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Master's Thesis in Economics

Adolescent Marriage and Rainfall

The Effect of Climate Change in Nepal and Uganda

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Abstract

This paper studies the relationship between the amount of rainfall and the probability of adolescent marriage in two countries where marriage payments are prevalent: dowry in Nepal and bride price in Uganda. Dowry is a marital payment from the bride's family to the groom, whereas bride price is the transfer from the groom to the bride's family. Adolescent marriage is a short-term decision that has long-term consequences, as it often leads to domestic violence, lower educational attainment and early childbearing. We show that an increment of rainfall affect adolescent marriage and that the marital payment decides the sign of the effect. In Nepal, the relationship between rainfall and adolescent marriage is convex, whereas the relationship is concave in Uganda. In addition, the relationship between rainfall and the transition into secondary education is concave in both countries, indicating that the marginal effect of more rainfall is increasing at a decreasing rate.

Supervisor: María Lombardi
Keywords: Adolescent marriage, dowry, bride price, climate change, rainfall, Nepal, Uganda

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Emma Dolderer & Linnéa Frid

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1. INTRODUCTION

The world is already facing the economic effects of climate change in the form of reduced crop yields (Lobell & Field 2007), and the losses are predicted to increase (Sterner 2015). The effect of climate change on agricultural production will differ depending on where in the world the crop is produced, since some regions will experience a negative effect whereas others will experience a positive effect (Costinot, Donaldson and Smith 2012; Piao et al. 2010; Schlenker & Lobell 2010). Additionally, the distribution of global income can become more unequal due to climate change, as it is mainly the already rich regions that benefit, whereas the poor regions are those that will suffer from the changes (Burke, Hsiang & Miguel 2015).

Several studies show that developing countries are more vulnerable to climate changes (see Schelling 1992; Kraemer & Negrila 2014; Burke et al. 2015), as most families in developing countries are dependent on agricultural production (IPCC 2007). Therefore, it is of importance that societies, which strongly depend on agricultural production, adapt to the new geographical conditions. Previous literature has pointed out several different adaptation strategies that people engage in when faced with an income shock, in order to cope with climate change. For example, by taking on insurances, selling off assets, migrating or engaging in a job in the non-agricultural sector (Alem, Maurel & Millock 2016; IPCC 2014). However, a large part of the households in the least developed countries do not have access to credit markets, nor are they able to take on an insurance and they might not even possess any assets to sell off. Therefore, another way that households might adapt is by marrying off their daughters, as child marriage could be seen as a (mal)-adaptation strategy to climate change (Alston, Whittenbury, Haynes & Godden 2014). This is because parents can use marriage as a consumption smoothing mechanism, where the marriage is postponed when the female's parents must pay, and where the marriage is brought forward if her parents receive a payment (Corno, Hildebrandt & Voena 2017).

Previous studies show that early marriages have negative impacts on various aspects of young females' lives, since they are often associated with early childbearing, a higher likelihood of experiencing domestic violence and lower educational attainment (Anukriti & Dasgupta 2017; Kalamar, Lee-Rife & Hindin 2016; Nguyen & Wodon

2015; Nour 2009; Jensen & Thornton 2003). Even though preventative measures have been on the global agenda since the enforcement of the Millennium Development Goals, and now a part of the Sustainable Development Goals (UNFPA 2014), marrying off one's daughter before the age of 18 is still a common practice that violates human rights (UNFPA 2012; Nour 2009; Jensen & Thornton 2003). According to a report by the United Nations Population Fund, 39 000 females around the world are being victims of child marriages every day (UNFPA 2014). The global partnership organisation Girls Not Brides report that the percentage of females aged 20-24 that were married before the age of 18 in 2016 was 45% in South Asia, 39% in Sub-Saharan Africa, 23% in Latin America and 18% in the Middle East and North Africa (Girls Not Brides 2016).

The objective of this study is to investigate if climate change, proxied by the annual amount of rainfall, is a driver of adolescent marriages in the context of Nepal and Uganda. An adolescent is defined as a person aged 10-19 (WHO & UNFPA 2006). The analysis focuses on adolescent females, since females are likely to suffer the most from the effect of climate change, as they often are forced to adapt themselves for the greater good of others (Atkinson & Bruce 2015), and since adolescence is an important period in a female's life where gender roles start to emerge (Swarup, Dankelman, Ahluwalia & Hawrylyshyn 2011). Using survey data from the Demographic and Health Surveys (DHS) Program, together with geospatial covariates from the same source, we estimate a simple linear probability model followed by multiple robustness checks to support the findings. We find that the effect of rainfall on adolescent marriages differ depending on where in the distribution of rainfall the female appears, i.e. we find that there is a convex relationship between rainfall and adolescent marriages in Nepal, and concave relationship in Uganda. This implies that for Nepal, one more decimetre of rainfall decreases marriage probability at low levels of rainfall, whereas at high levels of rainfall, one more decimetre of rainfall increases the probability of marriage. A concave effect size indicates the opposite. This empirical evidence shows that climate change in the form of an increment of rainfall will affect the lives of young females differently, dependent on the traditional marital payment and where in the rainfall distribution she appears. Additionally, we find that an increment in rainfall increases the probability of secondary education at a decreasing rate for adolescent females in both countries.

Drivers of early marriages are poverty, the belief that it will offer the young girl protection (Nour 2009), gender inequality, traditions and social norms (see Muhanguzi, Bantebya & Watson 2017; Raj et al. 2014; Gage 2013), as well as lack of alternative options for young females (Girls Not Brides 2016). Early marriages take place in a marriage market where parents need to find a counterpart in order to marry off their young daughter, and clear the market with the help of marital payments in the form of dowry and bride price (Corno et al. 2017; UNFPA 2012; Jensen & Thornton 2003). Dowry is the economic payment from the bride's family to the groom's family, whereas bride price is when the payment goes in the opposite direction (Jensen & Thornton 2003). Dowries are mostly prevalent in South Asia, whereas bride prices are mostly prevalent in Sub-Saharan Africa (Girls not Brides 2016). In some communities, the size of the marital payment is affected by the age of the female; an older age equals a higher dowry (UNFPA 2012), and respectively a lower bride price (Nour 2009). Dowries hit especially hard on poor families who not seldom must take loans or sell assets in order to pay the groom's family (Alston et al. 2014). Duflo (2012) states that due to shrinking cost of sex identification and abortion, it is cheaper for the parents to abort the female fetus than to raise and marry her having to then endure the cost of the dowry. Furthermore, since the male can demand a higher price if he is well-educated or comes from a high-status family, the parents of the female are unwilling to educate her since education increases the probability that she will marry someone that is equally educated (Maharjan, Karki, Shakya & Aryal 2012). In contrast, Ashraf, Bau, Nunn and Voena (2016) show that the tradition of bride price can have a positive effect on female's educational attainment, since more education leads to a higher bride price.

The two studies closest to ours are conducted by Corno & Voena (2016) and Corno et al. (2017). Corno & Voena (2016) investigate if a negative income shock increases the likelihood of child marriages in Tanzania where bride price is customary. They explore this by developing a simple model to investigate if parents that have no access to credit markets, whilst being exposed to a negative income shock due to rainfall variabilities, have a higher probability of marrying off their daughters at an early age. They find that the practice of bride price in combination with poor credit markets are a key driver of early marriages and that young females whose families are affected by a negative rainfall shock have a higher probability of being married by the age of 18. Building on to the work by Corno & Voena (2016), Corno et al. (2017) conduct a cross-country analysis of more than 400 000 females in Sub-Saharan Africa and India. They find that droughts that decreased the crop yield with 10-15% increased the likelihood of child marriage in bride price countries in Sub-Saharan Africa with 3%, and decreased the probability in the dowry prevalent country India by 4%. Furthermore, they state that the decision to marry off teenage girls is based on both a reaction of short-term changes in aggregate income and traditional norms, as early marriages are being used as a consumption smoothing mechanism. The fact that girls are more vulnerable than boys when the household is hit by an income shock can also be seen in Findley's (1994) qualitative paper, which examines households in Mali[1] that are being exposed to drought. Findley finds that there was an increased number of women that migrated during the drought since they were encouraged to marry earlier than they otherwise might have done. Contrary to the findings by Corno et al. (2017), Alston et al. (2014) find that a negative income shock created by climate changes increases the number of young females being married in the dowry prevalent country Bangladesh, instead of a corresponding decrease. They argue that climate change increases early marriages since the dowry is less expensive the younger the female is, and since the husband-to-be views the dowry as a source of capital accumulation.

Against this background, this study aims to answer the following research question: *Does rainfall affect the probability of marriage for adolescent females in Nepal and Uganda?* By using another approach than Corno & Voena (2016) and Corno et al. (2017), we increase the knowledge in this evolving field of research on marriages as an adaptation strategy to climate change. To our knowledge, no study has investigated the impact of a negative income shock due to weather variabilities on adolescent marriages in Nepal, which makes this another contribution to the field of research. As adolescent marriage is accompanied by negative consequences for young females, we also want to investigate the effect of rainfall on a potential outcome, i.e. educational attainment. Some researchers have examined the relationship between early marriage and education, whereas others have examined the relationship between a negative income shock and education. However, as far as we know, there is none that has investigated the linked relationship between an income shock, early marriage and education. This

[1] According to Corno et al. (2017), the prevalent marriage payment is bride price in Mali.

study attempts to link these three components together by using a constrained sample of unmarried adolescents that are exposed to an income shock.

The remainder of this study is structured as follows. Section 2 discusses the contextual background of chosen countries. Section 3 outlines the economic theory behind the marriage market developed by Becker (1973; 1974), which was further extended to include income shocks by Corno et al. (2017). Section 4 provides the empirical strategy and data, followed by the results in section 5 and additional results in section 6. Section 7 analyses our findings and provides potential policy implications. Finally, section 8 concludes.

2. CONTEXTUAL BACKGROUND

This paper focuses on Nepal and Uganda, two countries on different continents that are both vulnerable to climate change and projected to experience large negative impacts on the agricultural yield as they are heavily dependent on rain fed agriculture (World Bank, 2010). Moreover, both countries have high rates of adolescent marriages but different marital payments on the marriage market. Nepal is located in South-East Asia where approximately 70% of the population work in the agricultural sector (USAID 2017) and where the marital payment is dowry. Uganda, on the other hand, is located in Sub-Saharan Africa, where 70% of the population work in the agricultural sector (USAID 2012a) and where the traditional mean of marriage transaction is bride price. Nepal and Uganda share the 16th place in the international ranking of child marriage rates. Both countries show that approximately 10% of the females aged 20-24 were married or in a union before they turned 15, whereas approximately 40% were married or in a union before they turned 18 (UNICEF 2017).

2.1 Nepal

Nepal is a small landlocked country along the Himalayas, and is one of the poorest countries in the world with 25% of the approximately 29 million inhabitants[2] living in poverty (USAID 2017). The country is divided into three ecological regions, namely the Mountain region around the Nepal-Tibet border, the Hill region in the middle and the Terai region next to the Nepal-Indian border. The three different regions differ both

[2] Accessed 2018-04-03, from: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=NP&view=chart.

with regards to climate (Maharjan et al. 2012), the composition of castes and thus socio-cultural traditions and norms, and the availability of food and health services (Guragain, Paudel, Lim & Choonpradub 2017). Due to its diverse geography, Nepal is vulnerable to climate changes in the form of droughts and floods, extreme temperatures and glacier retreats (USAID 2017; Colom & Pradhan 2013; Shrestha & Aryal 2011). For example, the warming climate has already resulted in rapid shrinking of the majority of glaciers in Nepal, which has had negative effects on the agricultural production (Shrestha & Aryal 2011). Furthermore, as 75% of the agricultural production is rain fed, both the crop and livestock production will be affected by variabilities in the amount of rainfall. These negative shocks could harm the agricultural production and create food insecurity since, for example, the rice yields are very sensitive to climatic conditions (USAID 2017).

Adolescent marriages are both a social problem and a health issue for young females in Nepal, and recent evidence show that females who marry young have a higher risk of being victims of domestic violence (Pandey 2017; Atteraya, Gnawali & Song 2015; Oshiro, Poudyal, Poudel, Jimba & Hokama 2011). Even though the Government of Nepal is working against adolescent marriages, these types of marriages still prevail due to weak law enforcement and cultural norms in the societies (Guragain et al. 2017). The highest rates of adolescent marriages are found amongst the uneducated, underprivileged indigenous groups. Moreover, the practice of giving dowry is prevalent in all parts of Nepal, and in 63% of the cases the parents of the female arrange the marriage (Maharjan et al. 2012).

2.2 Uganda

Uganda is a landlocked country in East Africa with approximately 41.5 million of inhabitants[3]. The country is divided into four different regions, i.e. Central, Eastern, Western and Northern, and the poorest share of the population live in the north (Deininger & Okidi 2003). The climate is tropical and 15% of the total land area is constituted by lakes and swamps (Temple 1971). Furthermore, Uganda struggles with climate changes in the form of rising temperature, water restrainment and an increment in the frequency of droughts and floods (USAID 2012a; Hepworth & Goulden 2008).

[3] Accessed 2018-04-03, from: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=NP-UG&view=chart

These climate changes impact on the agricultural production and thus on the food security in Uganda, since just like rice is climatic sensitive in South-East Asia, maize is a climatic sensitive crop in East Africa, which accounts for a significant share of the food supply in Uganda. Moreover, climate change will not only affect the agricultural population directly via the availability and access of food, but also indirectly via reduced agricultural income (Kikoyo & Nobert 2015; USAID 2012b). Additionally, Uganda has the second highest population growth rate in the world, which further strains on the country's resources (USAID 2012a).

Adolescent marriages are common in Uganda, even though the government is actively working against its prevalence (Muhanguzi et al. 2017). The social norms and attitudes are still gender discriminatory which to a large extent has to do with the high value placed on women's fertility, as well as the traditional socio-cultural expectations of the young female (Bantebya, Muhanguzi & Watson 2014). The tradition of giving bride prices in rural areas of Uganda is still perceived as the norm, though varying by ethnic group, region and culture (Hague, Thiara & Turner 2011). Additionally, given the fact that the bride's family receives a marital payment upon marriage, young females are seen as a source of economic security (Rubin et al. 2009; Sekiwunga & Whyte 2009).

3. THEORETICAL FRAMEWORK

This section presents the theoretical framework, i.e. the theory of marriage market developed by Becker (1973; 1974) and extended by Corno et al. (2017). With the predictions of this theory in mind, we will empirically test if adolescent marriages increase or decrease as a response to climate change. One of the main differences between early marriages, and other more known adaptation strategies, is that marriage is a mutual decision between two individuals or families.

3.1 The Marriage Market

We position our theoretical framework within the marriage market theory developed by Becker (1973; 1974). The marriage market consists of a fixed number of men and women (or families), and in the simplest version of the marriage market theory, the females and males are assumed to be identical. The individuals can choose between marriage and remaining single, and the decision to marry is only made if both spouses (or both families) gain a higher utility by marriage. Thus, the theory is based on two basic assumptions, i.e. that the individuals (or family) maximize their utility and that the market is in equilibrium. Furthermore, marriage is seen as the most beneficial decision for the spouses (or their parents) in comparison to remaining single, since a marriage enables the spouses to be more efficient in both the household and on the labour market. This model is further extended to include men and females with different qualities. This lead high-quality men to be matched with high-quality females, and low-quality men to be matched with low-quality females, and no person can get better off by changing spouses. However, Becker further points out that this model is still insufficient since both the perception of what makes up a high or a low quality differs between cultures, and since the social norms surrounding the marriage (e.g. marriage payments, divorce and polygamy) differ between societies and changes over time.

In many developing countries, the supply side consists of parents who have several underlying economic incentives to marry off their daughters; either as a safety net, a mean to ease the economic burden of raising a daughter, settling familial debts or enabling new alliances (UNFPA 2012; Nour 2009; Jensen & Thornton 2003). The demand side consists of the groom and his family who may prefer younger brides, as they have longer reproductive lives. Thus, the demand for young brides will be higher in communities where high fertility is desired. Additionally, young brides could be preferred since their young age makes them easier to control and increases their likelihood of being virgins (Jensen & Thornton 2003).

Due to the prevalence of marital payments on the marriage market, Corno et al. (2017) are able to extend the basic model by Becker (1973; 1974) to a simple equilibrium model, by adding negative income shocks (e.g. poor yield or natural disasters). By incorporating this, they can investigate how aggregated income fluctuations affect the probability of early marriages. They argue that parents will use marriages as a consumption smoothing mechanism, since the negative income shock affects the probability of the bride's parent's willingness to marry off their daughter and the groom's family's willingness to accept a new family member. They further assume that there is a pool with a fixed number of daughters and sons, and that females live in two time periods (i.e. childhood and adulthood), and males in one (i.e. young adulthood, since they usually are older than the female at the time of marriage). They set up a model where the aggregated income of the household consists of the income from the agricultural yield y_t (i.e. depending on the weather), household specific characteristics $\epsilon_{i,t}$ and the workforce of the family's adult children, represented by w^f for females and w^m for males. Thus, the total income of household i with a daughter is represented by $y_t + \epsilon_{i,t} + w^f$, and $y_t + \epsilon_{i,t} + w^m$ for a household with a son. Following Boserup's (1970) hypothesis that females could be seen as either a contributor or a burden to the household (as historically, females' agricultural productivity were dependent on the tools used to farm the land), w^f can be either positive or negative. In Africa, societies used light tool which made it possible for females to contribute to the agricultural production, whereas in Asia, societies used the heavy plough technology, which made the females unable to contribute to the family's income. Therefore, female labour is more valuable in Africa, then in Asia. On the other hand, w^m is always a positive contribution to the household's total income. Corno et al. (2017) further argue that the differences in the female's ability to contribute to the family's total income, is the underlying channel for the variation of marital payments across countries. Thus, societies were $w^f > 0$ have bride price as their marital payment, and societies with $w^f < 0$ have dowry. They further assume that societies are virilocal, i.e. that the wife moves to live with her husband's family after marriage and contributes to his family's aggregated income.

The changes in the probabilities of early marriages are also dependent on the fact that the groom's family value future payments of marriages less, given a sufficiently large w^m (as they can rely on their son even after he is married, whilst the bride's family is less likely to rely on their daughter's support once she is married). This indicates that the changes in the equilibrium quantities of early marriages, that the variation in income onsets, are more reflective of the bride's family's decision to marry off their daughter, than the groom's family's decision. Moreover, they theorise that when a society is hit by a negative income shock, the size of the payment will fall independent on marital practice. Thus, Corno et al. (2017) assume that in societies where dowries are prevalent, the supply of brides is increasing with aggregated income and with lower dowry. However, the demand for brides is decreasing with aggregated income and when the payment decreases. Thus, in societies where dowries prevail, a negative income shock is assumed to decrease the probability of young marriages, since the bride's family will postpone the marriage in order to consume the marital payment. Societies where bride prices are customary are assumed to respond in the opposite direction. The supply of brides decreases with aggregated income, but increases when the payment increases, and the demand for brides increases with aggregated income and decreases when the payment increases. Therefore, Corno et al. (2017) theorise that when the bride's family is faced with a tighter budget constraint, the probability of early marriages will increase in societies where bride price is prevalent.

We assume that an increment in rainfall is a positive income shock at low levels of rainfall, but a negative income shock at high levels of rainfall, as the agricultural dependent populations in Nepal and Uganda are sensitive to both droughts and flooding. Thus, we hypothesise that a negative income shock decreases the probability of adolescent marriages in Nepal (i.e. dowry), but increases the probability in Uganda (i.e. bride price). Furthermore, we hypothesise that a positive income shock will have the opposite effect in both countries.

4. EMPIRICAL STRATEGY AND DATA

This section presents the empirical strategy and data. The dependent variable is a binary variable representing the marital status of an adolescent female at time *t* (i.e. at survey year), whereas the independent variable is a continuous variable representing the annual amount of rainfall at time t-1. We use both the annual amount of rainfall and its quadratic specification, as either too little or too much rainfall will negatively affect the yield (Lobell & Field 2007). By investigating the variation in rainfall across the entire distribution instead of a specific weather shock, we add to the existing literature and we are thereby able to increase the understanding of how climate change affects the probability of adolescent marriage. Table 1 and Table 2 show descriptive statistics for the main variables of interest.

4.1 Empirical Strategy

The dependent variable, $married$, is a binary variable where $married_{i,t} = 1$ if female i is married at time t, and where $married_{i,t} = 0$ if otherwise. Following the recommendation by the DHS Program, we first need to identify the survey design characteristics using the *svyset* command and then prefix the estimation command with *svy:* in Stata[4]. By using this prefix command, we take sampling weights, cluster sampling and stratification into consideration, which we must do in order to compute the right standard errors when using survey data. Furthermore, the *svy:* command computes robust standard errors by default.

The baseline regression specification estimates the likelihood of adolescent marriages, as dependent on annual amount of rainfall:

$$married_{i,t} = \beta_0 + \beta_1 rainfall_{i,t-1} + \beta_2 rainfall^2_{i,t-1} + \beta_3 age_{i,t} + \beta_4 rural_{i,t} + \beta_5 \phi + \beta_6 \gamma + \varepsilon_{i,t}$$

where ϕ represents regional fixed effects and γ represents year fixed effects, which are added to control for time-, and region invariant characteristics. $\varepsilon_{i,t}$ is the composite error term consisting of c_i and $u_{i,t}$, where c_i captures the unobserved individual heterogeneity and $u_{i,t}$ is a normally distributed random error term. Thereafter, we extend our baseline model by including control variables one by one:

$$married_{i,t} = \beta_0 + \beta_1 rainfall_{i,t-1} + \beta_2 rainfall^2_{i,t-1} + \beta_3 age_{i,t} + \beta_4 rural_{i,t} + \beta_5 \boldsymbol{X}_{i,t} + \beta_6 \phi + \beta_7 \gamma + \varepsilon_{i,t}$$

where $\boldsymbol{X}_{i,t}$ is a vector consisting of: religion dummies, wealth dummies, dummy for high drought risk, dummy for growing season length, proximity to water, and three different interaction terms between the rainfall variables and religion dummies, a dummy for young cohort and finally, urban areas. The coefficients of interest are β_1 and β_2, and $\beta_1 + (\beta_2 \times rainfall)$ measures the impact of rainfall within regions, keeping our controls constant. A drawback with our empirical strategy is that within regions, we still might compare places that on average have different levels of rainfall. The potential differences in average rainfall might result in different baseline rates of adolescent marriages. Therefore, as a robustness check, we include cluster fixed effects in all of our regressions, even though some clusters consist of few observations.

[4] For more information, see https://www.stata.com/manuals13/svy.pdf.

4.2 Data Sources and Description

A. Geographical Data

Using rainfall as a proxy for climate change is a common approach (see Gentle et al. 2018; Corno et al. 2017; Alem et al. 2016; Dahal et al. 2016; Lobell & Field 2007). As researchers have established that there is a relationship between climate change and agricultural production in Nepal (Mainali & Pricope 2017; Sherestha & Aryal 2011) and Sub-Saharan Africa (Müller, Cramer, Hare & Lotze-Campen 2011; Schlenker & Lobell 2010; Challinor, Wheeler, Garforth, Craufurd & Kassam 2007), we feel confident to use variation in rainfall as our independent variable. Especially since lower agricultural output leads to lower agricultural income due to high agricultural dependency in these countries. Additionally, since the amount of rainfall is an exogenous shock, we argue that it is this highly unlikely that this variable is affected by the error term.

The geospatial covariates[5] used in this paper are provided by the Demographic and Health Surveys (DHS) Program[6], and are originally collected from the Climate Hazards Group (2017), Center for Hazard and Risk Research (2005), Food and Agriculture Organization (2007) and Wessel & Smith (2017). The geospatial covariates consist of data over the annual amount of rainfall every fifth year from 1985-2015, and other environmental factors such as drought episodes, proximity to water and the length of the growing season. This study uses rainfall data from the years 2000, 2005 and 2010. As seen in Table 1 and Table 2, descriptive statistics imply that there is variation in rainfall in the sample. This enables us to investigate the probability of being married at time *t*, given the annual amount of rainfall at time *t*-1. As Gentle and Maraseni (2012) show that rural communities respond to short-term weather-related shocks immediately, rather than as a planned initiative, we argue that we are able to observe the effect that rainfall has on adolescent marriages. Thus, we observe how families respond to variation in rainfall and can therefore shed more light on early marriages as a potential adaptation strategy to climate change.

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[5] For more information, see https://spatialdata.dhsprogram.com/methodology/#GEOSPATIAL%20COVARIATES.

[6] For more information, see https://dhsprogram.com/Who-We-Are/About-Us.cfm and https://dhsprogram.com/What-We-Do/Survey-Types/DHS.cfm.

The rainfall variables are measured in decimetres on a cluster level with a radius of 2 kilometres in urban areas and up to 10 kilometres in rural areas. There are 317 number of clusters matched with the geospatial covariates for Nepal and 837 for Uganda. Including a quadratic term in our specification allows for the relation between rainfall and the probability of marriage to be non-linear (i.e. enables a U- or inverted U-shape), which indicates that an increment of rainfall at low levels may positively affect agricultural production, whereas the same increment may have a negative effect in areas where there usually are high amounts of rainfall (Maertens 2016). A limitation with our rainfall variables is that the DHS does not provide annual rainfall data for every year, but just every fifth year. This limits our analysis since we are unable to construct a rainfall shock as either a drought or a flood, based on a deviation from the average annual rainfall in a specific area, which is a common approach in the literature investigating various relationships between rainfall and socioeconomic indicators (Corno et al. 2017; Burke, Gong & Jones 2015; Alem et al. 2016). This further means that we cannot determine if the chosen years are considered normal or if they are anomalies.

Furthermore, individuals that live in more climate sensitive locations might react to weather variations differently than individuals that do not live in environmentally risky areas. We control for this by including three different variables that reflect the environmental riskiness in a specific cluster. The first variable that we include is provided by Hazard and Risk Research (2005) and measures a particular area's historical risk of being exposed to an average number of droughts based on precipitation data from 1980-2000. This categorical variable ranges from 1 to 10, where 1 represents low drought and 10 represents high drought. Using this information, we construct a binary variable called high drought risk, where the threshold is > 6. Thus, this variable reflects how prone a specific area is of being exposed to droughts. Moreover, it is important to understand the patterns and changes in growing season length (Oguntunde, Lischeid, Abiodun, & Dietrich 2014). Ecosystems with longer growing seasons could indicate that the area is more vulnerable to seasonal drought and aridity (Oguntunde et al. 2014; Berdanier & Klein 2011) whereas shorter growing season days are often accompanied by higher rainfall intensity which could cause flooding and damage the crop (Oguntunde et al. 2014). Therefore, the second variable included, provided by the Food and Agriculture Organization (2007), measures the length of the growing season, based on data collected from 1961-1991. This categorical variable ranges from 1 to 16, where 1 represents 0 days and 16 represents > 365 days. Using this information, we construct a binary variable for each category. Lastly, the third variable is provided by Wessel & Smith (2017) and measures the straight line distance, in kilometres, to the nearest major water body in year 2017. We include this variable since individuals living closer to major water bodies have higher risk of being exposed to flooding (Boyce et al. 2016). As seen in Table 1 and Table 2, descriptive statistics imply that there is variation in these geographical variables.

B. Data on Marital Status

Most contributors to the existing literature on early female marriages have used data from the DHS Program (see Corno et al. 2017; Pandey 2017; Atteraya et al. 2015; Raj et al. 2014; Lloyd & Mensch 2008; Jensen & Thornton 2003), which surveys several countries around the world. The DHS Program is funded by the U.S. Agency for International Development (USAID) and collects data on various issues such as health and socioeconomic topics. Each standard DHS survey collects data from approximately 5 000 to 30 000 households by using a two-stage stratified cluster sampling method in order to receive a nationally representative sample. Our datasets consist of individual women's data, which has one record for every eligible woman in the surveyed household, aged 15-49. Our analysis covers two survey rounds for Nepal (i.e. NDHS 2006 and 2011) and three survey rounds from Uganda (i.e. UDHS 2001, 2006 and 2011). We choose to use the individual women's survey data and not the household level data (which is also available from the DHS), since we cannot separate the surveyed household from being the female's former (before marriage) or new household (after marriage).

Our dependent variable is a binary variable, representing whether an adolescent female is married at time *t*. All females aged 15-49 were asked their current marital status (i.e. "currently married"[7], "formerly married" or "never married"), and by combining "currently married" and "formerly married", we created a new binary variable called *ever married*. As we have DHS survey data from the years 2001, 2006 and 2011, and rainfall data from the years 2000, 2005 and 2010, we restrict the sample to only include

[7] "Currently married" includes females that formally are not married, but responded "living together" with their partner.

females below the age of 21 at the survey period time *t*, who reported their marital status to be "never married" two years prior to the survey period (i.e. at time *t*-2). Thus, we drop approximately 23% of the females below age 21 in Nepal and approximately 21% of the females below age 21 in Uganda, since they were married two years prior to the survey. By restricting our estimation sample this way, we are able to see if annual amount of rainfall increases or decreases the probability for female teenagers aged 13-19 (at time *t*-2) to be married at time *t*. Thereafter, we created a binary variable called *married*, where being married is denoted by 1 and being unmarried is denoted by 0. The size of our estimation sample is 5 235 observations in Nepal and 8 081 observations in Uganda. Approximately, 20% of the females are married at time *t* in Nepal, whereas 18% are married in Uganda.

A drawback with the DHS surveys is that they only report the female's location at time *t*, but not the female's location at time *t*-2 (i.e. when she is unmarried). Furthermore, they do not provide us with information regarding if she migrated upon marriage, nor the potential distance from her natal home to her new home. This may lead to measurement errors in our rainfall variables, since, recalling our theoretical framework, we assume virilocality and the new place the female resides in may be far away and thus different from the environmental setting in which she got married. However, Corno et al. (2017) show that 77% of the females in Sub-Saharan Africa do not move at the time of marriage and if they do, they do not move far away from their natal home. The fact that the female does not move far away from her natal home to live with her husband's family is also supported by Mbaye and Wagner (2017) who investigate the marriage market in Senegal, and Bohra and Massey (2009) who investigate internal migration pattern in Nepal and find that women move only locally upon marriage due to virilocality. Overall, marriage migration does not appear to be a major threat to our identification strategy and we conclude that the likelihood that marriage migration will bias our estimates is small. A minor drawback with the DHS dataset is that the youngest females in the surveys are 15 years old, whereas most studies focuses on marriage starting from age 10. This indicates that the lowest age of first marriage we will be able to detect is 14, which might be problematic since the most vulnerable females may already be married. Nevertheless, approximately 93% of the married females in Nepal were married at age 14 or older, whereas 91% of the married females in Uganda were married at age 14 or older (see Figure 1-4 in Appendix 1).

C. Other Country Characteristics and Interaction Terms

The remaining data are provided by the country specific DHS surveys. Age is a continuous variable that we control for to improve the precision of our estimates. As females living in rural areas are more likely to marry as a child, than those living in urban areas (UNICEF 2014), it is important to control for the environment in which the female resides in. Besides, we further hypothesise that an individual living in a rural area will be more affected by the rainfall variation than an individual living in an urban area, since the agricultural outcome (i.e. the household's aggregated income) will be affected. Therefore, we include the dummy variable rural, which takes the value 1 if the female lives in a rural area and 0 if she lives in an urban area. Additionally, we include region fixed effects as we want to control for regional characteristics that might influence the likelihood of being married, since different regions have different marriages rates and rainfall patterns. There are three regions in Nepal and four in Uganda. As seen in Table 1 and Table 2, descriptive statistics show that approximately 85% in the Nepal sample live in a rural area, whereas 78% live in a rural area in Uganda. Furthermore, to increase the precision of our estimates we control for religion, as there is evidence that the prevalence of young marriages varies between different religions (see: Wodon, Nguyen & Tsimpo 2016; Prabhuswamy 2015; Aryal 1991). As seen in Table 1 and 2, 85% of the females belong to Hinduism in Nepal, which makes this the major religion. In Uganda, the major religion is Christianity where 45% are Protestants and 40% are Catholics. Lastly, the average years of education is on average approximately 6.5 years in both countries, and the average years of education is roughly the same for the female and her husband (the male has to some extent a higher average). However, we cannot include the female's educational level in our regression analysis, since the data provided is at time t and not at time t-2. If we would include this variable, our results would be biased since rainfall shocks could impact on the educational level.

Interaction terms are included to investigate the effect of rainfall given a particular characteristic, since some groups might be more sensitive to an income shock. We construct interaction terms with our two rainfall variables and religion dummies to examine the additional effect of belonging to a specific religion and being exposed to the variation in rainfall. We further include interaction terms with our rainfall variables and a dummy variable for being young (defined as 1 if the female is under 18 at time t and 0 otherwise), to see the additional effect of belonging to a specific cohort and being exposed to the variation in rainfall. Finally, interaction terms with our rainfall variables and a dummy that indicates if the female lives in an urban area are included. This interaction term is a test to investigate if our results are driven by the urban population in our sample. As females belonging to the poorest quintile on average are more likely to marry as a child compared to those in the wealthiest quintile (UNICEF 2014), we control for wealth in regression specification three. A limitation with this variable is that it is a relative measurement (i.e. compared to how wealthy other inhabitants are) and not an absolute measurement of wealth. Additionally, we do not have information on which wealth quintile the female belongs to prior to marriage, i.e. at time *t*-2, but only at time *t*. Nevertheless, we argue that this is a small limitation and that this variable still provides an indication of the wealth quintile at time *t*-2, since we hypothesize that most females marry someone within the same quintile, and that the weather variation will not "push" a household from a wealth quintile to another in the short run.

A drawback that limits our analysis is that we cannot use the background characteristics of the household, since the DHS survey do not provide us with information regarding if the family lives off agricultural income, the parents' educational attainment, the size of the household, or whether the female hold an insurance, and since we cannot separate between if it is the female's natal or new home that owns the agricultural land, or other assets such as cattle and electricity. We are also unable to compare different adaptations strategies that a household might use to adapt to climate changes, e.g. migration or working in the non-agricultural sector. Furthermore, it would have been useful to include if there had been any exchanges of bride price or dowry at the time of marriage, in order to directly investigate how this channel influences the prevalence of adolescent marriages.

TABLE 1
Descriptive Statistics - Nepal

Variable	Observations	Mean	Standard Deviation	Min	Max
Marriage Characteristics					
Age	5 235	17.225	1.759	15	21
Married	5 235	0.201	0.401	0	1
Age at marriage	1 022	16.886	1.418	14	19
Married <15	5 235	0.010	0.101	0	1
Married <18	5 235	0.132	0.338	0	1
Geographical Characteristics					
Rainfall in dm, *t*-1	5 235	15.140	3.628	7.083	30.22
Rainfall^2 in dm, *t*-1	5 235	242.375	123.469	50.165	913.248
Drought episodes	5 229	5.098	0.872	4	7
Growing season	5 235	9.706	1.395	1	12
Proximity to water	5 235	176.971	41.775	64.233	275.448
Other Country Characteristics					
Rural area	5 235	0.846	0.361	0	1
Region					
Mountain	5 235	0.064	0.244	0	1
Hill	5 235	0.419	0.493	0	1
Terai	5 235	0.517	0.500	0	1
Religion					
Hindu	5 235	0.850	0.358	0	1
Buddhist	5 235	0.087	0.282	0	1
Muslim	5 235	0.033	0.180	0	1
Christian	5 235	0.014	0.116	0	1
Kirat	5 235	0.016	0.127	0	1
Years of education	5 235	6.651	3.486	0	14
Husband's years of education	1 019	6.749	3.497	0	14

Note: Drought episodes is a categorical variable ranging from 1-10, where 1 indicates low drought and 10 indicates high drought. Our sample contains category 4-7 and the average number of drought episodes are approximately 5. The length of the growing season is divided into 16 categories, where 1 indicates 0 days and 16 indicates > 365 days. Our sample contains category 1-12, i.e. 0-329 days and the average number of growing days are approximately in the span between 210-239 days (i.e. 9th category) and 240-269 days (i.e. 10th category). Proximity to water measures the straight line distance, in kilometre, to the nearest major water body. All measures are obtained using individual weights as is recommended by the DHS.

TABLE 2
Descriptive Statistics - Uganda

	Observations	Mean	Standard Deviation	Min	Max
Marriage Characteristics					
Age	8 081	17.230	1.794	15	21
Married	8 081	0.178	0.382	0	1
Age at marriage	1 383	17.279	1.293	14	19
Married < 15	8 081	0.003	0.055	0	1
Married < 18	8 081	0.092	0.270	0	1
Geographical Characteristics					
Rainfall in dm, *t*-1	7 595	12.618	2.200	5.438	20.791
Rainfall^2 in dm, *t*-1	7 595	164.061	57.118	29.572	432.259
Drought episodes	2 793	1.338	0.935	1	4
Growing season	7 626	12.093	1.570	6	15
Proximity to water	7 626	38.021	33.624	0	218.980
Other Country Characteristics					
Rural area	8 081	0.783	0.412	0	1
Region					
Central	8 081	0.328	0.469	0	1
Eastern	8 081	0.232	0.422	0	1
Northern	8 081	0.440	0.496	0	1
Religion					
Protestant	8 081	0.452	0.498	0	1
Catholic	8 081	0.399	0.490	0	1
Muslim	8 081	0.127	0.333	0	1
Years of education	8 080	6.541	3.000	0	17
Husband's years of education	1 327	7.209	3.523	0	17

Note: Drought episodes is a categorical variable ranging from 1-10, where 1 indicates low drought and 10 indicates high drought. Our sample contains category 1-4 and the average number of drought episodes are approximately 1. The length of the growing season is divided into 16 categories, where 1 indicates 0 days and 16 indicates > 365 days. Our sample contains category 6-15, i.e. 120-365 days and the average number of growing days are approximately in the span between 300-329 days (i.e. 12th category). Proximity to water measures the straight line distance, in kilometres, to the nearest major water body. The variable indicating religion is divided into four different groups, i.e. Protestant, Catholic, Muslim and "Other". However, we exclude those who reported "Other" which represent 2.2% of the total sample. All measures are obtained using individual weights as is recommended by the DHS.

5. RESULTS

To estimate the relationship between adolescent marriages at time *t* and climate change, proxied by the annual amount of rainfall at time *t*-1, we begin with a simple baseline specification where only the age of the female and regional characteristics such as urban/rural environment are included. Thereafter, we build onto the baseline specification by controlling for individual specific characteristics such as religion and wealth, and other geographical measurement (i.e. high drought risk, number of growing days and proximity to water). Interaction terms are added to investigate the additional effect of being both exposed to the rainfall and belonging to a specific religion; or belonging to the younger segment of adolescents; or living in an urban area, in order to ensure that the results are only being driven by the rural population. All regressions include the age of the female, if the female lives in a rural or urban area and regional- and time fixed effects.

5.1 Comparison of OLS, Probit and Logit

As our dependent variable is binary, we need to investigate which regression model is the most suitable for our estimation analysis. Therefore, the baseline specification is estimated by three different regression models: an Ordinary Least Square (OLS), i.e. a Linear Probability Model (LPM), a Probit and a Logit model. As seen in Table 3, the obtained estimates are nearly identical across the different regression models. Moreover, there are no variables that are non-linear in parameters included in any regression specifications. We can therefore conclude that it does not matter which regression model we chose when performing our regression analysis. Thus, we restrict our attention to the linear specifications as it is simple to interpret, and as seen in the tables below, often predicts roughly the same results as the Probit and Logit models. A drawback with this regression model is that it can take illogical values and that the marginal effect is the same throughout the spectrum.

As seen in Table 3, the baseline specification (OLS) shows that the coefficient of interest, i.e. *rainfall*, has a negative effect on our dependent variable in Nepal, but a positive effect in Uganda. The results are significant at the 1% level and at the 10% level respectively. The quadratic effect of rainfall, i.e. $rainfall^2$, has a positive significant effect at the 5% significance level on our dependent variable in Nepal, whereas it has an insignificant negative effect in Uganda. This indicates that we have a convex relationship between rainfall and the probability of being married as an adolescent in Nepal, and a concave relationship in Uganda. Moreover, we find that both age and rural residence have a positive effect on the probability of adolescent marriage in Nepal and Uganda.

TABLE 3
Comparison of OLS, Probit and Logit
Dependent Variable: Marital Status, *t*

	Nepal			Uganda		
	OLS	Probit	Logit	OLS	Probit	Logit
Explanatory Variable	(1)	(1)	(1)	(1)	(1)	(1)
Rainfall in dm, *t*-1	-0.034***	-0.032***	-0.032**	0.031*	0.035*	0.033*
	(0.012)	(0.012)	(0.012)	(0.019)	(0.019)	(0.019)
Rainfall^2 in dm, *t*-1	0.001**	0.001**	0.001*	-0.001	-0.001*	-0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Age	0.040***	0.040***	0.039***	0.062***	0.060***	0.057***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
Rural	0.107***	0.117***	0.119***	0.079***	0.081***	0.085***
	(0.017)	(0.020)	(0.021)	(0.018)	(0.020)	(0.022)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.043			0.093		
Observations	5 235	5 235	5 235	7 595	7 595	7 595

Note: The dependent variable is a binary variable called *married* that takes the value 1 if the adolescent female is married at time *t*, but unmarried at *t*-2, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. Marginal Probit and Logit effects are evaluated at explanatory variable mean values. 2006 is the baseline year for Nepal and 2000 is the baseline year for Uganda. Regional- and time fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.2 Regression with Control Variables and the Effect Size

As seen in the second column in Table 4 and Table 5, the baseline specification is run with religion dummies (i.e. the second specification). The size and significance level of the estimates of the rainfall variables stays roughly the same for both Nepal and Uganda. Age and rural residence has still a positive effect in both countries. Additionally, females in Nepal who practise either Buddhism or Kiratism have a lower probability of adolescent marriage, whereas females belonging to Islam have a higher probability compared to Hindus. In Uganda, we find that Catholic and Muslim females have a higher probability of adolescent marriage than Protestant females.

TABLE 4
Regression with Controls – Nepal
Dependent Variable: Marital Status, *t*

	Ordinary Least Squares			
Explanatory Variable	(1)	(2)	(3)	(4)
Rainfall in dm, *t*-1	-0.034***	-0.031***	-0.030**	-0.031**
	(0.012)	(0.012)	(0.012)	(0.012)
Rainfall^2 in dm, *t*-1	0.001**	0.001**	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.040***	0.040***	0.043***	0.043***
	(0.004)	(0.004)	(0.004)	(0.004)
Rural	0.107***	0.106***	0.024	0.022
	(0.017)	(0.016)	(0.016)	(0.016)
Buddhist		-0.054***	-0.052***	-0.052**
		(0.020)	(0.019)	(0.020)
Muslim		0.100*	0.084	0.089
		(0.055)	(0.056)	(0.055)
Kirat		-0.119***	-0.112***	-0.126***
		(0.038)	(0.038)	(0.039)
Christian		-0.002	0.011	(0.011)
		(0.054)	(0.049)	(0.48)
Poorer			-0.001	0.004
			(0.023)	(0.023)
Middle			0.001	0.007
			(0.025)	(0.025)
Richer			-0.078***	-0.077***
			(0.023)	(0.024)
Richest			-0.155***	-0.151***
			(0.022)	(0.024)
Regional FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
High Drought Risk	No	No	No	Yes
Growing Season Length	No	No	No	Yes
Proximity to Water	No	No	No	Yes
R^2	0.043	0.048	0.065	0.068
Observations	5 235	5 235	5 235	5 235

Note: The dependent variable is a binary variable called *married* that takes the value 1 if the adolescent female is married at time *t*, but unmarried at *t*-2, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. 2006 serves as the baseline year, Hindu is the baseline religion and the poorest quintile is the baseline wealth quintile. High drought risk is a binary variable based on the variable drought episodes, which is a categorical variable ranging from 1-10, where 1 indicates low drought and 10 indicates high drought. The threshold for high drought risk is > 6. The length of the growing season is a binary variable divided into 16 categories, where 1 indicates 0 days and 16 indicates > 365 days. Proximity to water measures the straight line distance, in kilometres, to the nearest major water body. Regional- and time fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 5
Regression with Controls – Uganda
Dependent Variable: Marital Status, *t*

	Ordinary Least Squares			
Explanatory Variable	(1)	(2)	(3)	(4)
Rainfall in dm, *t*-1	0.031*	0.035*	0.060***	0.050*
	(0.019)	(0.019)	(0.020)	(0.29)
Rainfall^2 in dm, *t*-1	-0.001	-0.001	-0.002***	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Age	0.062***	0.062***	0.062***	0.062***
	(0.004)	(0.004)	(0.004)	(0.004)
Rural	0.079***	0.081***	0.004	-0.003
	(0.018)	(0.018)	(0.022)	(0.022)
Catholic		0.050***	0.031*	0.030*
		(0.015)	(0.018)	(0.018)
Muslim		0.048**	0.044*	0.041*
		(0.021)	(0.024)	(0.024)
Poorer			-0.063**	-0.064**
			(0.029)	(0.029)
Middle			-0.135***	-0.131***
			(0.031)	(0.032)
Richer			-0.175***	-0.172***
			(0.027)	(0.029)
Richest			-0.237***	-0.227***
			(0.029)	(0.031)
Regional FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Growing Season Length	No	No	No	Yes
Proximity to Water	No	No	No	Yes
R^2	0.093	0.097	0.128	0.132
Observations	7 595	7 595	6 134	6 134

Note: The dependent variable is a binary variable called *married* that takes the value 1 if the adolescent female is married at time *t*, but unmarried at *t*-2, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. 2000 serves as the baseline year, Protestant is the baseline religion and the poorest quintile is the baseline wealth quintile. High drought risk is not included due to missing data of the drought episode variable[8] for Uganda. The length of the growing season is a binary variable divided into 16 categories, where 1 indicates 0 days and 16 indicates > 365 days. Proximity to water measures the straight line distance, in kilometres, to the nearest major water body. Regional- and time fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The third column shows the third regression specification, which adds wealth quintile dummies upon the second specification. The size of estimates of the rainfall variables in Nepal is approximately the same, but now they are only significant at the 5% level.

[8] As seen in Table 2, showing descriptive statistics, only 2 793 out of 8 081 observations are registered.

However, for Uganda the size of the *rainfall* estimate increases and the significance level of goes from 10% to 1%. The quadratic effect of rainfall goes from insignificant to significant at 1%. This might be due to the fact that income probably is correlated with rainfall levels and marriages rates, thus not including wealth quintiles in previous estimations biased our estimates downwards. Furthermore, we find that age still has a positive effect on the probability of adolescent marriage in Nepal and Uganda, but that rural residence no longer is significant in either country. This could be since the majority of the poor people live in rural areas and that this effect is caught by the wealth index. Additionally, Buddhist and Kirat females in Nepal still have a lower probability of adolescent marriage than those females that practise Hinduism. However, there is no significant effect of being Muslim. In Uganda, the effect of being Catholic or Muslim is still positive. Belonging to the richer and richest quintile decreases the probability of adolescent marriages in both Nepal and Uganda, compared to females belonging to the poorest quintile.

The fourth column show the fourth regression specification, which adds the geographical variables: high drought risk (only for Nepal)[9], the number of growing days and proximity to nearest major water body (measured in kilometres), upon the third specification. As seen in Table 4, the estimates of the rainfall variables for Nepal are robust to the inclusion of high drought risk, the length of the growing season and proximity to nearest major water body. Overall, this indicates that the effect of rainfall is robust to the inclusion of other geographical measurements. When it comes to Uganda, the size of the *rainfall* variable decreases and the significance level of goes from 1% to 10%, with the inclusion of the length of the growing season and the proximity to water in kilometres. Moreover, $rainfall^2$ is robust to the inclusion of other geographical measurements, and goes from significant at 1% to 10%. Our findings indicate that the effect of rainfall on adolescent marriages differ depending on where in the distribution of rainfall the female appears, i.e. the curvature of the effect size[10] is convex for Nepal and concave for Uganda (see Figure 5 and Figure 6 in Appendix 2). This implies that for Nepal, at low levels of rainfall, one more decimetre of rainfall decreases marriage probability, whereas at high levels of rainfall, one more decimetre

[9] As seen in Table 2, showing descriptive statistics, only 2 793 out of 8 081 observations are registered in Uganda.
[10] The effect size is calculated by adding the product of the multiplied coefficient of β_1 and *rainfall*, and the multiplied coefficient of β_2 and $rainfall^2$.

of rainfall increases the probability of marriage. A concave effect size indicates the opposite, which is the case for Uganda. The amount of rainfall that minimise the probability of adolescent marriage in our estimation sample is approximately 22 decimetres of rainfall per year for Nepal. Thereafter the probability of adolescent marriage starts to increase. The amount of rainfall that maximises the probability of adolescent marriage in Uganda is approximately 15 decimetres, after this point the probability of adolescent marriage decreases.

The main concern is whether different areas have area specific characteristics that does not change over time, i.e. that some areas that are always dryer might have a different marriage pattern than areas that normally gets more rainfall. We try to control for this bias by including regional fixed effects and other geographical measurement. Since this might not be enough, we also include cluster fixed effects as another robustness check for regression specification 1-4 (see Table 9 and Table 10 in Appendix 2). The sign of the coefficient of the estimates for the rainfall variables are robust for Nepal, and the size is basically the same. However, they are no longer significant. The inclusion of cluster fixed effects is also performed for Uganda. The sign of the coefficient of the estimates for the rainfall variables changes in some specifications, and the size of estimates is smaller and no longer significant.

An explanation for the loss of significance in Table 9 and Table 10, is that we only have two survey years for Nepal and three for Uganda. This may lead to too little variation within the clusters, since we have 317 clusters and 5 235 observations for Nepal and 837 clusters and 8 081 observations for Uganda. We test for this formally by running two additional regressions of rainfall against time fixed effects to see how much the time explains the variation in rainfall. First, we investigate this relationship without cluster fixed effects and find that R^2 is approximately 0.09 in Nepal and 0.21 in Uganda, which indicates that the time by itself does not explain all of the variation of rainfall in our sample. Second, we run the same regressions with cluster fixed effects and find that R^2 increases to approximately 0.93 in Nepal and 0.85 in Uganda. This implies that there is very little variation of rainfall within our clusters across the different time periods. This further infers that running the regressions with cluster fixed effects kills most of our variation, which might be the reason why our coefficients lose significance in Table 9 and Table 10. Nevertheless, since the magnitude of the rainfall coefficients in Table

9 basically does not change (compared with Table 4), we conclude that not including cluster fixed effects in all of regression for Nepal will essentially not lead to a lot of omitted variable bias. Thus, the results obtained in Table 4 are to be considered robust. On the other hand, when it comes to comparing Table 10 and Table 5, which show the results for Uganda, we see that the magnitude of the coefficients' drastically decreases. This might imply that not including cluster fixed effects in all of our regression for Uganda, could be a source of omitted variable bias. Thus, we cannot argue that the results obtained in Table 5 are robust.

5.4 Heterogeneous Effects

As described in section 4.2 *part C*, the effect of rainfall on marriage might differ, as individuals with different characteristics may react in different ways to the same treatment. We therefore add interaction terms between our rainfall variables and background characteristics as a robustness upon the fourth specification, which is shown in Table 6 and Table 7. First, we explore the heterogeneity of the adolescent female's age, by interacting our rainfall variables with an age dummy indicating younger cohort, shown in the second column in both tables (i.e. fifth specification). We find that there is an additional negative effect of *rainfall* on belonging to the younger cohort in Nepal. Furthermore, as $rainfall^2$ loses its significance when we include the interaction term between the rainfall variables and younger cohort, it seems like the quadratic effect of rainfall is driven by the older cohort in our sample. In Uganda, there is an additional negative effect of *rainfall* on belonging to the younger cohort, but adds nothing to the effect of $rainfall^2$. However, this additional effect on *rainfall* does not cancel out the positive effect of rainfall on the probability of being married. Nevertheless, this indicates that an increment in the amount of rainfall have a smaller impact for the younger cohort, compared to the older cohort.

Secondly, we explore the heterogeneous effect of living in an urban area, by interacting our rainfall variables with a dummy for urban area. As seen in Table 6 and Table 7 in the third column (i.e. the sixth specification), the results are not driven by the urban population in our sample. This is in line with the assumption that it is the rural population that is affected by the amount of rainfall, as they are dependent on agricultural production, and therefore use adolescent marriages as a consumption smoothing mechanism. Thirdly, we explore the heterogeneity across religious groups,

TABLE 6

Regression with Interaction Terms – Nepal

Dependent Variable: Marital Status, *t*

	Ordinary Least Squares			
Explanatory Variable	(4)	(5)	(6)	(7)
Rainfall in dm, *t*-1	-0.031**	-0.026**	-0.031*	-0.039***
	(0.012)	(0.013)	(0.017)	(0.012)
$Rainfall^2$ in dm, *t*-1	0.001**	0.001	0.001	0.001***
	(0.000)	(0.000)	(0.001)	(0.000)
Rainfall × Young		-0.011**		
		(0.005)		
$Rainfall^2$ × Young		0.000*		
		(0.000)		
Rainfall × Urban			0.001	
			(0.025)	
$Rainfall^2$ × Urban			0.000	
			(0.001)	
Rainfall × Buddhist				0.060**
				(0.028)
Rainfall × Muslim				0.089
				(0.062)
Rainfall × Kirat				0.073
				(0.070)
Rainfall × Christian				0.026
				(0.081)
$Rainfall^2$ × Buddhist				-0.002**
				(0.001)
$Rainfall^2$ × Muslim				-0.003*
				(0.002)
$Rainfall^2$ × Kirat				-0.002
				(0.002)
$Rainfall^2$ × Christian				-0.001
				(0.002)
Regional FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
R^2	0.068	0.070	0.068	0.071
Observations	5 235	5 235	5 235	5 235

Note: The dependent variable is a binary variable called *married* that takes the value 1 if the adolescent female is married at time *t*, but unmarried at *t*-2, otherwise 0. Young is a binary variable taking the value 1 if the female is < 18 years old and 0 otherwise. Urban is a binary variable taking the value 1 if the female lives in an urban area and 0 if she lives in a rural area. 2006 serves as the baseline year, Hindu is the baseline religion and the poorest quintile is the baseline wealth quintile. Regional- and time fixed effects are included in all regressions. Control variables included in model specification 4 are included in all regressions shown in this table. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 7
Regression with Interaction Terms – Uganda
Dependent Variable: Marital Status, *t*

	Ordinary Least Squares			
Explanatory Variable	(4)	(5)	(6)	(7)
Rainfall in dm, *t*-1	0.050*	0.061**	0.051*	0.058
	(0.029)	(0.029)	(0.031)	(0.038)
$Rainfall^2$ in dm, *t*-1	-0.002*	-0.002**	-0.002*	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)
Rainfall × Young		-0.015**		
		(0.007)		
$Rainfall^2$ × Young		0.001		
		(0.000)		
Rainfall × Urban			-0.016	
			(0.068)	
$Rainfall^2$ × Urban			0.001	
			(0.003)	
Rainfall × Catholic				-0.032
				(0.055)
Rainfall × Muslim				0.043
				(0.085)
$Rainfall^2$ × Catholic				0.001
				(0.002)
$Rainfall^2$ × Muslim				-0.00
				(0.003)
Regional FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
R^2	0.132	0.136	0.132	0.132
Observations	7 595	7 595	7 595	7 595

Note: The dependent variable is a binary variable called *married* that takes the value 1 if the adolescent female is married at time *t*, but unmarried at *t*-2, otherwise 0. Young is a binary variable taking the value 1 if the female is < 18 years old and 0 otherwise. Urban is a binary variable taking the value 1 if the female lives in an urban area and 0 if she lives in a rural area. 2000 serves as the baseline year, Protestant is the baseline religion and the poorest quintile is the baseline wealth quintile. Regional- and time fixed effects are included in all regressions. Control variables included in model specification 4 are included in all regressions shown in this table. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

by interacting our rainfall variables with country specific religion dummies (shown in the fourth column in both tables). Surprisingly, we find that in Nepal the additional effect of being Buddhist and exposed to an increment of rainfall, shows an opposite relationship since the probability of adolescent marriages increases with regards to *rainfall*, but decreases with regards to *rainfall*^{2}, i.e. similar to the trend shown in Uganda. One explanation for this might be that the tradition of dowry is not prevalent amongst Buddhists, contrary to Hindus. The interaction terms with the rainfall variables and the different religions are not statistically significant in Uganda.

6. ADDITIONAL RESULTS

In this section, we investigate the effect of rainfall on a potential outcome of adolescent marriage, i.e. educational attainment. Due to a potential simultaneous causality problem, previous studies on the relationship between early marriage and educational attainment have been investigating the relationship from two directions, i.e. either assuming that education affects early marriage in a preventative way (Raj et al. 2014), or that early marriage affects education (Field & Ambrus 2008; Lloyd & Mensch 2008). Furthermore, Buchmann (2017) show that females receiving cash conditional on them remaining unmarried decreased the level of early marriages and increased schooling. Another branch of research focuses on the relationship between income shocks and educational attainment. Ferreira and Schady (2009) develop a framework in order to analyse this relationship and show by analysing previous literature on the subject that the expected outcome is ambiguous due to the income and substitution effect. Poorer countries tend to show a pro-cyclical pattern, where school enrolment decrease during a recession, whereas middle-income and richer countries experience a counter-cyclical pattern of improvements during recessions. Jensen (2000) examines school enrolment in Côte d'Ivoire and finds that children living in villages affected by drought experienced a decrement in school enrolment, compared to children living in villages unaffected by the drought. Moreover, contrary to the theory that poverty forces children to engage in child labour, Kruger (2007) finds that a positive production shock in the form of higher value of the agricultural production decreased the average school enrolment in Brazil, since it was more valuable for the parents to send their children to work.

6.1 The Effect of Annual Rainfall on the Educational Level

There are to our knowledge no study that investigates the relationship between variation in rainfall on adolescent females' educational level, and the likelihood of getting married. It would therefore be interesting for policymakers to know which one of these outcomes that were affected first and/or the most. Ideally, we would have liked to investigate this over time, by using the amount of rainfall as an exogenous shock that changes the economic conditions for the household, and thus the economic incentives parents face when they chose how to invest in their daughter. The changes in economic conditions might onset changes in the given adaptation strategy, i.e. whether to marry off their daughter or withdraw her from school, or both. We would thus have been able to observe if adolescent females that are enrolled in school marry while in school and then drop out, or if they drop out of school and then decide to marry. However, due to lack of data this is not possible. Therefore, we run the exact same regression as before, with the same sample, but with a different dependent variable. By doing so, we are able to see if the annual amount of rainfall increases or decreases the probability of making the transition from primary to secondary school for unmarried female teenagers aged 13-19 (at time *t-2*). As before, all regressions use regional fixed effects and time fixed effects. Thus, to detect the transition into *higher education*, we created a binary variable that represents whether an adolescent unmarried female has enrolled in secondary school at time *t*, where being in secondary school is denoted by 1, and not being in secondary school is denoted by 0. As seen in Table 11 in Appendix 2, the baseline specification is estimated by an Ordinary Least Square (OLS), a Probit and a Logit model, but as the obtained estimates are nearly identical across the different regression models we restrict our attention to the linear specification.

As shown in Table 8, the baseline specification in the first column shows that *rainfall* is positive and significant at 1% for both countries, and that the quadratic effect of rainfall is negative and significant at 1% for both countries. This indicates that the effect of rainfall on the transition into secondary education differ depending on where in the distribution of rainfall the female appears, as the curvature of the effect size is concave for both Nepal and Uganda (see Figure 7 and Figure 8 in Appendix 2). This further implies that at low levels of rainfall, one more decimetre of rainfall increases the probability of higher education, whereas at high levels of rainfall, one more decimetre of rainfall decreases the probability. In addition, age has a positive effect and rural residence has a negative effect on educational level in both countries. The results in Table 8 are robust to the inclusion of the same control variables as in the second and third specification for Nepal. However, for Uganda the coefficients of the estimated rainfall variables are only statistically significant in the first and second specification.

TABLE 8
Additional Results - Regression with Controls
Dependent Variable: High Education, *t*

	Nepal				Uganda			
	Ordinary Least Square				Ordinary Least square			
Explanatory Variable	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Rainfall in dm, *t*-1	0.109***	0.106***	0.096***	0.087***	0.068***	0.066***	0.030	0.023
	(0.020)	(0.019)	(0.017)	(0.017)	(0.024)	(0.024)	(0.025)	(0.035)
$Rainfall^2$ in dm, *t*-1	-0.003***	-0.002***	-0.002***	-0.002***	-0.003***	-0.003***	-0.001	-0.001
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Age	0.023***	0.022***	0.012***	0.013***	0.060***	0.060***	0.060***	0.059***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
Rural	-0.212***	-0.210***	-0.032	-0.043**	-0.212***	-0.212***	-0.082***	-0.088***
	(0.023)	(0.022)	(0.021)	(0.019)	(0.024)	(0.024)	(0.031)	(0.032)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R	0.127	0.160	0.246	0.263	0.169	0.169	0.216	0.220
Observations	5 235	5 235	5 235	5 235	7 595	7 595	6 134	6 134

Note: The dependent variable is a binary variable called *high education* that takes value 1 if the female has started or completed secondary education, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. 2006 is the baseline year for Nepal and 2000 is the baseline year for Uganda. In column 2 country specific religions are added, whereas in column 3 wealth quintiles are added and finally, in column 4 variables that indicates environmental riskiness are added. Regional- and time fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As when investigating the effect of annual rainfall on the probability of being married as an adolescent, we control for whether different areas have area specific characteristics that do not change over time (see Table 12 in Appendix 2). The inclusion of cluster fixed effects provide us with significant estimates of the rainfall variables in the first three columns, but insignificant estimates in the fourth specification which includes variables indicating environmental riskiness. Thus, with the inclusion of cluster fixed effects, the estimates of the rainfall variables in the fourth specification for Nepal goes from significant to insignificant, and the estimates of the rainfall variables goes from insignificant to significant in the third specification for Uganda. Moreover, the size of the estimates of *rainfall* and $rainfall^2$ decreases in Nepal. This indicates that the coefficients of the rainfall estimates' in Table 8 might be upward biased, due to heterogeneous effects within the clusters. On the other hand, the size of the estimates of *rainfall* and $rainfall^2$ increases in Uganda. This indicates that the coefficients of the rainfall estimates' in Table 8 might be downward biased, also due to heterogeneous effects within the clusters. However, the concave relationship between rainfall and higher education is prevalent in both Table 8 and Table 12.

7. DISCUSSION

By testing the predictions of the marriage market theory developed by Corno et al. (2017), we show that the annual amount of rainfall affects adolescent marriage in Nepal and Uganda. Our findings indicate that the effect of rainfall on adolescent marriage differ depending on where in the distribution of rainfall the female appears, as we find a convex relationship between adolescent marriages and rainfall in Nepal, and a concave relationship in Uganda. In contrast to the theoretical framework and our hypotheses presented in Section 3, we find that a positive income shock in Nepal decreases the probability of adolescent marriages, but increases the probability in Uganda, and that a negative income shock increases the probability in Nepal, but decreases the probability in Uganda.

In comparison to the previous studies that are the closest to ours, which investigate the effect of a drought on early marriages (see Corno et al. 2017; Corno & Voena 2016), we investigate the effect of rainfall throughout its whole distribution, i.e. more rainfall could be considered as either a positive or a negative income shock. Opposite of their findings, we find that the probability of adolescent marriages decreases at an increasing rate when the amount of rainfall increases in Nepal, whereas the pattern is reverse in Uganda. This indicates that, given that the annual amount of rainfall before the minimising point in Nepal, and maximising point in Uganda (see Figure 5 and Figure 6), is considered as low levels of rainfall (i.e. a drought), more rainfall implies a positive income shock for the agricultural dependent families. Moreover, if the annual amount of rainfall after the minimising and maximising points are considered as high levels of rainfall, more rainfall implies a negative income shock (i.e. a flood). Thus, in conclusion, our findings are the opposite of what we expected, given the predictions of the theoretical framework that we based our hypothesis on. Below, we will discuss three possible explanations to why we receive results that are opposite of the predictions of the theory. As our analysis does not reveal whether the supply of brides increases or decreases (or if the demand increases or decreases), only if the probability of adolescent marriages changes, the arguments behind these explanations will be hypothetical. The first scenario is based on one of the underlying assumptions in the theoretical framework by Corno et al. (2017), whereas the second scenario is based on the fact that we cannot determine if the chosen years of rainfall data are to be considered normal or if they are anomalies, and the third scenario discusses the possibility of an intermediate channel. Nevertheless, our results strengthen the assumption that climate change affects adolescent marriages and that the marital payment decides the direction of how climate change will affect adolescent marriages.

In order for the predictions of the theory to hold, the workforce of the family's son w^m must be sufficiently large. Thus, one explanation might be that our countries violates this assumption. Given that both Nepal and Uganda are poor, it is possible that the son's contribution to the household does not significantly exceed the contributions of the daughter. As we find a decrement in the probability of adolescent marriages with aggregated income in Nepal (instead of an increment), it is possible that our results are driven by the groom's decision not to marry, since, according to the theory, the demand of brides decreases with aggregated income. This is reasonable, since from the groom's perspective, when his family get more income, they do not have as strong incitement to take in one more family member (i.e. the bride), as they do not need to consume the dowry. According to the theory, the supply of brides are assumed to increase with aggregated income, as they might take opportunity to marry her off in order to avoid a higher dowry when she is older. However, this effect might not outweigh the effect of the decrement in demand of brides, thus making the probability of adolescent marriages decrease. It is also possible that the positive income shock generates a decrement in the supply of brides, as the bride's family have a higher income, which might make them chose to postpone the marriage until she is older, as they can afford the dowry anyway.

On the other hand, at high levels of rainfall, when they are hit by a negative income shock, the theory assumes that the supply will decrease, whereas the demand will increase. As we find an increment in the probability of adolescent marriages, it is possible that our results are driven by the groom's decision to marry. This is reasonable, since the groom's family might need to consume the dowry as w^m is not sufficiently large. The decrement in supply could originate from the bride's family's inability to pay the dowry when they are hit with a negative income shock. However, this effect might not outweigh the effect of the increment in demand of brides. It is also possible that the negative income shock will lead to an increment in the supply, as the female's family might take the opportunity to marry off their daughter with a lower dowry (as the size of the dowry reduces when the society is hit by a negative income shock).

Turning our focus to Uganda, where the female is considered a contributor (and not a burden), the theoretical framework assumes that the supply of brides will decrease with aggregated income, but that the demand will increase. Given that w^m is not sufficiently large, the workforce of the female will arguably be even more valuable. We believe that once again, our results are driven by the groom's household, as they will be willing to pay the bride price in order to expand the workforce, and that this effect will outweigh the effect of the decrement in supply. However, it is also possible that the supply of brides increases if the demand is sufficiently high, as the bride's family may be willing to give her up if they receive a higher price, which arguably will be higher due to higher demand. On the other hand, a negative income shock is assumed to increase the supply, but to decrease the demand. As we find a decrement in the probability of adolescent marriages, it is possible that our results are driven by the groom's decision not to marry, as the groom's family neither have the money or the need for the bride's workforce (since their yield might be destroyed). This effect might outweigh the effect of the increment in supply, which presumably would arise due to the bride's family's need to smooth their consumption. It is also possible that the negative income shock will lead to an decrement in the supply, as the bride's family might be less price sensitive and would rather postpone the marriage in order to receive a higher bride price.

As we cannot determine if the annual amount of rainfall that is observed before the minimising point in Nepal, and maximising point in Uganda, is low levels of rainfall *per se*, the second scenario and possible explanation is that we do not receive results that are opposite of the theory, until the minimising and maximising points, as the increment in rainfall will be considered as a negative income shock. Therefore, a second reason to why we receive results that seems to go in opposite direction of our hypothesis, is that we cannot determine if the chosen years of rainfall data are to be considered normal or as anomalies. We discuss this limitation with our rainfall variables in Section 4.2. part *A*. It is therefore possible that the baseline level of rainfall is too much rain (i.e. a flood), and not too little (i.e. a drought) or the average amount. Thus, given that our countries recently experienced a flood, more rainfall will have a negative effect on the agricultural yield. This indicates that no matter where in the rainfall distribution (that we observe) the female appears, societies are being hit by a negative income shock. If this possibility holds, then our results are in line with the theoretical framework, and our hypothesis, until the minimising and maximising points of the curvature. Thereafter, the effects goes in the opposite direction, i.e. even more rainfall increases the probability of adolescent marriage in Nepal, but decreases the probability in Uganda. These opposite effects could be explained by the arguments in the first scenario.

The third scenario and possible explanation to why we receive results that are opposite of the predictions of the theory, is that it might be some other underlying channel that affects our results. As other studies have shown that there is a relationship between rainfall and conflicts (see Miguel, Satyanath & Sergenti 2004), and between conflict and marriage (see Jayaraman, Gebreselassie & Chandrasekhar 2009), this intermediate effect could potentially originate from the fact that both Nepal and Uganda have experienced civil conflicts during our survey period (see UCDP/PRIO Armed Conflict Dataset[11]). Thus, independently of how the amount of rainfall in itself affects household *i* (i.e. could both be a positive or a negative shock depending on the baseline level of rainfall), on a larger scale, the amount of rainfall could onset a civil conflict that in turn could affects the probability of adolescent marriage. This implies that these conflicts could be affecting the direction of our results, and be the underlying channel to why we receive results that are opposite of the theory.

Furthermore, the probability of commencing secondary school increases at a decreasing rate when the amount of rainfall increases in both countries, since they are hit by a positive income shock at low levels of rainfall, but a negative income shock at high levels of rainfall. This is in line with the pro-cyclical pattern shown in poor countries, where education decreases when the family receives lower income (Ferreira & Schady 2009). An explanation of this could be that the alternative cost of letting the females stay in school is lower compared to other adaptation strategies. Additionally, public expenditure on schooling may also cancel out a negative income shock.

[11]See: http://ucdp.uu.se/?id=1#country/790 for Nepal and http://ucdp.uu.se/?id=1#country/500 for Uganda.

As discussed in Section 1, there exists several potential drivers of adolescent marriages. However, one could argue that adolescent marriages originates in gender inequality, where females are believed to be subordinated males, seen as an economic burden or something fragile that needs protection. Unfortunately, it is difficult to define a concise measurement of gender inequality, but evidence have shown that households prioritize their sons during tough economic conditions. Therefore, it is theoretically possible that the amount of rainfall affects gender inequality and, hence the probability of adolescent marriages. Other drivers that create a vicious cycle and preserve the practice of adolescent marriages are traditions, poverty and lack of alternative options. These underlying mechanisms can vary across regions, e.g. several societies use marital payments as part of the marriage tradition, which influence the prevalence of adolescent marriages. This is supported by our findings, as we see that the amount of rainfall has different effects depending on which marital payment that is customary in the country. Furthermore, religion can be seen as another form of tradition, which affect the probability of adolescent marriage. In comparison to being Hindu in Nepal, our results show that belonging to Buddhism and being affected by an increment of rainfall cancel out the convex effect that rainfall has on the probability of adolescent marriage. Thus, in our sample, it seems like Buddhists have a concave response to the rainfall shock, which is in line with the predictions of the theory. As none of the interaction terms are significant in Uganda, we cannot interpret this heterogeneous effect.

But what are the real-life implications of these results? One of the main differences between Nepal and Uganda, besides one being located in South Asia and one in Sub-Saharan Africa, is the tradition of marital payments, a practice which is accompanied by adolescent marriages. Previous studies have shown that adolescent females are those that suffer the most from negative income shocks, as they are not seldom used as "shock absorbers" that adapt themselves for the greater good of others. For example, walk an extra mile to collect water, drop out of school to sell firewood or engage in prostitution. Furthermore, all evidence suggests that climate change will worsen and that it is foremost the already most vulnerable countries with agricultural dependent populations that will suffer the most. Especially since these countries often suffers from weak institutions and are financially constrained. Therefore, it is important for policy makers to address adolescent females when they design new policies in order to mitigate the effect of climate change, and prevent an intergenerational poverty trap created by adolescent marriages. Our findings suggest that the effects of climate change will vary depending on what kind of marital payment that is prevalent in the specific country, which implies that the consequences of variation in rainfall will be context-based. It is therefore important that policymakers not only take gender into consideration, but also the contextual setting when developing and implementing policies. However, since these countries most likely have weak institutions it might be difficult for policy makers to implement suggested policies.

Future studies could investigate if our findings persist in another context, by examining another country, as it would be important for policymakers to know if the pattern is country specific. Particularly, as our results are opposite of the predictions of the theory. Previous studies on the relationship between rainfall and early marriages focuses on countries where the marital payment tradition is either bride price or dowry. It would therefore be interesting for future studies to investigate if the relationship persists in countries where there is no prevalence of marital payments, but where early marriages is common, for example in Latin America. This would enhance the knowledge about how weather variation affects early marriage. As climate changes are complex, it would also be interesting to use other definitions of climate change, which may impact the household's income. For example, controlling for the timing of rainfall (since the timing most likely affects the agricultural yield), the temperature and the influence of pests or the prevalence of malaria (as variation in temperature and the frequency of pests could affect agricultural production, and malaria the health status of the workers). By investigating different types of climate change, we would enhance the knowledge of the relationship between climate change and adolescent marriage. Moreover, variations in rainfall will most likely affect other sectors such as tourism, since both vegetation and wildlife are sensitive to climate change, which will affect the employment opportunities in the tourism sector. Investigating other sectors than the agriculture sector, will increase the knowledge of how populations in climate sensitive areas adapt to climate changes.

8. CONCLUSION

This paper studies the relationship between the amount of annual rainfall and the probability of adolescent marriages in Nepal and Uganda, where marriage payments are prevalent. By using the predictions of the marriage market theory, we show that an increment of rainfall affect adolescent marriages and that traditional marital payment decides the sign of the effect. We find that rainfall has opposite effects on the probability of adolescent marriages in Nepal and Uganda, even though we assume that the amount of rainfall affects the agricultural output in a similar way. Opposite of the predictions of the theoretical framework and our hypotheses, we show that there is a convex relationship between rainfall and adolescent marriages in Nepal, and a concave relationship in Uganda. In Nepal, where dowry is prevalent, an increment in the annual amount of rainfall decrease the probability of adolescent marriage at low levels of rainfall, but increase the probability at high levels of rainfall. On the other hand, the estimates in Uganda show that an increment in the annual amount of rainfall increase in the probability of adolescent marriage at low levels of rainfall, but decreases the probability at high levels. In addition, we find that there is a positive, concave relationship between rainfall and secondary education in both Nepal and Uganda. Future studies could investigate countries where there is no prevalence of marital payments, but where early marriages are common, for example Latin America. Moreover, the complexity of climate changes make it interesting to use other definitions of climate change. Studies like these would enhance the knowledge about how climate change affects adolescent marriage.

Adolescent marriage is a short-term decision that has long-term consequences as it is a violation of human rights that often leads to domestic violence, lower educational attainment and early childbearing. In addition, all evidence suggests that climate change will worsen. As our results strengthen the assumption that climate change affects adolescent marriages, it is important to further investigate this relationship. Furthermore, it is crucial that policymakers take traditions and cultural norms into consideration when developing and implementing policies in order to reduce adolescent marriages, as our findings suggests that the effects of climate change will vary depending on what kind of marital payment that is prevalent in the specific country.

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APPENDIX 1 – Descriptive Statistics

Distribution of married females in estimation sample, and the distribution of age at first marriage from the full DHS sample in Nepal and Uganda. The first two graph show Nepal and the second two graphs show Uganda.

Figure 1: Distribution of Married Females – Nepal

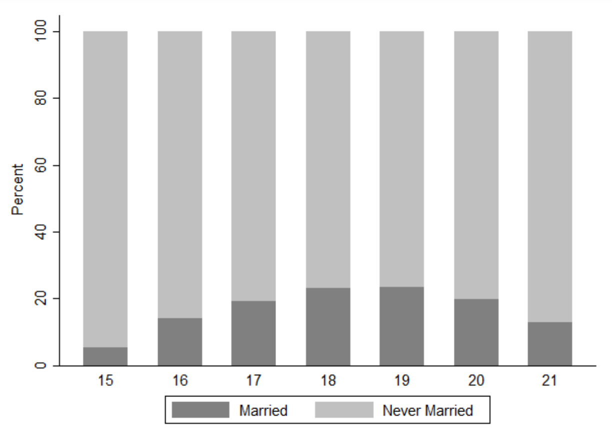


Figure 2: Age at First Marriage

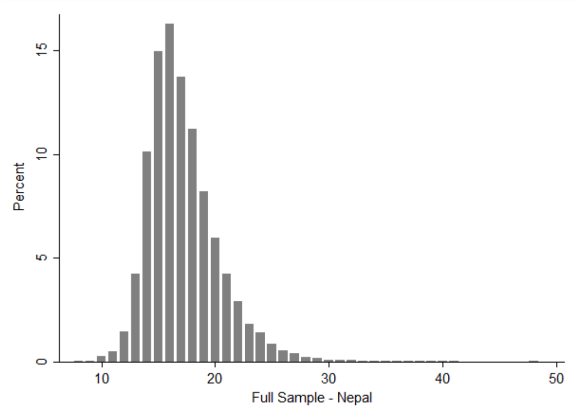


Figure 3: Distribution of Married Females – Uganda

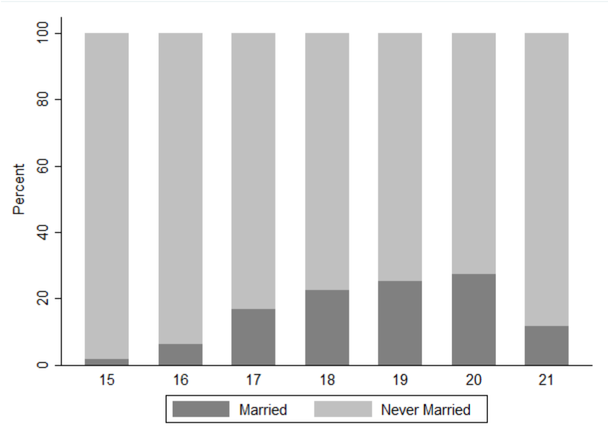
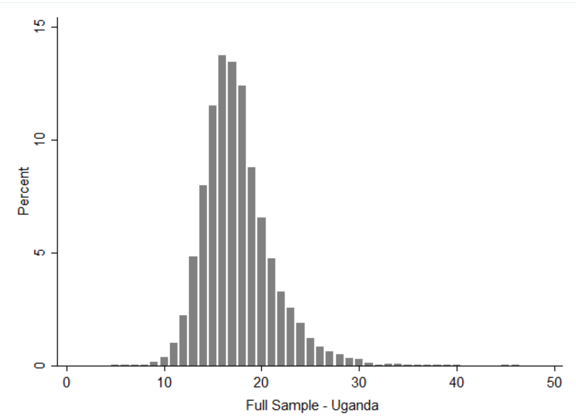


Figure 4: Age at First Marriage



APPENDIX 2 – Results

These two graphs show the effect size and distribution of rainfall in our sample, based on the fourth regression specification. The first graph shows Nepal and the second shows Uganda.

Figure 5: Distribution of Rainfall and the Effect Size - Nepal

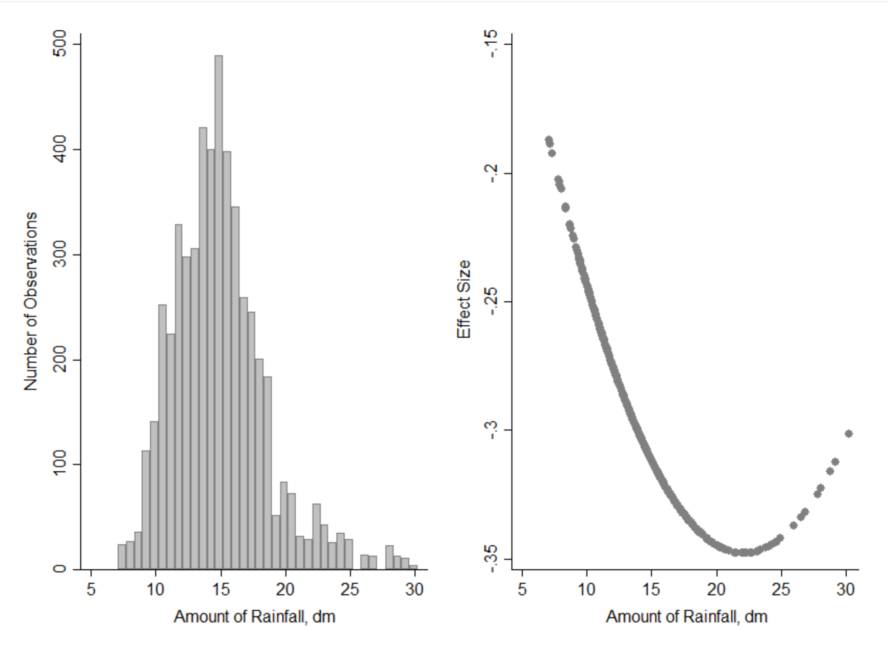


Figure 6: Distribution of Rainfall and the Effect Size - Uganda

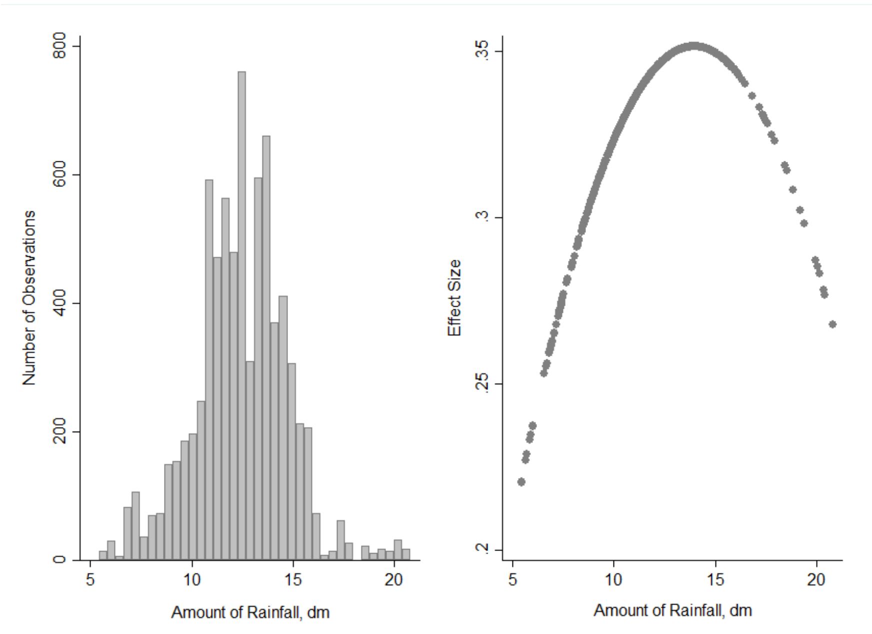


TABLE 9
Regression with Controls and Cluster FE – Nepal
Dependent Variable: Marital Status, *t*

	Ordinary Least Squares			
Explanatory Variable	(1)	(2)	(3)	(4)
Rainfall in dm, *t*-1	-0.034	-0.033	-0.033	-0.027
	(0.024)	(0.024)	(0.024)	(0.024)
Rainfall^2 in dm, *t*-1	0.001	0.001	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Age	0.045***	0.045***	0.046***	0.046***
	(0.004)	(0.004)	(0.004)	(0.004)
Rural	0.047**	0.046**	-0.012	-0.021
	(0.019)	(0.019)	(0.021)	(0.021)
Buddhist		-0.004	-0.005	-0.007
		(0.024)	(0.024)	(0.024)
Muslim		-0.012	-0.025	-0.009
		(0.048)	(0.048)	(0.049)
Kirat		-0.070	-0.072*	-0.073*
		(0.043)	(0.042)	(0.043)
Christian		-0.025	-0.018	-0.017
		(0.044)	(0.042)	(0.042)
Poorer			0.008	0.009
			(0.027)	(0.027)
Middle			0.017	0.019
			(0.029)	(0.029)
Richer			-0.066**	-0.065**
			(0.028)	(0.028)
Richest			-0.137***	-0.138***
			(0.030)	(0.031)
Cluster FE	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
High Drought Risk	No	No	No	Yes
Growing Season Length	No	No	No	Yes
Proximity to Water	No	No	No	Yes
R^2	0.145	0.146	0.156	0.157
Observations	5 235	5 235	5 235	5 235

Note: The dependent variable is a binary variable called *married* that takes the value 1 if the adolescent female is married at time *t*, but unmarried at *t*-2, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. 2006 serves as the baseline year, Hindu is the baseline religion and the poorest quintile is the baseline wealth quintile. High drought risk is a binary variable based on the variable drought episodes, which is a categorical variable ranging from 1-10, where 1 indicates low drought and 10 indicates high drought. The threshold for high drought risk is > 6. The length of the growing season is a binary variable divided into 16 categories, where 1 indicates 0 days and 16 indicates > 365 days. Proximity to water measures the straight line distance, in kilometres, to the nearest major water body. Cluster-, regional- and time fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 10
Regression with Controls and Cluster FE – Uganda
Dependent Variable: Marital Status, *t*

	Ordinary Least Square			
Explanatory Variable	(1)	(2)	(3)	(4)
Rainfall in dm, *t*-1	0.003	0.007	0.030	0.008
	(0.026)	(0.026)	(0.027)	(0.042)
Rainfall^2 in dm, *t*-1	0.000	0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.002)
Age	0.065***	0.065***	0.061***	0.061***
	(0.003)	(0.003)	(0.003)	(0.003)
Rural	0.060***	0.062***	0.039	0.024
	(0.022)	(0.022)	(0.025)	(0.027)
Catholic		0.031***	0.026*	0.027**
		(0.012)	(0.013)	(0.013)
Muslim		0.045***	0.037**	0.036**
		(0.016)	(0.017)	(0.017)
Poorer			-0.085***	-0.087***
			(0.025)	(0.025)
Middle			-0.138***	-0.140***
			(0.027)	(0.027)
Richer			-0.156***	-0.160***
			(0.026)	(0.026)
Richest			-0.187***	-0.187***
			(0.027)	(0.028)
Cluster FE	Yes	Yes	Yes	Yes
Regional FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Growing Season Length	No	No	No	Yes
Proximity to Water	No	No	No	Yes
R^2	0.301	0.303	0.311	0.312
Observations	7 595	7 595	6 134	6 134

Note: The dependent variable is a binary variable called *married* that takes the value 1 if the adolescent female is married at time *t*, but unmarried at *t*-2, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. 2000 serves as the baseline year, Protestant is the baseline religion and the poorest quintile is the baseline wealth quintile. High drought risk is not included due to missing data of the drought episode variable for Uganda. The length of the growing season is a binary variable divided into 16 categories, where 1 indicates 0 days and 16 indicates > 365 days. Proximity to water measures the straight line distance, in kilometres, to the nearest major water body. Cluster-, regional- and time fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 11
Additional Results – Comparison of OLS, Probit and Logit
Dependent Variable: High Education, *t*

	Nepal			Uganda		
	OLS	Probit	Logit	OLS	Probit	Logit
Explanatory Variable	(1)	(1)	(1)	(1)	(1)	(1)
Rainfall in dm, *t*-1	0.109***	0.097***	0.095***	0.068***	0.076***	0.076***
	(0.020)	(0.021)	(0.022)	(0.024)	(0.028)	(0.028)
Rainfall^2 in dm, *t*-1	-0.003***	-0.002***	-0.002***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age	0.023***	0.023***	0.023***	0.060***	0.058***	0.057***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Rural	-0.212***	-0.241***	-0.253***	-0.212***	-0.186***	-0.183***
	(0.023)	(0.028)	(0.030)	(0.024)	(0.020)	(0.019)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
R	0.127			0.169		
Observations	5235	5235	5235	7595	7595	7595

Note: The dependent variable is a binary variable called *high education* that takes value 1 if the female has started or completed secondary education, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. Marginal Probit and Logit effects are evaluated at explanatory variable mean values. 2006 is the baseline year for Nepal and 2000 is the baseline year for Uganda. Regional- and time fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 12
Additional results - Regression with Controls and Cluster FE
Dependent Variable: High Education, *t*

	Nepal				Uganda			
	Ordinary Least Square				Ordinary Least square			
Explanatory Variable	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Rainfall in dm, *t*-1	0.053**	0.053**	0.048**	0.031	0.097***	0.100***	0.071**	0.074
	(0.026)	(0.025)	(0.023)	(0.024)	(0.033)	(0.033)	(0.034)	(0.055)
Rainfall^2 in dm, *t*-1	-0.001*	-0.001*	-0.001*	-0.001	-0.004***	-0.004***	-0.003**	-0.003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Age	0.014***	0.014***	0.011***	0.011***	0.059***	0.059***	0.061***	0.061***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
Rural	-0.161***	-0.152***	-0.007	-0.003	-0.161***	-0.162***	-0.072*	-0.060
	(0.020)	(0.020)	(0.020)	(0.020)	(0.032)	(0.032)	(0.038)	(0.042)
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.313	0.322	0.387	0.389	0.360	0.360	0.372	0.374
Observations	5 235	5 235	5 235	5 235	7 595	7 595	6 134	6 134

Note: The dependent variable is a binary variable called *high education* that takes value 1 if the female has started or completed secondary education, otherwise 0. Rural is a binary variable taking the value 1 if the female lives in a rural area and 0 if she lives in an urban area. 2006 is the baseline year for Nepal and 2000 is the baseline year for Uganda. In column 2 country specific religions are added, whereas in column 3 wealth quintiles are added and finally, in column 4 variables that indicates environmental riskiness are added. Regional- time- and cluster fixed effects are included in all regressions. All measures are obtained using individual weights as is recommended by the DHS. Robust standard errors in (parentheses).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These two graphs show the effect size on educational level and distribution of rainfall in our sample, based on the fourth regression specification. The first graphs show Nepal and the second two graphs show Uganda.

Figure 7: Distribution of Rainfall and the Effect Size on Educational Level - Nepal

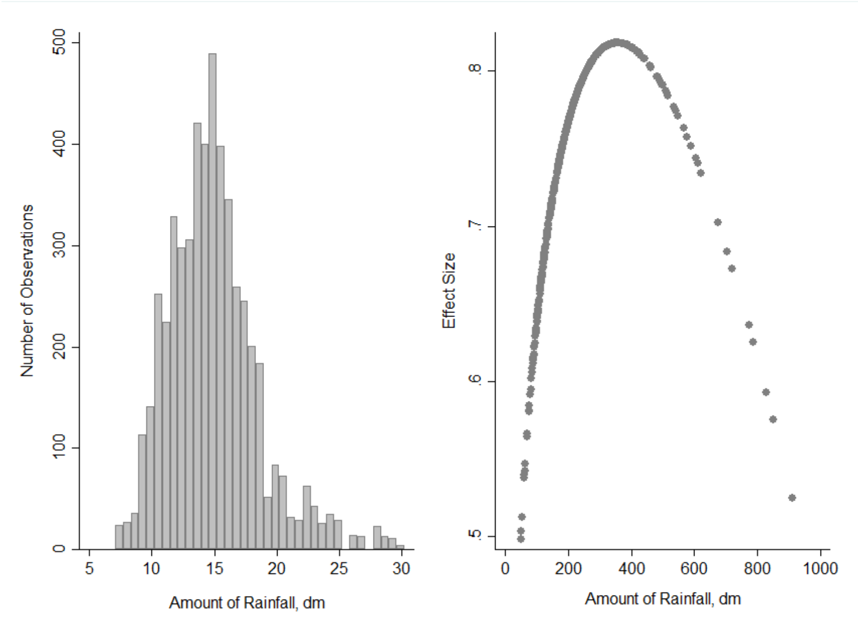


Figure 8: Distribution of Rainfall and the Effect Size on Educational Level - Uganda