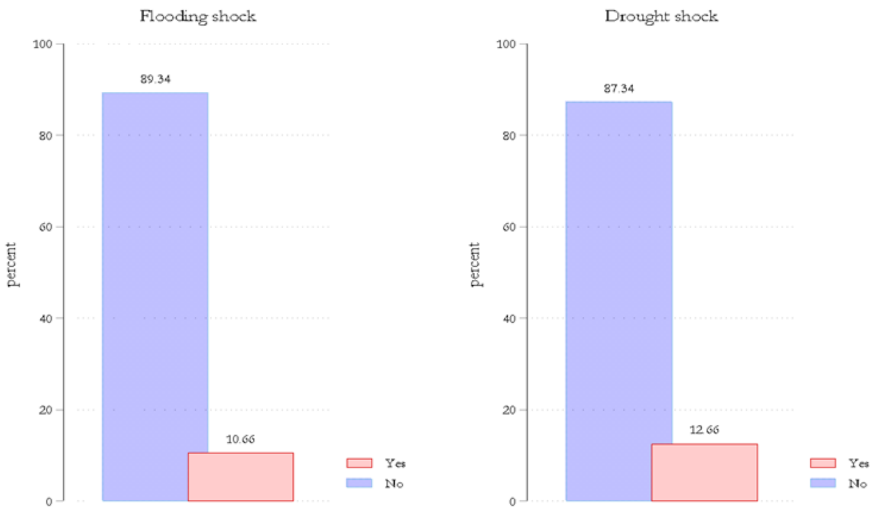
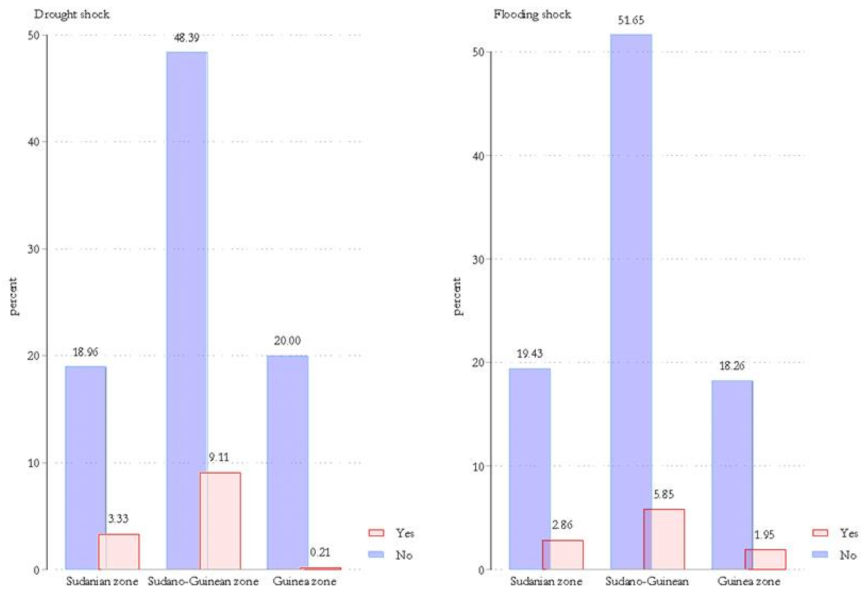
Figure 1: Descriptive statistics for climate shocks



Source: Authors, 2024

Analysis of the graph shows that approximately 10.66% of the households were affected by flooding, compared with 89.34% unaffected households. A significant proportion of households were therefore affected by floods. In addition, households were more affected by drought, as evidenced by the 12.66% of affected households versus 87.34% of unaffected households.

Figure 2: Floods and drought shocks by climatic zone



Source: Authors, 2024

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The graph above shows that the Sudano-Guinean climatic zone (5.85%) is the most affected by floods. This zone is followed by the Sudanian zone (2.86%) and the Guinean zone (1.95%). For drought, the Sudano-Guinean climatic zone (9.11%) was also the most affected. This zone is followed by the Sudanian zone (3.33%) and the Guinean zone (0.21%). The Sudano-Guinean zone is therefore the most affected by climatic shocks.

Table 2 shows that, on average, expenditures on human capital investment in households unaffected by drought and floods are estimated at 20,007.36 XOF and 19,045.919 XOF, respectively. Each drought- and flood-affected household spent an average of 9,356.998 and 15,420.157, respectively, on human capital expenditures (education and health). This shows that households affected by climate shocks spend less on their human capital on average than unaffected households. This pattern is also observed when looking separately at health and education expenditures. These statistics therefore reveal a negative effect of climate shocks on household spending on human capital. The econometric results will enable us to examine this effect in greater depth.

Table 2: Descriptive statistics of human capital expenditure (XOF)

	Floods		**Drought**	
	Mean	**Std.dev**	**Mean**	**Std.dev**
No				
Health expenditure	7 536.442	30 514.709	7 805.886	31 030.002
Education expenditure	11 509.477	48 001.385	12 201.473	49 627.541
Total expenditure on human capital	19 045.919	58 546.844	20 007.36	60 105.810
Yes				
Health expenditure	7 331.457	32 632.124	5 504.261	28 637.125
Education expenditure	8 088.7	33 102.344	3 852.737	11 743.473
Total expenditure on human capital	15 420.157	45 979.711	9 356.998	308 97.862

Source: Authors' calculations, 2024

Econometric analysis and discussion of results

Table 3 shows the regression results considering drought shocks. Analysis of the results in the table shows that drought reduces human capital expenditure in the overall sample, as well as in the Sudanian and Sudano-Guinean zones. The opposite effect is observed in the Guinean zone. The negative effect is more pronounced in the Sudano-Guinean zone, with 31,051.164 XOF, as opposed to 8,446.350 XOF in the Sudanian zone at the 1% threshold. Households in the Sudano-Guinean zone therefore suffer more from the degrading effect of drought on their investment in human capital. The likelihood ratio test (rho) indicates rejection of the null hypothesis of no correlation between drought assignment errors and outcome errors (human

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capital expenditure). A positive sign indicates that unobserved variables that reduce observed human capital expenditure tend to occur with unobservable variables that favour being affected by drought. This reveals that the decline in human capital expenditure can be explained by any parameter that increases the probability of being affected by drought.

The results also reveal that living in a rural area increases the probability of being affected by drought in the Sudanian and Sudano-Guinean zones. This, in turn, would lead to lower capital expenditures. This result makes sense, given that farming is more common in rural areas. Drought would have an impact on agricultural yields and therefore on expected household income. Under these conditions, the decrease in income may explain the decrease in human capital expenditure. This may also be due to the coping strategies adopted by households. Indeed, as a coping strategy, households may take their children out of school or opt for traditional, nonformal health care. This argument is supported by the work of Joshi (2019), which reveals that there is an income effect whereby households with limited means to smooth their consumption disinvest in their children's education in response to drought. The present results are in line with those of Khalili et al. (2021), who showed that drought has a significant negative impact on the health expenditure of mainly agricultural households. They explained that, in response to a severe drought, households are more likely to reduce their spending on human capital, particularly health, than less-affected households are. This would justify the decrease in human capital expenditure observed.

However, the negative sign of rho obtained in the case of the Guinean zone indicates that unobserved variables that increase observed human capital expenditure tend to occur with unobservable variables in which disadvantage is affected by drought. This reveals that the increase in human capital expenditure is explained by all variables decreasing the probability of being affected by drought. This is explained by the fact that the Guinean zone is the most urbanized. As a result, agriculture is not the dominant activity. Exposure to drought is explained by economic well-being and wage income. Less well-off households suffer from drought. The consequence is an increase in their expenditure on human capital, which may be due to spending on health care following the deterioration in their health caused by the drought or to greater investment in education to keep children in school. This result corroborates those of Khalili et al. (2020), who reported that drought-affected households increased their spending on their children's education because this spending was necessary. In the same vein, Lohmann & Lechtenfeld (2015) reported that drought shocks cause a financial burden for many households. These authors explained that drought induces an increase in health expenditures from 9% to 17% of total consumption.

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Table 3: Effect of drought on household spending on human capital[1]

Human capital expenditure	**Global**	**Sudanian zone**	**Sudano-Guinean zone**	**Guinea zone**
Age	285.070***	83.382***	160.418***	569.931***
	(47.170)	(25.339)	(50.269)	(191.502)
Male (ref)				
Female	7 902.810***	-1 254.702	4 615.091*	9 600.972
	(2 467.517)	(2 038.842)	(2 646.749)	(7 931.817)
Household size	384.089*	58.130	391.480	616.178
	(210.366)	(101.523)	(261.923)	(744.090)
None (ref)				
Primary	6 398.905***	2 834.289*	3 222.727***	8 289.062*
	(1 123.876)	(1 461.228)	(1 188.488)	(4 708.944)
Secondary	16 967.523***	8 749.868***	8 324.668***	25 960.075***
	(2 033.007)	(1 627.105)	(1 995.330)	(5 744.707)
Higher	53 041.169***	11 181.894**	35 586.922***	59 532.492***
	(6 444.636)	(5 219.385)	(9 695.479)	(9 989.776)
Single (ref)				
Married	-7 195.732*	-8 177.151**	-6 889.981	-10 616.297
	(4 094.224)	(4 047.185)	(4 779.772)	(9 242.725)
Divorced	-6 182.240	-6 984.527*	-5 986.651	-4 321.281
	(4 689.661)	(3 737.558)	(5 399.062)	(12 179.373)
Widowed	-6 573.333	-5 854.163	-9 501.361*	105.933
	(5 030.825)	(3 827.682)	(4 978.010)	(13 844.704)
Flooding	**- 47 417.336*** **	**- 8 446.350*** **	**- 31 051.164*** **	**135 948.545*** **
	(6 497.866)	(1 381.320)	(6 614.668)	(19 685.033)
Flooding				
Well-being	-0.000***	-0.000***	-0.000***	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Rural	0.433***	0.346***	0.296***	0.118
	(0.038)	(0.083)	(0.047)	(0.101)
Salary income	-0.000***	0.000	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
athrho	0.446***	0.207***	0.383***	-2.721***
	(0.070)	(0.034)	(0.074)	(0.454)
lnsigma	10.954***	9.717***	10.705***	11.481***
	(0.058)	(0.069)	(0.092)	-2.721***
Constant	7 242.714	10 797.182**	12 524.342**	-1 523.210
	(4 723.156)	(4 266.702)	(5 554.626)	(12 133.742)

Robust standard errors in parentheses
*** p<0.01 ** p<0.05 * p<0.1
Source: Authors, 2024.

[1] The table shows the average treatment effect on treated (ATT), which is the same as the average treatment effect (ATE) in this case because the treatment indicator variable did not interact with any of the outcome covariates.

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Like drought, floods have a negative impact on human capital expenditure. Table 4 shows that the flood shock reduced human capital expenditure in all three climatic zones. However, the effect was not significant in the Sudanian zone. The negative effect is more marked in the Guinean zone, amounting to 46,282.635 XOF, as opposed to 19,706.145 XOF in the Sudano-Guinean zone. Households in the Guinean zone therefore suffer more from the degrading effect of flooding on their investment in human capital. Taken together, these results corroborate the trends revealed by the descriptive statistics, which showed that, on average, households affected by drought and flood shocks spend less on their human capital than unaffected households.

Table 4: Effect of floods on household human capital expenditure[2]

Human capital expenditure	Global	Sudanian zone	Sudano-Guinean zone	Guinea zone
Age	252.400***	85.293***	168.767***	693.206***
	(37.085)	(25.639)	(50.874)	(209.452)
Male (ref)				
Female	6 287.393***	-1 228.964	4 260.072	14 053.651
	(1 809.365)	(2 061.053)	(2 686.280)	(8 581.699)
Household size	169.770	36.730	255.904	1 619.531
	(180.568)	(103.091)	(262.830)	(994.498)
None (ref)				
Primary	7 309.973***	2 951.606**	3 608.221***	6 986.012
	(1 104.953)	(1 458.952)	(1 177.451)	(4 572.709)
Secondary	17 309.996***	9 051.640***	9 169.954***	28 211.053***
	(1 606.690)	(1 628.210)	(1 978.863)	(5 911.612)
Higher	48 133.999***	11 613.161**	36 928.195***	67 223.185***
	(5 968.198)	(5 256.511)	(9 614.423)	(10 727.967)
Single (ref)				
Married	-7 101.317**	-8 470.872**	-7 445.980	-13 550.399
	(3 595.880)	(4 047.181)	(4 722.079)	(10 513.524)
Divorced	-5 753.350	-7 177.493*	-6 308.635	-6 440.541
	(3 928.736)	(3 747.248)	(5 415.164)	(14 053.173)
Widowed	-5 300.141	-5 989.607	-9 572.293*	-4 401.452
	(4 070.787)	(3 839.277)	(4 915.835)	(15 521.706)
Flood	**84 193.017*** **	**- 1 729.376**	**- 19 706.145*** **	**- 46 282.635** **
	(4 740.850)	(2 149.874)	(5 701.173)	(19 367.217)
Flood				
Well-being	0.000	0.000	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Rural	0.061***	0.118	0.493***	-0.118

[2] The table shows the average treatment effect on treated (ATT), which is the same as the average treatment effect (ATE) in this case because the treatment indicator variable did not interact with any of the outcome covariates.

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Human capital expenditure	Global	Sudanian zone	Sudano-Guinean zone	Guinea zone
	(0.021)	(0.086)	(0.057)	(0.130)
Salary income	-0.000***	-0.000*	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
athrho	-1.280***	0.061	0.216***	0.284***
	(0.148)	(0.045)	(0.054)	(0.093)
lnsigma	11.024***	9.711***	10.685***	11.479***
	(0.057)	(0.069)	(0.088)	(0.077)
Constant	-4 994.433	10 022.812**	10 183.197*	-5 546.909
	(3 646.638)	(4 236.988)	(5 341.810)	(12 767.835)

Robust standard errors in parentheses
*** p<0.01 ** p<0.05 * p<0.1
Source: Authors, 2024.

To sum up, this article has shown that drought and flood shocks reduce household spending on human capital. Specifically, drought negatively impacts human capital expenditure in the Sudanian and Sudano-Guinean zones but positively impacts human capital expenditure in the Guinean zone. The greatest negative effect is recorded in the Sudano-Guinean zone. This implies that households in the Sudano-Guinean zone suffer more from the degrading effect of drought on their investment in human capital. Floods have a negative impact on human capital expenditure in all three climatic zones, although the effect is not significant in the Sudanian zone. The greatest negative effect is felt in the Guinean zone, implying that households in the Guinean zone suffer more from the degrading effect of floods on their human capital investment. The results also confirm the endogeneity of climate shock variables, thus justifying the method employed**.**

Conclusion

Improving the resilience and well-being of rural households is highly important for achieving the sustainable development goal of building resilience by reducing exposure and vulnerability to climate-related extreme events, as well as to other economic, social and environmental shocks. Given the frequency of climatic extremes, this article examines the impact of climatic shocks on household human capital expenditure across climatic zones based on the context of Benin. It estimates a linear regression model of the endogenous treatment applied to data from the Harmonized Survey of Household Living Conditions.

Analysis of the estimation results shows that drought and floods have a reducing effect on human capital expenditure. A disaggregated analysis according to climatic zone indicates that households in the Sudano-Guinean zone suffer more from the degrading effect of drought on their capacity to invest in human capital, while the effect is more pronounced in the case of

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flooding in the Guinean zone. Based on these results, it would not be an exaggeration to conclude that climate shocks are detrimental to human capital investment, at least in Benin. Several economic policy implications can be formulated to strengthen household resilience for increased investment in human capital.

These include the need for public authorities to invest in resilient infrastructure, such as water drainage and anti-flood infrastructure; to introduce social and health assistance measures and school subsidies to cushion the impact of these shocks on the human capital expenditure of disaster-stricken households; and to develop and maintain an early warning system to anticipate the occurrence of flood and drought shocks. It is also important to map the areas at greatest risk of flooding and drought to develop effective adaptation policies, especially in rural areas where agriculture is the main activity. Furthermore, diversifying households' economic activities to reduce their dependence on agriculture and increase their resilience to climate shocks can mitigate the effect of shocks on their income and, consequently, on their investment in human capital.

This article has a few limitations that are important to highlight. In particular, food expenditures are not taken into account in the analyses. Indeed, food is an important aspect of human capital that contributes to the health dimension. This article could also decompose human capital expenditures to analyse the likely differential effects that might exist. The construction of an index of climatic shocks taking into account households that have suffered several shocks at the same time in the same year would also enable us to determine the extent of the consequences on household investment in human capital. All these aspects represent prospects for future research.

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