Impact of the civil war in Sierra Leone on deforestation

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Abstract

The process of deforestation in Sierra Leone already started before the civil war, but it is generally assumed that the conflict exacerbated it. The present study investigated the impact of the civil war on deforestation, fallow periods and commercial logging, in the region around the Gola Rainforests National Park. Forest covers were affected by the civil war in two ways: directly through farm abandonment (i) and indirectly through defined channels (ii), such as preferences towards natural resources and social capital, property rights, labour supply and human capital. Furthermore, traditional deforestation drivers were tested, such as population pressure, market distance, and topography. 176 villages and 2460 households were surveyed around Gola forests. This allowed collection of unique data set from post-war region. Data were analysed on the village level. The present results suggest that a shorter market distance and a higher population put additional pressure on the forests. Plots with better characteristics for agriculture favour deforestation and the local topography has a large impact on the outcome of all tested models. As a direct consequence of the civil war, farm abandonment led to significantly lower deforestation rates. Furthermore, human capital, property rights and willingness to preserve forests were identified as important indicators for the indirect effects of the conflict on deforestation. Plots with better access, better soil quality and sufficient precipitations experience shortening of the fallow period and are farmed more intensively. Higher soil quality and improved social capital lead to decreased probability of commercial logging; better soil is preferred for agriculture, social capital improves investments into natural resource management. In conclusion, present results indicate that the civil war in Sierra Leone had a significant impact on deforestation, yet its effects can be moderated by policy measures. It is suggested that increased investments into human capital and property rights regimes, as well as an intensification of agriculture in order to increase the fallow periods, decrease deforestation rates and decrease the probability of commercial logging. However, further research is needed.

Keywords: civil war, deforestation, Sierra Leone

Table of Content

List of Tables

List of Figures

1. INTRODUCTION

Agriculture, mining, hunting and urbanization can all have a negative impact on forest integrity. This negative effect can be further exacerbated by armed conflicts. It is generally acknowledged, that wars and conflicts have an impact on the environment; however, there is barely any solid evidence of a wars impact on forests and deforestation. Most available data is rather qualitative and deals with biodiversity in general. The deforestation process in Sierra Leone already started before the civil war but it is generally assumed that the conflict had an impact on the forests integrity. Nonetheless, it remains uncertain how the war impacted forests and biodiversity in Sierra Leone (Squire, 2001, United Nations Environment Programme, 2010). Forests in Sierra Leone were directly involved in the war. This fact combined with natural environment mismanagement affected the forests (Squire, 2001, Suthakar and Bui, 2008). The question is, if the negative effects of the war prevail and if the conflict impacted war victims in such a way, that deforestation was increased. This study assessed the effect of the Sierra Leonean civil war on deforestation particularly in the villages around the Gola forests and those factors underlying the deforestation decision making. According to Sutherland *et al.* (2009), identifying direct and indirect effects of a violent conflict on biodiversity is one of the "100 Questions of Importance to the Conservation of Global Biological Diversity".

1.1 Problem statement

Squire (2001), one of the few authors that studied the impact of the civil war on biodiversity in Sierra Leone, is concerned about the impact of the war on environment and forests and he identified several direct impacts. Forests were part of the war strategy, shelter for displaced people, and source of supplies (Squire, 2001). The Revolutionary United Front of Sierra Leone (RUF) forces' headquarter was situated in North Gola Forest. The forests became part of their war strategies for survival, for the attacks and for their bush camps.

Forests served as a shelter for displaced people, as a source of food and living, a source of construction material and firewood (Squire, 2001). It is estimated that about half of the population of Sierra Leone had to flee during the civil conflict. Some of them fled into refugee camps, forest areas, or into urban settlements. In refugee camps, some food was supplied but the rest of the food and firewood had to be arranged by the refugees. Urban areas faced increasing population pressure, there was increasing need for land, food, firewood and construction material. People who fled into forests or other villages were fully dependent on forest resources (Squire, 2001). This group of internally displaced persons had the most harmful effects for the environment, as stated by the United Nations report (United Nations Environment Programme, 2010).

Some villagers were forced to clear forests close to roads and settlements in order to decrease the risk of ambushes. Therefore, surrounding forests were an immediate threat, which intensified local deforestation (Richards, 1996). Forests were crucial for all the parties involved in the conflict and the forests were impacted by all of them. Due to destruction of infrastructure, market stagnation and high transaction costs, many people were left dependent on exploitation of natural resources. All these factors in addition to natural environment mismanagement impacted forests.

Breakdown of the legal system caused other negative effects, like excessive mining and logging activities. All armed forces used diamonds as a source of income and to purchase military supplies. The involved sites were heavily exploited including those in forest reserves (Squire, 2001).

The end of the war did not mean the end of an excessive pressure on the forests. UNEP report (United Nations Environment Programme, 2010) mentions continuation of excessive exploitation of resources even after most people had returned to their homes in the rural communities Gola forests. This was exacerbated by increased post-war population growth.

Mentioned arguments seem to predict forest cover reduction. Klop et al. (2008) and Lindsell et al. (2011) showed that Gola forests remained relatively intact during the war. This could mean that there was an extensive pressure on community forests. The community forests are in surrounding of Gola forests. They are owned and managed by the villages and usually form part of the agricultural cycles. The community forests are researched in this report and they are not part of the Gola Rainforests National Park. Klop et al. (2008) reported decreased community forests in surrounding areas of Gola forests by evaluating satellite images. The highest clearing rate was in the Eastern boundary of Gola North and the Liberian border, and around the Western part of Gola North (Klop et al., 2008).

Most evidently, deforestation is not the only impact of the eleven year lasting war in Sierra Leone, the war had also a complex range of impacts. Those impacts subsequently affected the forest covers, but there is no clear insight into the relationship between the war and the change in the land use decision making process. There is no evidence on impacts of war on different aspects and their consequent effect on deforestation. It is yet unknown to what extent warfare influences deforestation indirectly and whether this affect is temporary or persists over time; whether deforestation patterns are affected by changes in human behaviour, preferences and other aspects, as a direct consequence of warfare and whether those changes can have an impact on deforestation. Anecdotes talk about the destructive aspects of a war, however, recently empirical studies discover new dimensions of positive impacts. Nevertheless, evidence is still rare and more research is needed.

This report studied the indirect effects of the war on deforestation and tried to explain link between those two phenomena by identifying other potential mediators. It is hoped, that the present results will increase our understanding of the drivers that lead to deforestation in post-war countries and will help identifying the contribution of each of these drivers to the observed pattern.

1.2 Research objective

The main research objective of this study is to identify the main links between war and deforestation and to analyse and quantify those links for Sierra Leone in particular. Agriculture is used as a proxy for deforestation as it is considered the main trigger for forest clearing (see section 4.3.3). However, agriculture is not the only factor driving deforestation. Therefore, also commercial logging as the outcome of war driven deforestation, is taken into account. The last aspect of the study is the fallow period, which is impacted by the war and affects land degradation.

1.3 Research questions

General research question:

- What are the impacts of the civil war on deforestation around Gola Rain Forests National Park in Sierra Leone?

Specific research questions:

- What was the spread of the violence and its impacts on communities around Gola forests?
- What are the main factors driving deforestation?
- What are the direct and indirect pathways through which the war impacts deforestation?
- What is the impact of the war on farming (upland rice production and fallow periods) and commercial logging?

1.4 Relevance of the study

Quantitative evidence of war impacts on deforestation is scarce and deserves further attention in research. Most of the available studies focused on the consequences of war by making qualitative statements. They restrict themselves to naming impacts of war on descriptive basis. This is due to the lack of reliable data from war torn countries and the general complexity of the issue.

Latter gap in knowledge makes it imperative not only to quantify the relationship between deforestation and war in Sierra Leone but also to explain the link between them.

1.5 Structure of the report

Chapter 2 presents background information on Sierra Leone including the aspects of local agriculture, the civil war and the forests in Sierra Leone. Chapter 3 identifies the major deforestation findings and the main impacts of a war on aspects of human lives of the victims. Chapter 4 presents the empirical model used for the analysis, the conceptual framework, all identified variables, the data exploited and methods used. Chapter 5 discusses results of the analysis and chapter 6 brings deeper discussion and recommendations for future research.

2. BACKGROUNGD INFORMATION

This chapter provides an overview of Sierra Leone including some basic information about the country (section 2.1) and the civil war (section 2.2). In addition, it discusses the state of the forests in Sierra Leone (section 2.3).

2.1 Sierra Leone

Sierra Leone is West-Africa's smallest country. It borders to the South-East with Liberia and Guinea in North-East. To the West lies the Atlantic Ocean (see figure 1). Sierra Leone has four provinces, namely Northern, Southern, Eastern, and Western Province (where the capital Freetown is situated); they can be subdivided into 14 districts. Furthermore, the country has 149 traditional local chiefdoms, ruled by a paramount chief (United Nations Environment Programme, 2010).

Agriculture is a crucial sector in Sierra Leone and two-thirds of the population are still highly dependent on agricultural production (International Monetary Fund, 2011). 75% of the total land area is cultivatable (Mohammed et al., 2004). Currently, over 9% of total land use is devoted to agricultural production (International Monetary Fund, 2011). Agricultural production is traditionally performed in the so-called 'slash-and-burn technique'. Rice is the traditional agricultural staple food crop and its culture is a political priority (Gleave, 1996). Sierra Leones farming ecosystems can be classified into: upland, inland valley swamp, mangrove swamp, bolilands, and riverine grassland. With 80 % of the total culture area, upland is the prevailing farming ecosystem. Uplands, low areas and swamps are sown with different varieties of rice, with vegetables, roots and grains as intercrops. The majority of the farming households plants rice and about half of the production is grown in upland. Cleared secondary bush plots can be cultivated with rice for only one year; sometimes second and third years are farmed with non-rice crops before the plot is left fallow. Leach (1994) mentions a preferred fallow period of 8-15 years in areas around Gola forests. A common cycle for shifting agriculture is depicted in appendix 1. According to Mohammed *et al.* (2004) upland farming reached its maximum productivity applying the present technology and is experiencing a shortening of the fallow periods.

Also the agricultural sector was severely impacted by the war. In 2001, only 20% of the rice demand was produced domestically and still today the rural population is largely dependent on foreign aid (Maconachie, 2008). The development of agriculture is considered crucial to fight poverty. Yet in combination with a steadily increasing population growth, the pressure on natural systems and forests is augmented (Maconachie, 2008). (United Nations Development Programme).

Sierra Leone has an immense abundance of natural resources, including diamonds, gold, bauxite, rutile, as well as a rich biodiversity. However, this "rich" country experienced five coups, decades of dictatorship and eleven years of civil war since the year of independence in 1961 (United Nations Environment Programme, 2010). Despite its natural resources endowment, Sierra Leone is considered as one of the poorest countries in the world[1]. GDP depreciated by 43% during the war period and in 2002, 90% of total population was living underneath the poverty threshold (Mohammed et al., 2004). Today, the GDP of Sierra Leone is 325 \$/capita with 66.4% of population living below the poverty line (World Bank, 2011). The GDP growth in 2010 was 5% compared to 3.2% in 2009. This was mainly due to recovery of agricultural production and the

[1] Considering the Human Development Index of UNDP, which assesses life expectancy, literacy, education, and standards of living, Sierra Leone was ranked as the 180th country out of 187th - The lower in the ranking the lower level of human development is (United Nations Development Programme, 2011).

mining sector (International Monetary Fund, 2011). Inflation in 2010 reached 16.8%, mainly caused by increasing international food and oil prices and a depression of the exchange rate (International Monetary Fund, 2011). Tax revenues increased by almost 40% in 2010 compared to 2009 due to increased collection of income taxes (International Monetary Fund, 2011), which signifies increasing accountability of the government.

Figure 1: Map of Sierra Leone. *Source*: (United Nations Environment Programme, 2010)

2.2 Civil war in Sierra Leone

"In March 1991, a small group of about one hundred guerrilla fighters entered eastern Sierra Leone from Liberia" (Peters, 2006), they were called Revolutionary United Front of Sierra Leone, and it was the beginning of the conflict in Sierra Leone. This was followed by a military coup and 11 long years of civil war.

RUF claimed that they want to restore a multi-party political system, but their initial support was miserable (Richards, 1996) Subsequently RUF grew bigger, as socially excluded and marginalized youths voluntarily joined this army (Peters and Richards, 1998). Others joined RUF just to save their lives and many were abducted. The diamond mines were the main target of RUF units (United Nations Environment Programme, 2010) generating numerous conflicts.

The poorly equipped governmental army was not able to face the RUFs attacks and also the government military troops started recruiting youths (Peters and Richards, 1998). Inability of the government to protect civilians forced the formation of the Civil Defence Forces (CDF, known as tamaboro or kamajo). In April 1992, a successful coup was made and the National Provisional Ruling Council (NPRC) was formed. NPRC troops immensely recruited their units among street kids, young criminals and frustrated youths. In 1993, RUF was forced to back up to Gola forests and to regroup (Peters, 2006). The RUF units established many jungle camps around the country which served as the base camps for their attacks. Figure 2 shows main bush camps of RUF troops. The camps are circled and three out of six are around Gola forests.

In May 1999, a peace negotiation started and an agreement was signed in Togo, giving RUF blanket amnesty and offering them governmental positions. Subsequently, 17 500 UN peacekeepers observed the disarmament and the demobilization, which actually started in May 2001 (Peters, 2006). It is estimated that the total number of combatants involved was in range 50 000–75 000, and about half of the RUF rebels were in the age range between 8-14 years (Peters and Richards, 1998).

Diamonds happened to be the driving force for all groups involved in the war. Although it might seem that diamonds brought all the problems into the country, many areas without diamond mines experienced violence and rebel attacks, too (Keen, 2003). The actual causes for the war were far more diverse, including: corruption, poverty, weak institutions, poor governance, injustice, unemployment, and insecure human rights (Keen, 2003). As stated by Richards (2005) *"Institutional failure, and not criminal 'greed', should be regarded as the motor of the Mano River conflicts."* The reason why the RUF units expanded so quickly was that in rural areas were predominately unemployed, marginalized, uneducated young men living in poor social and economic conditions. For them, joining the army meant escape and an opportunity to achieve more. This thrive is strongly embedded in Sierra Leones history and for more detail consider Chauveau and Richards (2008).

The end of the war was declared in January 2002. According to the UN (Kaldor and Vincent, 2006) this war caused 70 000-100 000 causalities, approximately 250 000 amputees (Dyfan, 2003), 4 000 abducted men (Ministry of Development and Economic Planning, 2003) and 2.6 million of displaced people (Kaldor and Vincent, 2006). After the war up to 72 000 ex-combatants had to be disarmed (United Nations Development Programme, 2011, Keen, 2003). Around 12 000 girls were forced to join armed troops, 257 000 women and girls were sexually abused or exploited (Dyfan, 2003). Since 2001, 543 000 people returned to their homes and these number are still increasing (United Nations, 2004).

Even though the war ended 11 years ago, its impacts are still noticeable. War in Sierra Leone affected economy, governance, civil society, environment, health, and education systems (United Nations Environment Programme, 2010). Economic and physical infrastructure, markets, institutions, social and human capital were destroyed, resources were exploited on excessive level, especially in rebel-held areas (USAID, 2007). Economic performance was hampered and nearly all economic activities ceased during the war. During this period, the country had a negative GDP growth, a budget deficit and a strongly increasing inflation. Only the damage to private and public buildings was estimated to be 120% of GDP (Ministry of Development and Economic Planning, 2003). Blattman and Annan (2010) described negative long term effects of this conflict, stand in contradiction to the results of Bellows and Miguel (2009) and Voors (2011). Latter authors did not report any persistent impacts of the war on household asset holdings, income and expenditure. This inconsistency is conspicuous.

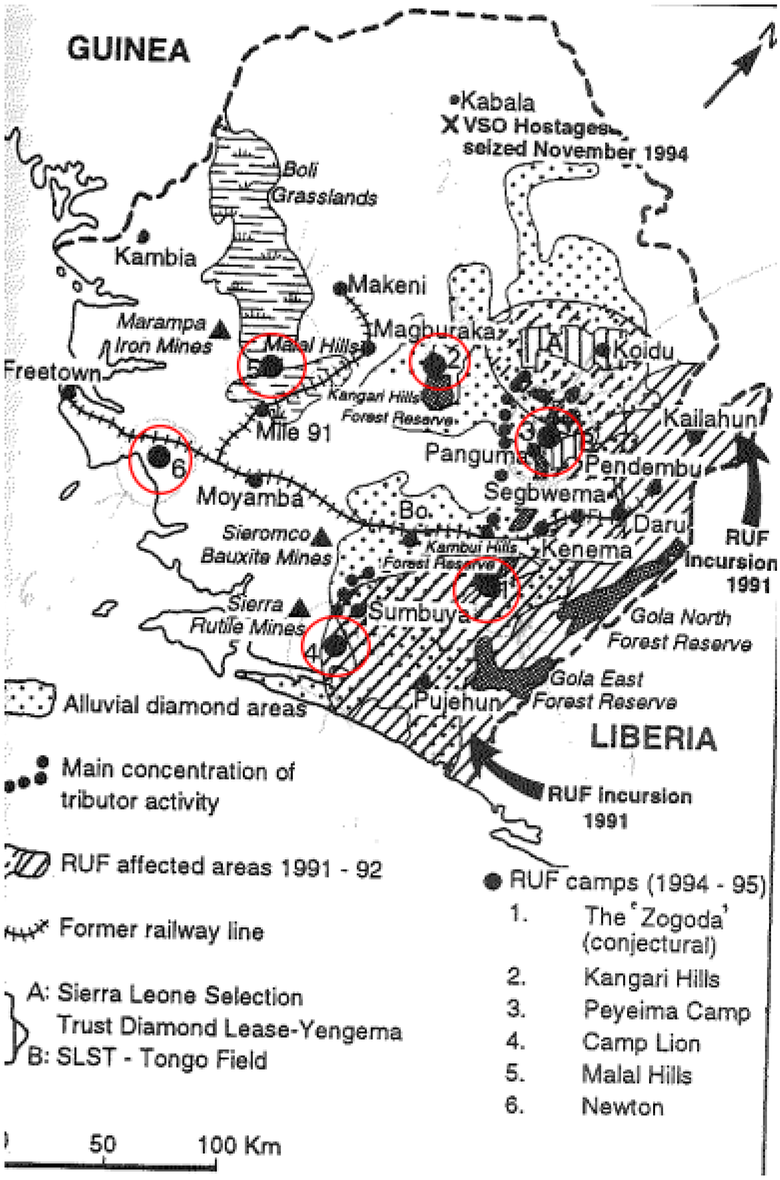


Figure 2: Map of RUF bush camps. *Source: (Richards, 1996)*

2.3 Forests in Sierra Leone

Sierra Leone's natural resources are very rich but severely degraded. According to Yale Centre for Environmental Law and Policy, Sierra Leone reached the lowest score out of 163 countries considered in the Environmental performance index which evaluates environmental degradation and environmental policies (Emerson et al., 2010).

Historically, Sierra Leone had huge forested areas with more than 70% of overall forest cover. Large parts of the forest were cleared during colonization. First surveys focused on deforestation were conducted in the beginning of 20th century and resulted in the foundation of the Forestry Department. The first forest reserves were defined, including the Gola Rainforests National Park as the biggest one (Squire, 2001). Currently, rainforests in Sierra Leone are sheltering a huge biodiversity of endemic species. Today, Sierra Leone has 55 protected areas, which cover about 4.5% of the country's surface area (United Nations Environment Programme, 2010).

This exceptional wild life is endangered. There is a huge pressure on forests due to the expansion of agriculture, increasing demand for firewood, increasing urbanization needs, searching for new mining sites, and increasing timber demand. Still today, 95% of the Sierra Leonean population is dependent on firewood as the main source of energy (Ministry of Development and Economic Planning, 2003). All these factors are a threat for biodiversity and particularly for the forests of Sierra Leone. The loss of biodiversity in the country has received interest since the 1960s (Squire, 2001). Deforestation was estimated at a rate of 0.7% per year (USAID, 2010). The civil war changed and accelerated processes related to the forest transformation. The United Nations Environmental Programme (2010) quotes the Ministry of Agriculture, Division of Forestry: "if the current deforestation trend does not change, Sierra Leone will be without any forests by 2018".

The present study focuses on villages around the Gola Rainforests National Park. Latter is part of the Upper Guinea forests, which is part of the forest belt, reaching from Guinea through Sierra Leone to Ghana. Myers (2000) defined it as one of the worlds 25 hotspots, or places with exceptional biodiversity, which are under the immediate threat of being destroyed. The Gola forest borders with Liberia and with 750 km^2 it is one of the most important forested covers in the area (Lindsell et al., 2011). It is located in the Eastern Province within the Pujehun, Kenema and Kailahun districts; within seven chiefdoms, namely Koya, Gaura, Tunkia and Nomo in the Kenema district, Barri and Makpele in the Pujehun district, and Malema in the Kailahun district (Klop et al., 2008) (see figure 3 and figure 6). It is divided into Gola North (the largest one), Gola West and Gola East. Since 1989 the Gola forest is under the conservation programme of the Royal Society for the Protection of Birds, the Conservation Society of Sierra Leone, where any logging or farming are banned. Furthermore, also communities around the forest agreed on a protective regime (Klop et al., 2008). Even if the communities own land in Gola they are not allowed to exploit it anymore. This study focuses on the community forests in the villages around Gola forest boundaries, which are allowed to be exploited by villagers. The villages around the forests were particularly destroyed (Richards, 1996) as RUF focused their attacks and activities to the surroundings of Gola forests.

Figure 3: Map of Sierra Leone and Gola Rainforest National Park in red. *Source: (Klop et al., 2008)*

3. DEFORESTATION, IMPACTS OF THE WAR AND OTHER FACTORS

Section 3.1 discusses the available literature on deforestation and its main drivers. Section 3.2 summarizes the impacts of the war based on scientific literature. Sections 3.2.1, 3.2.2 and 3.2.3 show the direct impacts of war and conflicts on forests and agriculture, fallow periods and commercial logging, respectively. The major indirect impacts of the war are described in section 3.2.4 preferences and social capital, in 3.2.5 property rights, and in section 3.2.6 human capital and labour supply. The impact pathways identified in this chapter are crucial links between deforestation drivers and the war.

3.1 Deforestation literature

The phenomenon of deforestation is widely discussed among scholars and attracts increasing attention. Concerns about tropical deforestation are currently increasing as they are related to issues like the greenhouse effect and climate change, loss of biodiversity, soil erosion and degradation, flooding, loss of nutrients, and threat to ecosystem (Kaimowitz and Angelsen, 1998). Scientists are trying to study land use changes, paying particular attention to forest clearing. They try to understand the driving factors behind the deforestation and why the stakeholders decide to clear the forest, which is then replaced by agricultural land or by infrastructure. Deforestation is the outcome of a diversity of pressures on the environment.

The early models of deforestation assumed the road and population density as the main drivers for forest clearing. Thereafter, scholars started to be concerned about the endogeneity problem[2] and started including other variables as biophysical drivers, such as (soil quality, elevation, precipitation). The most commonly tested driving factors are: population density, distance to road/market, soil quality, features of neighbouring plot, elevation, slope, distance to the forest, zoning etc. (factors are not ordered according to importance).

Geist and Lambin (2001) divided the driving factors of deforestation into proximate causes or direct causes (agricultural expansion, wood extraction and expansion of infrastructure), underlying causes or indirect causes (demographic pressure, economic, technological, policy and institutional, and cultural factors) and other factors (biophysical factors, land characteristics, social trigger events, shocks). War is categorized as one of the "other causes" which are considered to shape deforestation rather than to cause it. In this study we claim that the war directly affects the underlying causes, which mediate deforestation as shown in figure 4.

3.1.1 Demographic factors

The early models assumed population pressure to be the main and only driving force of deforestation and every deforestation model still deals with some measure of demographic pressure. Demographic aspects of deforestation process are widely discussed in scientific papers. Yet, recently it was found that there are other forces triggering deforestation (Walker, 2004).

Even though the demographic aspects of deforestation are widely discussed, there is no clear and firm conclusion about it. The first theory highlights positive aspect of increasing population: as more labour is available, more skills, lower production costs and new innovations resulting in decreasing deforestation (Kooten and Folmer, 2004,

[2] Feedback going from explained to explanatory variable causes unclear causal relationship between them. At the moment of studying the phenomenon, we cannot be sure in which way the effect goes. This can bias the results.

Brown and Pearce, 1994). The other theory claims that increasing population puts extra pressure on the environment resulting in an increasing deforestation. However, countries with the same population densities experience different losses in forest cover. Therefore, some scientists doubt population growth to be the direct cause of deforestation and rather consider population growth in the context of other variables like unequal tenure and poverty (Palo, 1994). Scholars from different disciplines have not found agreement on the relationship between population growth and its impact on development, environment and deforestation (Palo, 1994).

Even though, the evidence of negative impact of population prevails, the results are inconclusive.

Hypothesis (1): The population pressure may have both a negative and a positive impact on deforestation.

3.1.2 Access to the market

Roads increase access to the forests and to markets and this is believed to increase deforestation (Kooten and Folmer, 2004, Freitas et al., 2010). Nevertheless, Vance and Geoghegan (2002) mentioned an opposite effect of roads and easier market access. According to these authors, latter can increase the opportunities for off-farm employment which will decrease the pressure on the forests. However, they did not prove it and empirical evidence is missing for the positive impact of the roads. All deforestation models deal with some variable representing market accessibility.

Access to the market is difficult to measure and several approaches have been used in the past. It is usually measured as a distance either to the market or to the road based on satellite images, which can be problematic depending on the degree of terrain accessibility. Another approach is based on self-reported distances by individuals. Access to the market measured by distance brings a spatially explicit factor into the model (Irwin and Geoghegan, 2001).

Hypothesis (2): A shorter market distance decreases transaction costs and accelerates deforestation.

3.1.3 Topography

Topography is a biophysical factor widely mentioned in scientific literature as driving factor of deforestation together with population pressure and market distance. Traditional measures of topography are: soil quality, soil type, soil pH, nitrogen content, slope, etc. Cropper *et al.* (1999), Southgate *et al*. (1991), Etter *et al.* (2006), and Deininger and Minten (2002) found significant result between poor soil quality, steeper land and decreasing forest clearing.

Hypothesis (3): A better quality plot is more prone to deforestation.

3.2 Impacts of war

In section 2.2, discrepancies in impacts of the war in Sierra Leone were indicated. The mentioned contradictions are typical for the literature focused on this topic. There are two theories of after-war recovery and the actual impact of the war on the country's performance. The first opinion claims a purely negative impact as the war destroys physical capital and infrastructure, as concluded by Collier *et al.* (2003) in their World Bank report. These authors claimed that wars have long term consequences, with the persistence of poverty and misery. From the neo-classical theory's point of view, since the war destroys only capital, this should boost a country's economy and create rapid economic growth (Bellows and Miguel, 2006). On the other hand, Cramer (2006) and Korf (2003) mentioned positive aspects of a war since it can produce important changes. Korf (2003) even calls conflicts, "*driving forces of change and development.*" But what if the war does not affect only physical capital and infrastructure? What if there are even more important prevailing effects?

Collier *et al.* (2003) divided the impacts into economic costs and social costs. Economic costs include: increased government expenses on military equipment which crowds out investments into infrastructure, health or education; and destroyed infrastructure. Also agricultural asset is damaged as it is captured by soldiers or abandoned by the farmers (Collier et al., 2003). Civilians are one of the most affected groups in any civil war. Many civilians flee in order to avoid involvement in the conflict and recruitment. Many civilians are killed and some are deeply affected by the direct involvement in the war. These consequences are the social costs of the war (Collier et al., 2003). War favours disease outbreaks, the deterioration of human rights, negative economic development, and it destroys the health- and educational systems (Collier et al., 2007).

Figure 4 shows the expected relationship among the predictors and the dependent variables. The channels ("mediators") are deforestation drivers as well as the other factors and they could be together in the same group of deforestation drivers. However, for the purpose of this study, they are divided into the other factors ("drivers") and the channels, because the channels do interact with the war and they mediate the indirect impact of the war on deforestation.

The subsequent sections will discuss the major direct and indirect impact pathways identified. These are based on the main findings of present war and post-war literature. They are linked to the deforestation drivers mentioned in section 4.3. The first section (3.2.1) discusses the direct impacts of the war on the forests and on agriculture. Each section presents the identified pathways and the main evidence for their impacts.

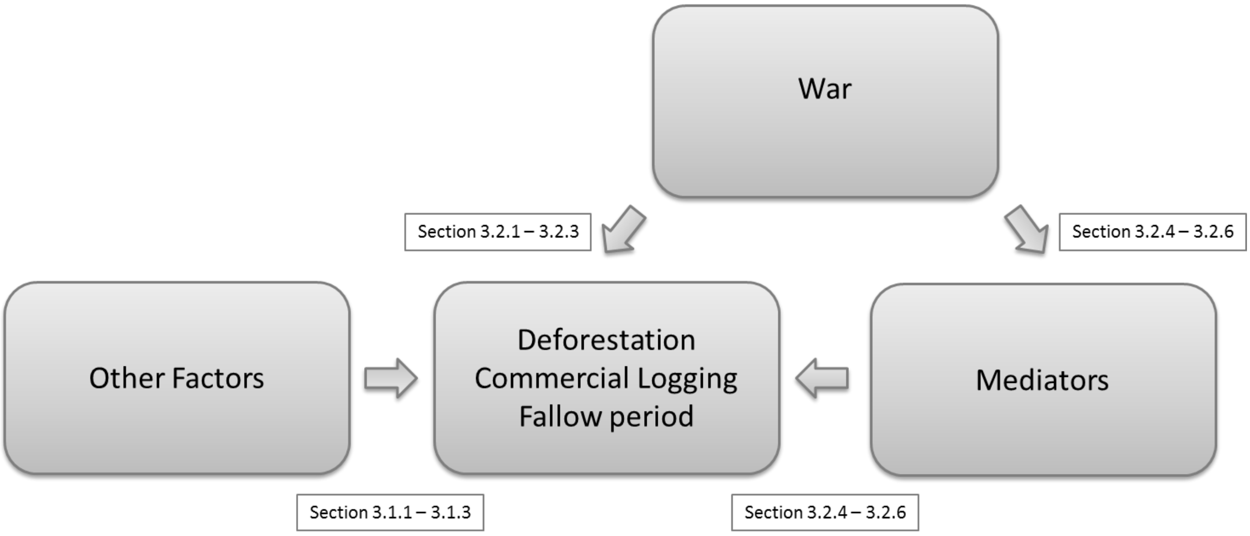


Figure 4: Impacts of war

3.2.1 Forests and agriculture

This section gives an overview on those studies focused on the war and its impacts on forest covers. Literature studying this topic is scarce and mainly direct impacts are discussed in a qualitative way, while no insight is given into the indirect driving forces. Nevertheless, these studies can be used as a starting point for the research on war and deforestation.

McNeely (2003) divided the effect of a war on the forests into direct and indirect impacts. The negative direct effects are caused by hunting, gathering, poaching, neglect of protected areas and destruction of biodiversity by armies. The indirect negative impacts are through the activities of refugees and internally displaced people. Some of the best studied examples are to be found in the Democratic Republic of Congo, a biodiversity-rich region affected by a civil war. In 1994, around 850 000 refugees lived around Virunga National Park and they cleared and destroyed about 300 km^2 of the forest while searching for food and firewood and collecting up to 410 to 770 tons of forest products every day (McNeely, 2003, Draulans and Van Krunkelsven, 2002). In latter scenario, the survival of many people was dependent on the forests' resources (McNeely, 2003). In some regions of the Congo commercial logging nearly stopped due to infrastructure damages, but on the other hand, illegal logging thrived in other areas (Draulans and Van Krunkelsven, 2002). Evidence for a large increase in illegal logging were also reported in the post-conflict Cambodia (Dudley et al., 2002). According to Kanyamibwa (1998), the forested areas in Rwanda suffered significantly from clearing mainly due to people displacement, new settlement establishment, and new agricultural land foundation.

Based on the above mentioned studies, a generally negative impact of a war on forests can be assumed. However, McNeely (2003) mentioned that also positive effects of a war may occur. Armies designate military restricted area thereby preventing hunting, logging or poaching. This was the case at the borders between Thailand and Malaysia where currently a national park is created based on former restricted areas in 60s and 70s. Also demilitarized zones, so called "no man's land" have the same effect as currently observed in Korea (McNeely, 2003). In addition, many people are forced to flee and to abandon their farms. This allows vegetation to recover and reduces pressure on environment. Leach (1994) gave examples from Sierra Leone itself in the 50s and 60s of the 19th century, where warfare led to depopulation and rapid forests regeneration. War also stops development projects, like infrastructure building, and that again leads to biodiversity recovery. However, these positive effects are random and rather accidental (McNeely, 2003).

Further evidence from war-torn countries is negative as well as positive. Stevens *et al.* (2011) and McNeely (2003) studied deforestation in Nicaragua using a remote sensing approach and detected that 15% of the area was deforested during conflicts and 10% of the total land area was reforested. The forest recuperation was in the period when the conflict in Nicaragua was intensifying. The same conclusion has also Suthakar and Bui (2008) who studied the land use changes in Jaffna Peninsula in Sri Lanka. Cultivated area decreased by 50% between 1982 and 1992 in Jaffna.

The impact of a war on forests and overall biodiversity can be devastating. But times of peace can do equal harm, especially in the case of low income countries. The peace after the war does not mean lowering pressure on forests and wildlife. As the infrastructure is destroyed, and supply channels do not work, there is instability and the locals still have to rely on wild animals harvesting and deforestation, to sustain their living. This aspect can be even escalated due to the lack of military forces and rebels, which create protected areas (Dudley et al., 2002). Weak institutions, insecure property rights, illegal activities (poaching, logging), agricultural activities and limited funds for conservation activities can be as destructive as the war itself, as it was in the case in Vietnam, Laos, Nicaragua, and Indonesia (McNeely, 2003).

As previously discussed, the scarce literature available, allows some insight into the direct effects of warfare on deforestation. However, the indirect effects through economic, social and institutional drivers among others, deserves further attention in research. If people increase clearing in the post-conflict regions what drives them? Why do they change patterns of deforestation? To our knowledge there is no available literature concerning this field of social science.

The direct impacts of the war on deforestation are assumed to be positive as many farms are left idle. Direct negative effects are not expected in the case of Sierra Leone, because neither heavy weapons, chemical weapons nor tanks, mines and bombs were used.

Hypothesis (4): The civil war in Sierra Leone is assumed to decrease deforestation due to population displacement and abandoned farms.

3.2.2 Fallow period

The fallow period is a crucial factor in the deforestation process, it indicates how long farmers leave the land idle before it is again cleared and farmed. Fallow period is used in shifting (slash-and-burn) agriculture to allow soil recovery and weed suppression (Gleave, 1996). It is considered one of the proximate drivers of deforestation, however, fallow systems also allow forests to recover (Ickowitz, 2006). The main concern is about fallow period shortening which causes unsustainable land exploitation, land degradation and a high environmental pressure (Gleave, 1996).

Previous research has investigated fallow periods in Sierra. Gleave (1996) used data from the national survey in Sierra Leone from 1965/6. The fallow periods reported ranged between years 3 and 20, with 75% of the cases in the range of 7-14 years; however, with high variability among households and crops. Leach (1994) reported usual fallow period of 8-15 years in the area around Gola forests. Gleave (1996) summarized the underlying decisive factors of the fallow periods into population pressure, environmental factors (rainfalls, soil type), plot accessibility and farmers' management practices. Karimu and Richards (1980, quoted by Gleave, 1996) found evidence that changes in fallow periods are caused by labour supply limitations and access to land. Richards (1996, quoted by Ickowitz, 2006) pointed out that farmers make decisions for every particular plot of a land based on soil characteristics and labour availability.

Slash-and-burn agriculture changed the countryside around Gola forests into mosaics of fallow bushes (Leach, 1994). Leach (1994) reported visible changes in the area of Gola forest as a consequence of fallow period shortening and population pressure. However, she added that these changes are "buffered" by a large availability of the high forest land and fallow bush. USAID report (2007) and Mohammed et al. (2004) explicitly mentioned a shortening of a the fallow periods in Sierra Leone.

Richards (1996), Leach (1994) and Maconachie (2008) identified labour scarcity as a problem in Sierra Leone rather than land scarcity. This would suggest longer fallow periods. However, we have to consider that the longer an idle period is, the more difficult the forest clearing becomes (Ickowitz, 2006). Bush older than 25 years requires twice as much labour as bush aged 8-12 years (Leach, 1994). Only two households tackled high forest (older than 20 years) in the research of Leach (1994). According to subjective observations in the villages surrounding Gola forests, the war decreased labour supply (Kontoleon, 2012), which is expected to prolong the fallow periods. Post-war food insecurity likely contributed to the shortening of the fallow period. Insecurity of a renewed war could also have changed the perspective of long term fallows.

Hypothesis (5): The civil war might affect the fallow period length due to labour scarcity, uncertainty, insecurity and the risk of a renewed war.

3.2.3 Commercial logging

Commercial logging is considered another driver for deforestation. Geist and Lambin (2001) defined logging as one of the proximate causes of deforestation together with agriculture and infrastructure expansion. Squire (2001) discussed examples of an overwhelming illegal concession issuing during the war in Sierra Leone, and Hatton *et al.* (2001) reported the same trend in post-war Mozambique. Timber business in Sierra Leone was re-established in the post-war period but mostly local operators were involved in commercial logging in an uncontrolled manner as stated by Peters (2006). Kenema is the main timber business centre and struggles with the illegal commercial logging by domestic and foreign operators. Exact data on commercial logging are missing but the report of UNEP (2010) reached the same conclusion as Peters (2006), namely that timber harvesting is uncontrollably expanding. According to the USAID report (USAID, 2010), the timber industry is not representative for the national economy and in the official statistics timber export is not mentioned at all. However, collected concession fees tell a different story. Peters (2006) adds that Kambui Hills Forest Reserve almost disappeared since the end of the war due to commercial logging. Chiefdoms profit from commercial logging as they receive compensations based on the harvested volume (United Nations Environment Programme, 2010) which could function as an incentive for excessive logging.

Hypothesis (6): The civil war might have both a positive and a negative impact on the probability of commercial exploitation of the forests.

3.2.4 Preferences and social capital

Mortality rate is a common measurement for the social costs of a war. However, mortality is not the only human damage for a conflicted country as Collier *et al.* (2007) named it. Among others are health costs and psychological damages. Ghobarah *et al.* (2003) found a long term effect of war on death and disability rates even long after the conflict terminates. It is not clear which institutions are exactly affected by a war, by how much and in which way (Blattman and Miguel, 2010). Richards (1996) pointed out institution deterioration as one of the applied strategies during the war in Sierra Leone. RUF sent young soldiers to attack their own villages in order to destroy social relationships there. In that manner, rebels could then easily access destroyed communities. RUF belligerents deliberately destroyed also institutions by targeting village chiefs, damaging schools and courthouses.

Psychological damages are not as easy to measure as mortality rate. Mental health of victims and people involved in an armed conflict are threatened and could be affected deeply. They lose families, neighbours, village inhabitants, their livelihood, and identity; they are witnesses of many atrocities. Those traumas have persistent consequences and affect individuals' behaviour, values, beliefs and preferences. This is confirmed by the findings of Blattman (2009), Voors *et al.* (2012), Voors *et al.* (2010), Bellows and Miguel (2006) Nillesen (2010) and Bellows and Miguel (2009) who reported changes in preferences of conflict victims. Bellows and Miguel (2009) defined two pathways, on how violence can affect behaviour. The first one is trauma which changes behaviour, preferences, values and beliefs. The second pathway is that conflicts help forming new institutions, social capital and norms. There are again two theories, one supporting a negative impact and one supporting a positive impact of warfare on preferences.

Supporters of negative impacts claim that institutions are usually disrupted during conflicts (Maconachie, 2008). Clover *et al.* (2004) and Korf (2003) share the same opinion regarding deterioration of social capital as one of the consequence of a violent conflict. Warfare causes mistrust, deteriorates relationships, distorts traditional cooperation networks, weakens moral and social rules (Clover et al., 2004). Opportunistic behaviour, rent seeking and moral hazard become prominent behaviours during a conflict due to increased risk, uncertainty, and distortion of social order. The time horizon decreases rapidly and people reconsider investments into any capital including social capital because the return to the investment is highly insecure (Korf, 2003). Grootaert and Bastelaer (2001) and Collier *et al.* (2007) proposed a prevalence of negative impact. Maconachie (2008) found a deterioration of traditional labour reciprocal relationships, social networks and co-operation in the Eastern Province of Sierra Leone.

There is a general assumption that conflicts and wars deteriorate social capital and institution, however, there is little empirical evidence about it (Goodhand et al., 2000). Blattman and Miguel (2010) stated that social and institutional impacts are the most important effects of a war. Clover *et al.* (2004) and Richards *et al.* (2004) argue that war strengthens social relationships or creates new ones. Bellows and Miguel (2009) found positive relationship between the provision of public goods, local social actions, social capital and violence in Sierra Leone. This is also confirmed by the outcome of a governmental survey, performed in 2005, where 60% of their respondents stated a positive impact of the war on how community works together (Bellows and Miguel, 2006). Goodhand *et al*. (2000) studied the impact of conflicts in Sri Lanka on social capital and discussed that, on one hand, people return to "*traditional sources of social capital*", and on the other hand, they launch on social changes. Voors *et al.* (2010) and Voors *et al.* (2012) studied the impact of violent conflicts on timing, riskiness, and social dimensions in Burundi and found that violence affects behaviour via changing preferences. People who experienced violent conflicts, have higher level of trust, are more altruistic, are more risk seeking, and have a higher discount rate. Victims were more trusting and more willing to contribute to public goods. Also Blattman (2009), Gilligan *et al.* (2011)and Voors *et al.* (2012) found a positive relationship between violent conflicts and social relationships.

Bouma *et al.* (2008) studied the relationship between social capital and the investments into local semi-public goods. Trust, as a proxy of social capital, is correlated with participation in community resource management, as long as activities are not subsidized. All villagers benefit from sustainable management of the forests, thus the higher level of social capital has a positive effect on investments into sustainable practices (Bouma et al., 2008). Beekman and Bulte (2012) called it spillover of positive externalities; they found a significant correlation between trust in other people on individual level and investments into erosion management. Strong social sanctions can be used in cases of overexploitation (Anderies et al., 2011). Godoy *et al.* (1998) tested the impact of time preferences on deforestation and found that more impatient household heads tend to clear less as they rather chose wage labour.

Recently, increasing quantitative evidence can be found on a positive impact of war on preferences, behaviour and social capital. However, there is no clear and firm conclusion how the armed conflicts affect preferences. Therefore, the hypothesis (7) is without given direction of expected effect of the war on preferences.

Hypothesis (7): The civil war might affect social capital and preferences and this may effect deforestation.

3.2.5 Property rights

Evidence and empirical studies regarding the effect of a war on property rights can be hardly found. According to a pessimistic theory of the impact of a war on institutions, property rights security deteriorates in the post-war period (Justino, 2010, Collier, 1999). Most qualitative studies favour a negative impact of a war on property rights. Interestingly, André and Platteau (1998) studied the war impacts in the context of land tenure systems, in post-conflict Rwanda. They found that land scarcity and the struggle for survival affected social relationships and lend tenure systems itself. The war acted as a catalyst for personal matters and conflicts. Persons causing any conflicts over land tenure were wiped out during the war which likely affected property rights and increased stability of the land tenure systems. Voors (2011) presented surprising empirical evidence in his study, claiming that the war increased land tenure security in post-war Burundi.

The aspect of property rights and their impacts on deforestation receives more attention and it is clear that insecurity increases deforestation. Mendelshon (1994), Geist and Lambin (2001), Southgate *et al.* (1991), Araujo *et al.* (2009) in Brazilian Amazon, Somanathan (1991) in Central Himalaya, Deacon (1999) and Godoy *et al.* (1998) showed that insecure property rights lead to higher deforestation. Deacon (1994) also found a positive relationship between insecure property rights, in time of instability, measured as lawlessness, instability, revolutions, assassinations and governmental changes in a sample of 120 countries. Bohn and Deacon (2000) found that political instability (revolutions, assassinations, guerrillas) increases insecurity of ownership and deforestation probability. Thus farmers choose clearing as a risk management strategy yielding immediate return rather than conservation and sustainable forest exploitation (Araujo et al., 2009). Furthermore, an insecure land tenure system decreases investments into soil management (Beekman and Bulte, 2012).

The impact of a war on property right regimes is yet poorly studied and therefore it is difficult to establish a justified hypothesis. However, it seems that property rights insecurity might increase deforestation. If a negative impact of a war on property rights regimes is assumed, then the deforestation is likely to increase as the outcome of more difficult living conditions.

Hypothesis (8): The civil war might have both a positive and a negative effect on the property rights regimes, thereby affecting deforestation rate.

3.2.6 Human capital and labour supply

The civil war in Sierra Leone affected human capital and labour supply substantially, especially in rural areas through causalities, injuries, health and education deterioration and loss of skills (Kondylis, 2008). 4 000 young men were abducted (Ministry of Development and Economic Planning, 2003), many young people joined one of the armed forces voluntarily and many of them never came back to their homes. This rapidly increased the number of female headed households (Mohammed et al., 2004). Amputees were a common consequence of this civil war. Amputations were done during the war (Dyfan, 2003) and left many people disabled. Human capital and labour supply were changed substantially.

The other aspect of human capital changes was a drop of school attendance, especially in the Northern and Eastern Provinces (Mohammed et al., 2004) as the RUF troops deliberately destroyed schools. Shemyakina (2011) and Chamarbagwala and Morán (2011) found a negative relationship between the war in Tajikistan and Guatemala, respectively, and school attendance. In Sierra Leone, school attendance dropped rapidly between 1990-2000 and the rate was 35% in the Eastern Province in 2000 (Mohammed et al., 2004). However, Bellows and Miguel (2006) did not find any significant impact of the war in Sierra Leone on school enrolment. Kondylis (2008, 2010) studied a comparison of stayers and returnees in post-conflict Rwanda. He found that returnees have a lower stock of agricultural know-how compared to stayers.

Geoghegan *et al.* (2001) and Godoy *et al.* (1997) reported a negative relationship between education level and deforestation rate; as the skills and knowledge increases there is less demand for clearance with modern technologies and more off-farm opportunities. Adesina *et al.* (2000) detected a positive relationship between education level and likelihood of adopting conservation techniques. So a higher literacy rate and increased human capital is expected to decrease deforestation and induce pro-conservation behaviour (Meyer et al., 2003). However, Voors et al. (2011) found negative relationship of education with illegal logging but also with pro-conservation preferences.

Anecdotes say that labour supply was deeply affected by the war in the villages around Gola forest (Kontoleon, 2012). Maconachie (2008) investigated the impact of the war on reciprocal relationships with respect to labour and labour supply. The most common pattern among answers was that poverty made reciprocal relationships progressively problematic, and reciprocal farming relationships in post-war regions are exclusively within family network and not within village networks anymore. Furthermore, cultivation of new land is restricted by labour supply limits. Maconachie and Binns (2007) interviewed farmers who expressed concern about decreased labour supply as youths were attracted more to the mining sector after the war. However, respondents of Richards (1996) were lacking any interest in the diamond sector as long term source of income. Unruh and Turray (2006) discussed the issue of war and mining sector changing the labour market. Labour in rural areas is monetized; people are less willing to work for communities or to take part in traditional labour relationships.

Based on the indications above, a deteriorated human capital, decreased health condition and a drop in school enrolment can be direct results of a war. However, conclusions are not firm. On the other hand, labour supply decreases suggest diminishing deforestation rate in the affected areas. Observations in the areas around Gola forests show that war decreased labour supply and by that decreased deforestation rate (Kontoleon, 2012).

Hypothesis (9): The civil war might have both a positive or a negative impact on human capital and thus on deforestation.

Hypothesis (10): The war decreases labour supply and thereby decreases the deforestation rate.

4. DATA AND METHODS

The first section 4.1 introduces the data set, section 4.2 describes the model which the empirical analysis is based on. Section 4.3 discusses the quantification of the main deforestation drivers and the war impacts. Sections 4.4 and 4.5 outline the sampling strategy and the main methods used for the data analysis.

4.1 Data

Primary data used were obtained from three separate surveys from the region around Gola Rainforests National Park. Two of the surveys are on the village level conducted in February-March 2011 and February-April 2010 and one on the household level from 2010. Data from the village survey 2010 and the household level survey 2010 matched in village cases and are combined for the purposes of the analyses.

176 villages and 2 460 households were visited in 7 chiefdoms. See Table 1 for details on number of villages per chiefdom and number of households per chiefdom. On the village level survey, there were up to 8 interviewees per village. In 96% cases, the village chief was interviewed. Among the others interviewed were chief assistants, elders, youth leaders, town speakers, chief lady, quarter head and women's leaders. The household level respondents were mainly heads of households, wives, children, parents of head of household. Respondents were interviewed with structured questionnaire. Information obtained from the village level survey 2010 was[3]:

- Respondents characteristics (name, title)
- General village information (foundation, chief characteristics, population information, ethnicity, village equipment, village distances to services and infrastructure, development projects present, land farmed and owned by the entire village)
- Village bylaws and community club rules
- Village institutions
- Experienced common shocks
- History of the war
- Conflicts and disputes
- Witchcraft issue
- Perceptions of the Gola Forest Programme and uses of Gola forest

Information obtained from the household level survey was[4]:

- Respondents characteristics (name, gender, age, relationship to head of household, literacy, religion, tribe)
- Household characteristics and changes within the households over the past years
- Household's upland, swamp and plantation farming information
- Household expenditures, assets, labour
- Migration during the war, the war shocks, conflicts and civilian cases
- Household finances
- Conservation attitude and preferences
- Social capital and social support matters

[3] The full survey is available online on http://www.dec.wur.nl/NR/rdonlyres/3F666B4B-DA72-4808-A45C-BE4944BCC40A/147457/GOLA2010CommunitySurvey1.pdf.
[4] The full survey is available online on http://www.dec.wur.nl/NR/rdonlyres/3F666B4B-DA72-4808-A45C-BE4944BCC40A/147456/GOLAForestProgramBaselineSurvey2011.pdf.

The Village questionnaires include also retrospective questions from the year 1990 before the war: total population 1990, infrastructure distances and number of buildings and developing projects in 1990.

In 86.4% cases 15 households per village were interviewed. On average, there are 13.9 households; the minimum is 2 household and maximum 15 households. Data obtained on the household level are aggregated to the village level as the average of the households involved.

Table 1: Table of chiefdoms

Province	Chiefdom	Number of villages	Number of households
Southern	Barri	32	469
Southern	Makpele	24	340
Eastern	Gaura	29	431
Eastern	Koya	18	248
Eastern	Malema	35	437
Eastern	Nomo	15	193
Eastern	Tunkia	24	342

4.2 Empirical model

This section introduces the empirical models the analysis is based on, discusses the origins of the models, their concerns and differences.

The model used for the analysis deals with direct and indirect impacts of a shock on deforestation. There is a lack of developed empirical models dealing with shocks and deforestation. Fisher and Shively (2005) were the only one, to our knowledge, who constructed a model of the shock and deforestation. Even though they dealt with an income shock, which is conceptually different kind of shock than a war, their model is very general and flexible and is still applicable also for this case of the war.

I base my empirical model on the model of Fisher and Shively (2005), who studied impact of a positive income shock (governmental seed assistance package) on deforestation in Malawi, and Andrade de Sá et al. (2011) who studied indirect impact of an expanded sugarcane production in Southern Brazil on deforestation of Amazon forest through cattle ranching displacement[5]. Both models analyze a reduced form regression predicting deforestation with a given range of characteristics.

In the present empirical model (1), a deforestation rate is a function of the pre-war village characteristics, the war variables and the interaction terms between them. This model of pre-war variables has systematically the same form as the following model (2); however, they are conceptually different and answer different questions. The pre-war variables model allows conditioning testing of the pre-war characteristics on current deforestation. On the other hand, model (2) tests impact of current drivers on current deforestation. The model (1) is presented below:

$$y_{j2010} = \alpha_0 + \sum \alpha_1 X_{j1990} + \sum \alpha_2 Z_{jt} + \sum \alpha_3 X_{j1990} Z_{jt} + \varepsilon_{jt} \qquad (1)$$

Where: y_{j2010} is a measure of deforestation rate in village j in 2010

X_{j1990} represents a vector of pre-war village specific characteristics in 1990 and a dummy variable for fixed chiefdom effect

Z_{jt} represents a vector of the war variables

[5] Both models are described in appendix 2.

$X_{j1990}Z_{jt}$ denotes interaction terms between the pre-war village characteristics and the shock
ε_{jt} is an error term

This is the full model (1) which was gradually developed. Testing of the pre-war variables model starts with including only the village characteristics in order to trace impact of them on deforestation, as shown in sub-model (1a):

$$y_{j2010} = \alpha_0 + \sum \alpha_1 X_{j1990} + \varepsilon_{jt} \quad (1a)$$

The sub-model (1a) is further developed and includes the war variables in sub-model (1b):

$$y_{j2010} = \alpha_0 + \sum \alpha_1 X_{j1990} + \sum \alpha_2 Z_{jt} + \varepsilon_{jt} \quad (1b)$$

The sub-model (1b) is gradually developed into the full model by including the indirect effect of the war (1).

The second model estimated in the empirical analysis is the model of the current village characteristics, the war variables, the mediating channels and the interaction terms between the channels and the war shock. The model (2) is presented below:

$$y_{jt} = \alpha_0 + \sum \alpha_1 X_{jt} + \sum \alpha_2 Z_{jt} + \sum \alpha_3 S_{jt} + \sum \alpha_4 X_{jt} Z_{jt} + \sum \alpha_5 S_{jt} Z_{jt} + \varepsilon_{jt} \quad (2)$$

Where: y_{jt} is a measure of dependent variable in village j
X_{jt} represents a vector of the village specific characteristics and dummy variable for fixed chiefdom effect
Z_{jt} represents a vector of war variables
S_{jt} represents defined channels
$X_{jt}Z_{jt}$ denotes interaction terms between some of the village characteristics and the shock
$S_{jt}Z_{jt}$ represents interaction terms of the channels with the war variables
ε_{jt} is an error term

Again, this model (2) represents the full model which was gradually tested. First, only village characteristics are analysed in the sub-model (2a):

$$y_{jt} = \alpha_0 + \sum \alpha_1 X_{jt} + \varepsilon_{jt} \quad (2a)$$

The sub-model (2b) tests only relationship between the war and the predicted variable without any other control variables in order to understand a direct effect of the war:

$$y_{jt} = \alpha_0 + \sum \alpha_2 Z_{jt} + \varepsilon_{jt} \quad (2b)$$

The sub-model (2c) examines all direct effects within the model (2):

$$y_{jt} = \alpha_0 + \sum \alpha_1 X_{jt} + \sum \alpha_2 Z_{jt} + \sum \alpha_3 S_{jt} + \varepsilon_{jt} \quad (2c)$$

In the full model (2), all direct and indirect effects are tested. Our model (2) allows testing of direct and indirect effects of current drivers on current deforestation rate. This model (2) is used for empirical analyses in chapter 5. This model is used for deforestation model as well as for commercial logging and fallow period models. They use systematically the same model but measure of dependent variable is changing – a rate of deforestation, presence of commercial logging and years of fallow periods. Therefore, y_{jt} as a measure of dependent variable is different for every particular model.

The model (2) testing deforestation rate is concerned with the endogeneity problem[6]. Therefore, the causal relationship is unclear and the model describes correlations among explanatory and explained variables rather than causal relations. The war variables are concerned with the endogeneity problem as the war spread could have been driven by some of the independent variables (discussed in section 5.2.5). All other drivers might be affected by the endogeneity. The variables which are not concerned with endogeneity are: rain shock 2009, slope of the farm, market distance[7].

However, even relationships explaining correlations between predictors and deforestation rate are very helpful in drawing overall picture of deforestation process with respect to the war. We can describe the underlying patterns based on correlations. This is the first study in this field and even correlations patterns shed light upon the relationships among selected variables. The pre-war variables model is not concerned with this causal relationship problem as the pre-war characteristics are used. However, there is limited range of pre-war variables. Both models together help understanding of relationships among the war, the pre-war and post-war village characteristics, and land clearance. It is very useful to look at both models as they give us overall picture of the upland farming patterns. Each of the models is based on different range of the village characteristics which gives us opportunity to see wider picture.

Those models are rather in their general form which provides more flexibility. This paper studies the effect of the war on different villages and its impacts on deforestation, commercial logging and fallow period. Shock is allowed to impact dependent variable measure directly in the model and indirectly via channels in interaction term. I explicitly assume that the war does not have only direct impact but also indirect impacts on deforestation through the channels.

Current economic scientific papers focusing on land use change are Bockstael (1996) who built an economic model for land use change, Pfaff (1999) who further developed economic model for deforestation, Irwin and Bockstael (2002) who improved model for urban settlement and others. Angelsen and Kaimowitz (1999) summarized scientific papers with economic background.

4.3 Channels and variables

The impacts of the war and deforestation drivers are defined in chapter 3. This section defines their measures. The war variables are discussed first as the treatment variables in section 4.3.1, channels in section 4.3.2, dependent variables measures in section 4.3.3, and the other drivers in sections 4.3.4-4.3.8.

If we assemble the war impacts defined by Collier et al. (2003) and Collier et al. (2007) and the causes of deforestation defined by Geist and Lambin (2001), we get three groups of the war impacts and deforestation causes. Logical grouping of the shock impacts with deforestation causes is following in table 2.

[6] Other models do not suffer from the endogeneity problem.

[7] Chomitz and Gray (1996) claim that market distance endogeneity can be overcome by controlling for slope of the plots and soil type and quality.

Table 2: The war impacts and deforestation drivers identified

War impacts	Deforestation drivers	Channels identified
Health, education, mortality, diseases, injuries, displacement, migration	Labour availability	Human capital and labour supply
Psychological traumas	Attitudes, values, beliefs	Preferences, attitudes, beliefs
Institutions and social capital	Institutions, policies	Property rights and social capital

We identify three channels how the war impacts deforestation indirectly, (i) human capital and labour supply, (ii) preferences attitudes, and beliefs, (iii) property rights, and social capital. Macroeconomic costs and factors are omitted as there is focus on microeconomic level. Technological aspect is not mentioned here because technology was neither part of the war nor part of deforestation in Sierra Leone. Those channels intermediate indirect effects of the war on deforestation. Figure 5 shows expected relationships of the variables.

4.3.1 War variables

Four war variables are chosen as a measurement for intensity of the war – scaled number of dead and permanently displaced, scaled number of temporarily displaced, number of attacks and village chief killed. I believe they have different indirect effects on deforestation. I assume differential impacts of the individual war variables on channels and their indirect impact on deforestation. I do not expect them to have different impacts on deforestation itself[8]. The four war variables are selected from the available range of the war characteristics and they are evaluated as the best measures of the war[9]. The expected different indirect effects are explained in the sections 4.3.1.1 – 4.3.1.3. Dead and permanently and temporarily displaced might mainly impact on labour supply, human capital and social capital; number of attacks might affect preferences and social capital; and village chief killed can affect institutions. Surprisingly, the selected war variables are not highly correlated (see section 5.1.2) which might also give evidence that they have differential impacts.

Firstly, the war index was constructed as averaged dummies of the chosen war variables. This is the same approach as Voors (2011), Voors et al. (2010) and Bellows and Miguel (2009) used[10]. But this appeared to be highly insufficient to build good model and to capture all the information. The effects within this war index cancelled out. As the outcome the war index was split back into separate war variables. Even though treating the war variables separately increases number of variables in the model, this method is chosen preferably as crucial for the better understanding of underlying processes in the model.

The selected war variables have direct effect on deforestation and at the same time they interact with all the channels to capture their indirect effect on deforestation[11]. They are believed to be proper measures of the war intensity and to have significant

[8] This is evident in hypothesis (4).
[9] Dummy of recruitment and property destruction dummy were considered and evaluated as redundant in the analyses. Other measures of the war were not available.
[10] They constructed victimization index based on experience of death, attacks, thefts, forced labour, rapes, injuries, property destruction. Gilligan et al. (2011) have the same approach but their household victimization index includes only one dummy variable based on death, injury, property destruction and displacement.
[11] These interaction terms increased number of variables and it required their reduction. Factor analysis could have been appropriate method but as the dummy variables are included as well then it cannot be used. I applied factor analysis on the continuous war variables but it did not produce strong factors. Consequently, variables were reduced based on logical processes and based on scientific literature.

effect on deforestation and its drivers. All war variables are based on village survey 2010 and they are presented in the following sections.

4.3.1.1 Dead and displaced population

Number of dead and displaced people is believed to be the main measure of the war intensity. Dead people variable is a ratio of killed people over the total village population in 1990. Factor of killed people is assumed to affect labour supply, human capital and social capital.

Displacement is divided into temporary and permanent because they are expected to have differential effects. Permanent displacement is summed together with the number of killed people because they are assumed to have the same effect on the channels, such as labour supply, human and social capital. Both will be represented by one variable of number of deaths and number of people permanently displaced over the total village population in 1990.

Temporary displacement could have different effects on channels rather than permanently displaced. Number of temporarily displaced people is a share of total village population in 1990 assuming to have an effect on human and social capital.

4.3.1.2 Number of attacks

The number of attacks is used as the measurement of the war severity. This war variable might affect preferences and social capital. It includes attacks of any of the armed troops during the whole period of the war.

4.3.1.3 Village chief killed

Dummy variable of a killed village chief is selected because the RUF forces were deliberately targeting the village chiefs to distort institutions and communities (section 0). The fact if village chief was killed could affect institutions, namely social capital and property rights.

4.3.2 Channels

This section introduces and describes selected channels which are assumed to have direct and indirect effects on the deforestation rate.

4.3.2.1 Human capital and labour supply

Three variables are chosen to measure human capital and labour supply – human capital expenditures, level of literacy and dependency ratio.

A traditional method of human capital measuring is chosen, particularly a cost-based approach. It is restricted only to directly defined investments into health and education. It is a share of expenditures for education (school fees, books, school uniforms, and other) and for health (medicines, hospital staying, herbalist, and other) over total expenditures (consumption goods and durable goods).

Literacy level is used to measure human capital. It is share of literate household heads. Differences in languages are not considered.

Dependency ratio is used as a proxy for labour supply. Ratio is counted as s sum of household members in age of 0 to 13.99 and 65 + over the number of household members in age 14 to 64.99. A denominator represents productive population and numerator inactive population. This represents number of dependents per working-age population expressing labour availability.

All variables are retrieved from the household level survey 2010 and aggregated to the village level.

4.3.2.2 Social capital and property rights

Institutions, as drivers of deforestation, are measured as social capital and property rights. We can distinguish several methods of measuring social capital: (i) self-reported measures[12], (ii) behavioural games measuring social capital indirectly[13], (iii) social capital measured as weighted membership and participation in community organisations[14]. Social capital measured by the self-reported questions is selected. This is due to data availability limitation for the other two methods. The self-reporting questions are concerning (i) trust towards household members, kin and friends in the village; (ii) asked help within the household members, kin and friends in the village. It is considered as the proper measurement of social capital. Those two components were averaged into one dummy variable – low level of social capital and high level of social capital. Data are from the household level survey and aggregated to the village level.

I follow the approach of Godoy et al. (1998) and Puppim de Oliveira (2008) who identified that insecure property rights increase conflicts over the land and increase deforestation rate. Property rights are measured as conflicts over the land and if anyone can claim the farmed land. Dummy variable of conflict over land in past years is retrieved from the village level survey 2010 and claims over the farmed land from the household level data and aggregated. Those two dummy variables are averaged into one variable.

4.3.2.3 Pro-conservation preferences

Preferences are measured with respect to forest and pro-conservation attitude. Preferences variables are: willingness to set aside community forest as natural reservation, willingness to set aside community forest as reservation financially compensated by the government, and any community forest already set aside as a natural reserve. Those three variables are averaged into one variable of a willingness to preserve. Willingness to set aside part of the forest is based on the information of the household level survey and aggregated; the others are from the village level survey.

4.3.3 Dependent variables

Three dependent variables are described in three following sub-sections. Deforestation rate is selected as the major dependent variables for the pre-war variables model and the main deforestation model. Fallow periods and commercial logging are studied as well in order to complete information about the impacts of the war on forests in Sierra Leone and to better understand process of deforestation.

4.3.3.1 Deforestation rate

The main dependent variable chosen for the deforestation model is a ratio of farmed upland land over the total land owned on the village level retrieved from the village survey in 2010. Upland farmed is assumed to be a proxy for the deforestation rate.

Every year a new plot is cleared for new rice farm and last year farm is left fallow or used for another crop; rice is staple food in this region and upland is used mainly for the rice production (Leach, 1994). Because every year the new plot has to be cleared to establish new rice farm, this clearance is assumed to be a deforestation rate. This is supported by the results of the village survey 2011. This survey provides precise information for the forested land owned by the village. The ratio of forested area over the total area owned is highly negatively correlated with the ratio of upland land over the total land owned. Based on above mentioned information, we assume that the ratio of

[12] This method is used in papers of Bellows and Miguel (2009), Maconachie (2008), and Blattman (2009).
[13] This measurement is preferred by Voors (2011), Nillesen (2010) and Gilligan et al. (2011)
[14] Approach of Narayan and Pritchett (1999)

farmed upland to the total land owned is a good predictor of deforestation. Moreover, deforestation in developing countries is mainly conversion of tropical forest into agricultural land (Food and Agricultural Organization, 2010). Richards (1996) studied perception of people around Gola forests about deforestation and forest itself. Respondents believed in decreasing forest cover, and they named as the main causes of deforestation in Gola forest region farming, then construction, expansion of settlements and road building, commercial logging and mining. Geist and Lambin (2002) studied 152 sub-national case studies and found out that the most of the cases are driven by the more factors. Agricultural expansion is considered as the most frequent cause of deforestation.

Kummer and Sham (1994) stressed the role of dependent variable in deforestation models and they actually doubted plausibility of using forest cover as a proxy for deforestation which does not have to capture the entire process of clearing and they rather recommend loss of forest cover as a better approximation of deforestation. Agricultural expansion is considered as a forest loss in the present study.

Figure 5 shows the expected relationships between the war as a treatment variable, the channels defined in the previous sections and upland farming used as the proxy for deforestation, commercial logging and fallow period, and other drivers.

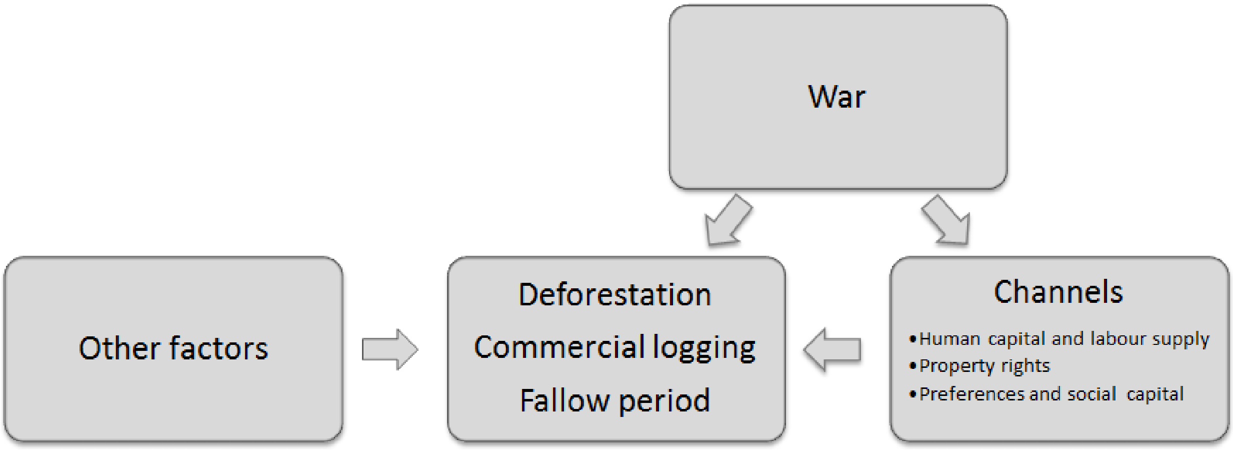


Figure 5: Expected causality of the variables

4.3.3.2 Fallow period

The fallow period is added into the range of dependent variables in order to track how long farmers leave the land idle before cleared and farmed again. The fallow period length is a count variable of the idle years. Fallow period is necessary for the soils recovery.

4.3.3.3 Commercial logging

An analysis of this dependent variable investigates commercial logging as another cause of deforestation and its drivers in details. The presence of a commercial logging in the villages is used to better understand also other proxies of deforestation and to understand the complex process of forest clearing in the villages around Gola forests. It is a dummy variable of the commercial logging present within the community forests.

4.3.4 Fixed chiefdoms effect

The fixed chiefdom effect is a constant term explaining unobserved differences among particular chiefdoms. There are seven different chiefdoms included – Barri, Gaura, Koya, Makpele, Malema, Nomo, and Tunkia.

4.3.5 Demographic factor

Population pressure is included in the model as a representative of the traditional drivers. Population is measured as a total population in 2010. Data are obtained from the village level survey 2010.

4.3.6 Access to the market

I follow model of Chomitz and Grey (1996), location prices are function of cost-of-access prices. Distance to the market is used as a proxy for the market access. The access is measured as walking distance to the market. Distance is based on the village survey 2010.

4.3.7 Topography

Soil quality and slope of a farm are included in the analysis as a proxy of the biophysical factors. Plots with poor soil quality and higher slope are less likely to be cleared for agricultural purposes as the clearing cost increases and profitability decreases (Freitas et al., 2010). Self-reported measures are used, soil quality from very infertile to very fertile and slope from steeply sloped to not sloped. They are based on the household level data and aggregated to the village level.

4.3.8 Rain shock

Rain shock of 2009 is included as a predictor of production decision for the year 2010. Rain shock is an aspect influencing farmers' decision and the last year amount of rain could be very important decisive factor of this year production. Data were retrieved from the village level survey 2010.

4.4 Sampling

Studied sample includes 176 villages in seven chiefdoms (Barri and Makpele in Southern province, and Gaura, Koya, Malema, Nomo and Tunkia in Eastern province) with selected households in the surrounding of Gola Rainforests National Park. The Gola Forest Programme staff selected villages based on the criteria of close distance to the Gola forests and wide biodiversity community forests. The map of surveyed villages is in the figure 6.

Sixty local enumerators from Kenema and Bo conducted interviews based on structured questionnaire. Enumerators were accompanied by the Goral Forest Programme staff to mediate the interviews with the local communities. Interviews were conducted in Mende and recorded in English in order to avoid any misunderstanding or exclusion of non-English speaking participants. Questions were asked during the group meeting. The village surveys took approximately 3 hours.

Fifteen households were randomly selected in each village. Enumerators assigned number to every household in the village and then randomly drew 15 of them. If there were fewer households in the village, then all of them were interviewed. Privacy and anonymity was assured for the respondents. Participants were questioned individually. The household surveys took approximately 2 hours.

Enumerators and surveyors were trained in order to minimize loss of the data and surveys were pre-tested. None of the households refused to take part in the household level survey.

This survey allowed collecting the unique data set covering wide range of issues with large number of the villages and households. Data sets from war-torn countries are usually rare or unreliable. This allows conducting more studies in post-war Sierra Leone with high quality data.

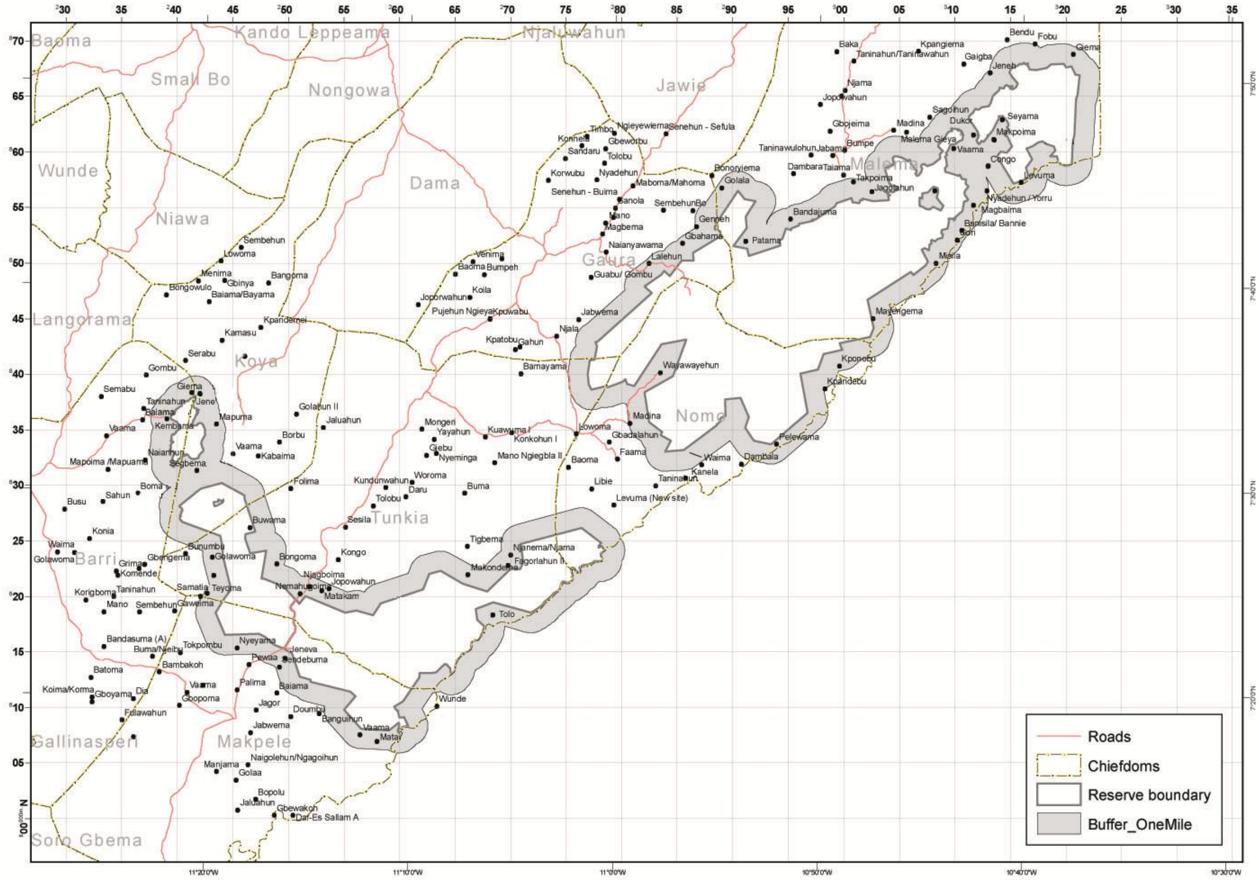


Figure 6: Map of Gola Rainforests National Park and surveyed villages. *Source: (Bulte et al., 2010)*

4.5 Methods

This section describes estimation methods used to summarize, understand and analyse the data. The proper methods are selected based on variables characteristics, model assumptions and based on information which is expected to be obtained.

4.5.1 Descriptive statistics

Descriptive statistic is one of the methods for data exploration. It is very useful tool for summarizing the collected data. Descriptive statistics produce table with minimum, maximum and mean values, frequencies, percentages, standard deviation, skewness and kurtosis for each variable included.

Descriptive statistics is used to summarize the data and also to analyse the war spread across the seven chiefdoms based on the survey questions concerning the war history. This helps to understand spread of violence in the study area. The study of violence spread is on chiefdom level in order to compare the differences and to examine variation of violence among them. Some chiefdoms were close to the RUF bases, through others RUF forces penetrated into Sierra Leone. This could cause a variation.

4.5.2 Estimation methods

Econometric regression model is used to analyse the collected data. There are several kinds of dependent variables and approach is changed according to them. The analyses used are ordinary least square method, logistic regression and ordered logistic regression.

Dependent variable in the main 'deforestation model' is the ratio of farmed upland land over the total land owned on the village level; explanatory variables concern the village war history, human and social capital, property rights, preferences, labour supply and biophysical village characteristics. The farmed upland ratio is a continues variable ranging from 0 to 1. The ordinary least square method (OLS) is used to analyze an effect of the predictors on the dependent variable.

The 'commercial logging' dependent variable reaches only values 0 or 1, which stands for '0' no commercial logging and '1' commercial logging present. It is non-continuous binary dependent variable limited in its range, hence OLS cannot be used. Variable does not satisfy assumptions of OLS and regression might give biased and inconsistent parameter estimates. Logistic regression is used to estimate these parameters. In multiple linear regressions, explained variable is predicted from the predictor variables. In logistic regression, probability of occurrence of the explained variable is predicted based on the known values of predictors (Field, 2009).

The 'fallow period' dependent variable has different characteristics compared with the previous two. It is count variable in the range 1 to 20 years of the fallow period. It has some characteristics of the continuous variable; however, it cannot reach all the values in the range. Only integral numbers are involved. This does not meet assumptions of OLS for continuous variable and this method would give us again biased parameter. Ordered or ordinal logit model is chosen. It is an ordered response model.

4.6 Multicollinearity test

Multicollinearity test for the predictors is run before conducting the analyses. Field (2009) defines multicollinearity as a strong correlation between predictors which can bias outcome of the analysis as the unique relationship between particular predictor and the dependent variable is hard to be separated from the other predictor. The problem for model increases with increasing collinearity of the predictors. It poses threat to predictors' coefficients and importance of the predictors.

One way of multicollinearity detection is correlation matrix projecting correlations among all variables included. Very high correlations (0.80+) could indicate collinearity problem among predictors. Another multicollinearity test is a variance inflation factor (VIF) and tolerance (Field, 2009). There are different opinions on the acceptable limits of VIF and tolerance. Field (2009) suggests that VIF greater than 10 and tolerance lower than 0.1 are worthy of concern for collinearity.

Multicollinearity threat is very probable for this model as the interaction terms of the channels and the war variables are introduced. Attention will be paid to the indicators proposing multicollinearity.

5. RESULTS

5.1 Descriptive statistics

This section presents the results of descriptive statistics of the selected variables. This part describes the spread of violence for every chiefdom. The presented descriptive statistics include the used dependent variables, treatment variables, independent variables and the perception of forests conservation of the villagers. Furthermore, results will be depicted in maps to help visualizing the results. Figure 7 shows a cut-out of the map of Sierra Leone with the studied chiefdoms.

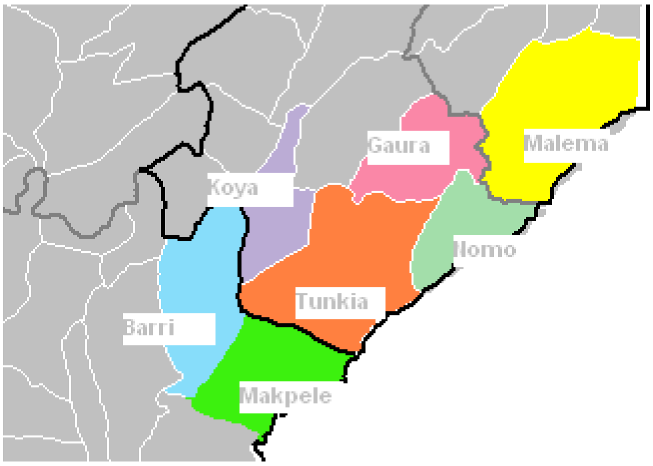


Figure 7: Map of studied chiefdoms

5.1.1 Dependent variables

Three dependent variables were used in the models, namely the ratio of farmed upland and the total land owned, commercial logging in the village and fallow period length. The descriptive characteristics of latter variables are summarized in Table 3.

Table 3: Descriptive characteristics of dependent variables[15]

	Obs	Mean	Std.dev.	Min	Max
Dependent variables					
Upland ratio	168	0.17	0.13	0.00	0.57
Commercial logging	170	0.24	0.43	0	1
Fallow period	166	9.29	3.92	1	20

The upland ratio ranges from 0 (no upland farmed) to 1 (all land owned is farmed upland). However, a value of "1" is highly unlikely. We can see that the highest value is 0.57; meaning that 57% of the total owned land is farmed upland. Our results indicate that on average 17% of the total land owned was farmed upland.

Commercial logging is used as a dummy variable ("0"=no commercial logging in the village, "1"=commercial logging present in the village). Nevertheless, this variable does not capture the logged quantities. Absence of commercial logging is prevailing in the villages.

Fallow period length ranges from 1 year to 20 years. A 1 year fallow period is considered very short for complete soil recovery. On average, farmers left land fallow for 9 years.

[15] Abbreviations used: number of observations (Obs), standard deviation (Std.dev.), minimum (Min), maximum (Max)

Table 4 shows the correlation coefficients between the dependent variables used for the analyses. Fallow period is negatively correlated with the upland ratio. This is an expected pattern, since with expanding cultivation, the demand for land increases, which decreases the fallow periods.

Table 4: Correlations among the dependent variables[16]

	Upland ratio	Com. logging	Fallow period
Upland ratio	1	-0.058	-0.171**
Com. logging		1	0.018
Fallow period			1

Figure 8 shows differences in the particular chiefdoms regarding the farmed upland as a share of total land owned within the chiefdom ("upland ratio"), share of the villages which reported that they have commercial logging within the village ("logging"), and average fallow period length in the chiefdom ("fallow period"). Furthermore, figure 8 includes information on the intensity of agriculture, farmed upland (acres) per person ("upland/person") and total land owned per person in the chiefdom ("total/person").

The upland ratio is similar among most chiefdoms, but lower in the Tunkia chiefdom. This might be due a lower population density. However, the ratios of upland farmed and total land owned per person in Tunkia do not differ from the other chiefdoms. This could mean that in Tunkia people farm less, the land is devoted rather to commercial logging which is among the highest of all chiefdoms. Koya chiefdom scored highest in the plot size per person, which might be related to the low population density. During the civil war, the Koya chiefdom experienced the highest share of dead and permanently displaced people (discussed in section 5.1.2), which likely relates to the lower population density. Fallow periods are not different between the studies chiefdoms.

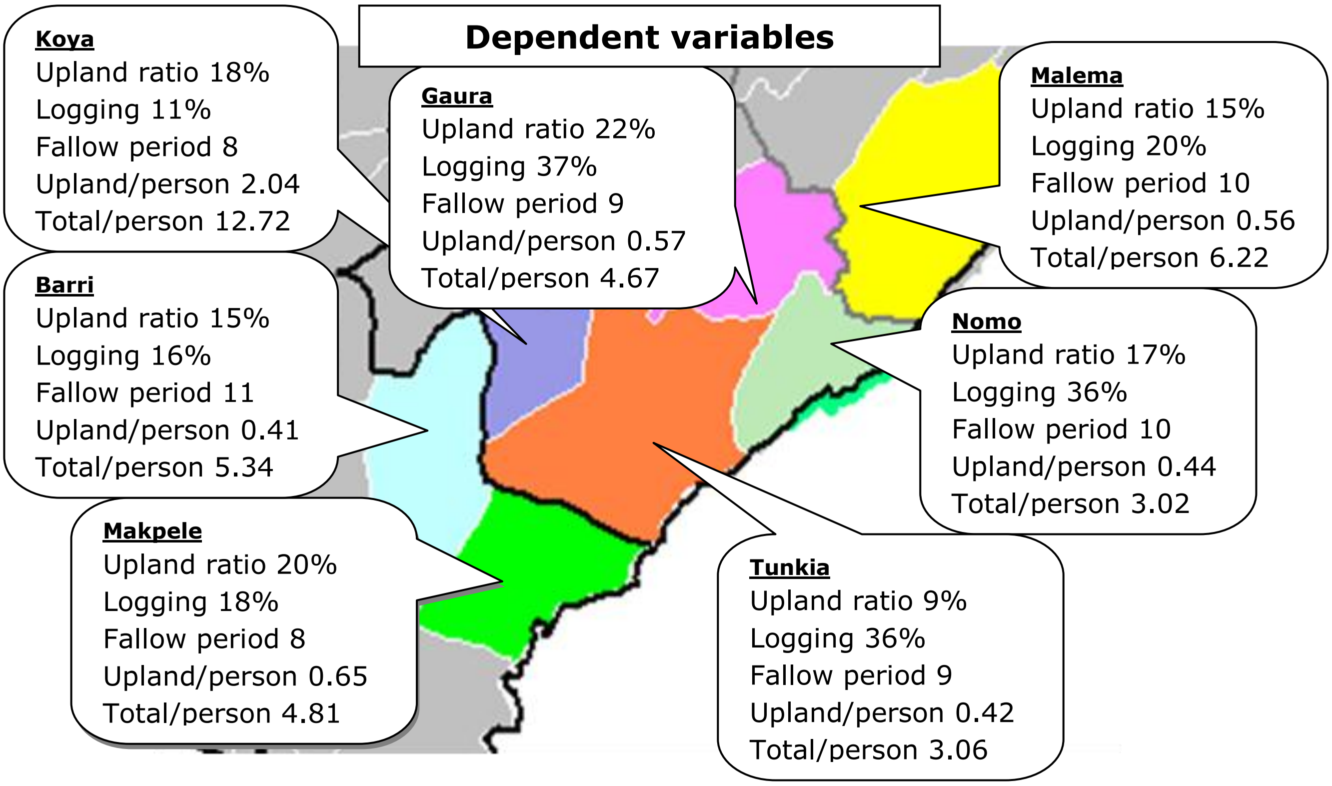


Figure 8: Distribution of the dependent variables

16 Significance level: *** p<0.01, ** p<0.05, * p<0.1

5.1.2 War variables

The war is considered as a treatment variable in the models used. This section studies this variable in more detail. It discusses the war history on the chiefdom level, with a special focus on the population of the chiefdoms, attack and migration history, refugee locations, property destruction, killed and displaced people, and recruitment history.

Table 5 depicts the results of correlation coefficient between the used treatment variables. The ratio of dead and permanently displaced people is significantly correlated to the scaled number of temporarily displaced people. The observed relationship is negative, since both parameter stand in competition with each other. More deaths and permanently displaced persons induce less of temporarily displaced.

Table 5: Correlations among war variables[17]

	Dead and perm. displaced	Temporarily displaced	Number of attacks	Village chief killed
Dead and permanently displaced	1	-0.515***	-0.070	0.001
Temporarily displaced		1	0.129	-0.078
Number of attacks			1	0.048
Village chief killed				1

The following table 6 shows the descriptive statistics of the war variables used in the analyses. Share of dead and permanently displaced and temporarily displaced over the total population in 1990. Both variables are in the range of 0 to 1. On average, 41% of the total population in 1990 died or was permanently displaced, and 58% of the population was temporarily displaced. This means that on average 99% of the population fled or was killed. It is observed, that the villages around Gola forests were highly affected by the conflict. On average, half of the villages reported a killed village chief.

Table 6: Descriptive statistics of the treatment variables

	Obs	Mean	Std.dev.	Min	Max
War variables					
Dead and permanently displaced	155	0.41	0.22	0.00	0.98
Temporarily displaced	163	0.58	0.24	0.00	1.00
Number of attacks	177	2.33	1.28	0	6
Chief killed	177	0.38	0.49	0	1

Our results in figure 9 indicate, that Gaura experienced the lowest share of dead people during the war. This chiefdom was neither close to the RUF camps nor the place of the RUF penetration to Sierra Leone. Malema experienced the highest absolute number of dead people. It was the spot of RUF troops penetration in 1991. Koya had the highest percentage of dead people. The highest shares of displaced population were reported in the chiefdoms of the South-West which border with Liberia. The northern chiefdoms, on the other hand, showed lower emigration. In Makpele and Koya, 100% of the population migrated away during the war. Makpele was the second place of RUF incursion in 1991 and Koya was the closest one to the RUF "Zogoda" bush camp in Kambui Hills (see figure 2**Figure 2**). This is in line with Lidow's research (2011), which showed that villages close to the military basements are the most affected. However, interestingly Koya

[17] Significance level: *** p<0.01, ** p<0.05, * p<0.1

experienced the lowest number of attacks but they were more severe than in other chiefdoms.

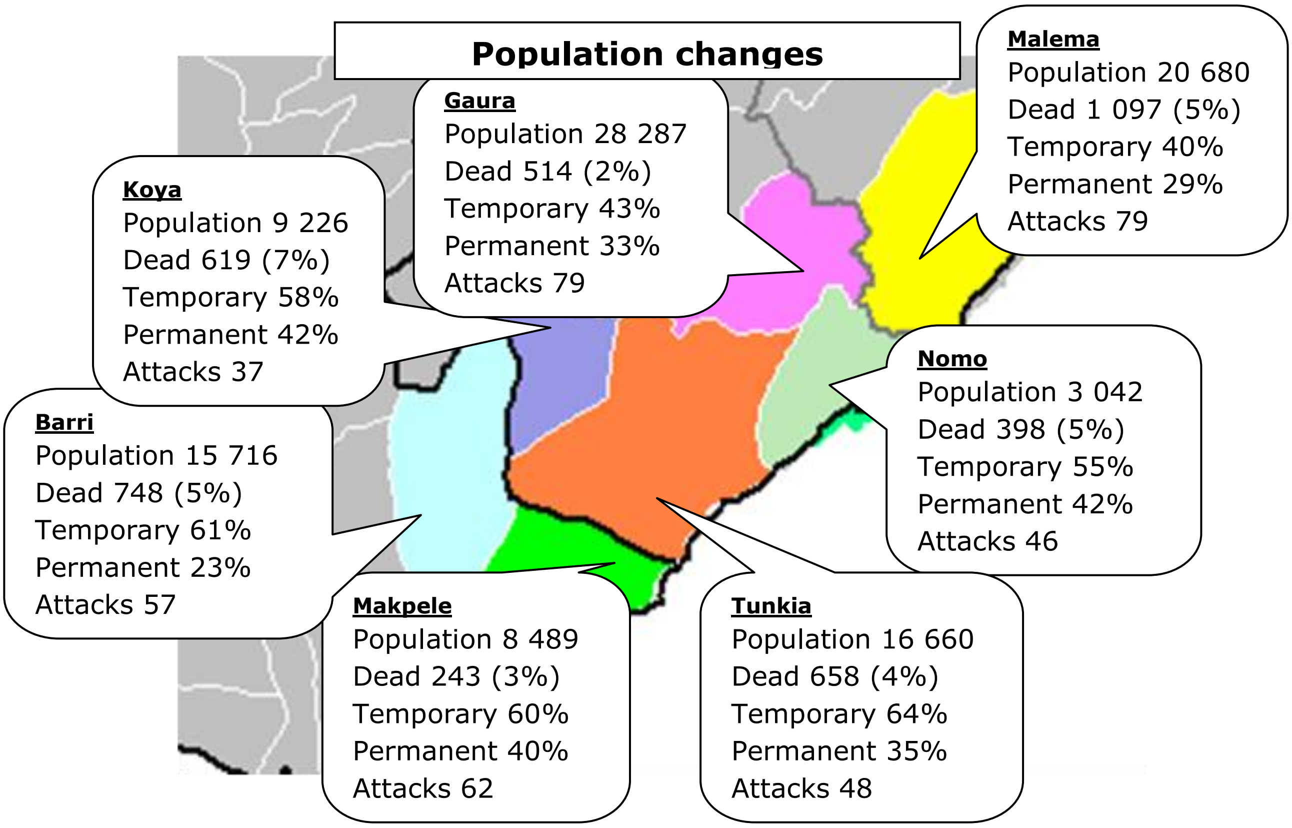


Figure 9: Population changes

The years in which the village population migrations took place had similar patterns in all chiefdoms. Most of the people fled in 1991 when the war began. 76.4% of all villages reported the year 1991 to be the time of the highest emigration. However, people migrated over the whole period of the war only with slight differences between chiefdoms. The prevailing pattern of emigration was between the years 1991 and 1993 and immigration between 1996 and 2001. Returning of the people did not show such clear patterns compared to emigration. Almost 50% of the population which migrated fled into refugee camps, 30% to foreign countries (mainly Liberia), 9% to other villages, and 8% to the Gola forests. Figure 10 shows the average property destruction per village in every chiefdom. It contains information about the number of houses destroyed, schools, mosques and churches destroyed (latter two are pooled in the group "mosques"). As previously discussed, the Southern chiefdoms had higher levels of displaced population. However, the Southern chiefdoms did not suffer more property destruction. Koya is the most affected chiefdom with respect to displaced population as well as to property destruction. Property destruction variable is not used in the analysis as it is considered as a redundant variable[18]; however, it is included here to draw the complete picture of the war consequences

[18] This decision was based on testing the property destruction variable in analysis where it was considered as redundant.

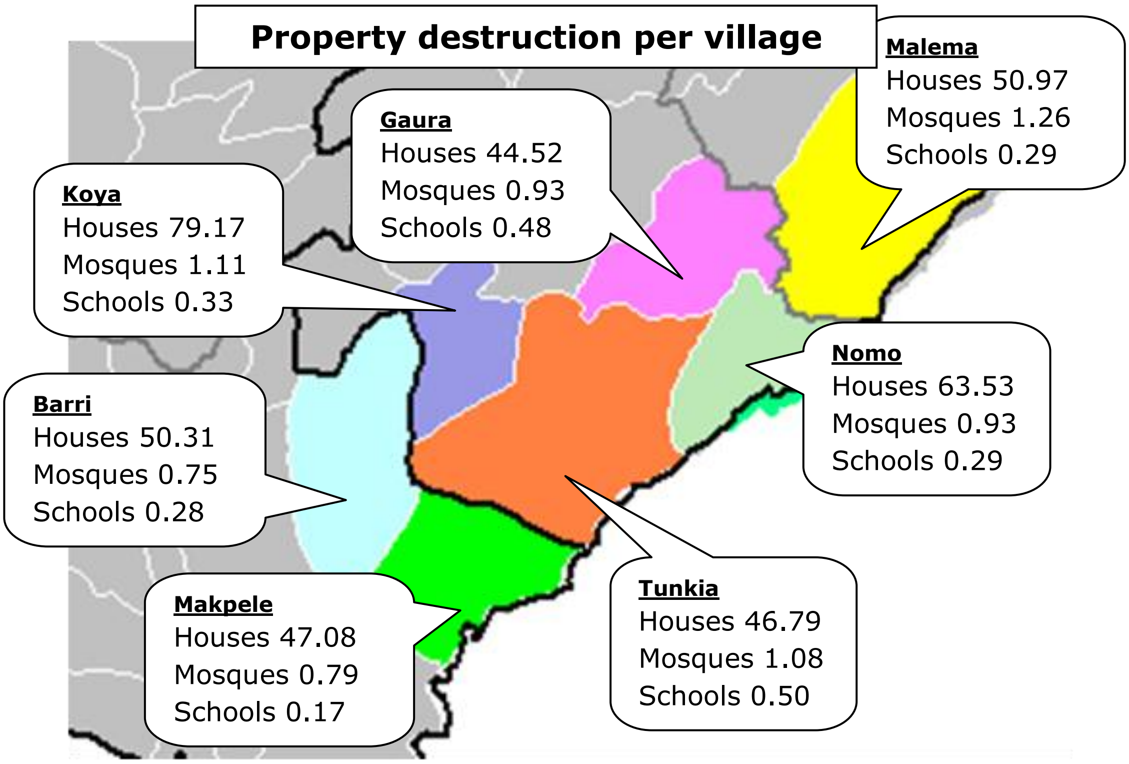


Figure 10: Property destruction

Figure 11 depicts the share of dead people and the main target groups: percentage of the villages which reported that the chief or other big men were killed and particular gender and age groups, which were most affected. The last two mentioned do not sum to 100% and the difference arises when no difference between genders was reported. This is due to the formulation of the survey questions, asking whether mostly men or mostly women were targeted or if the proportion was the same regardless of the gender. Another question is whether mainly children and youth were targeted (here assembled into one category "'youth") or whether rather the elders were targeted.

Results show that in general more big men were targeted rather than chiefs. Koya is the only chiefdom where more than half of the villages report assassination of the chief. Women were not particularly aimed by the troops. Mainly youth and children were targeted, which is consistent with the findings of Richard (1996). The number of villages that answered in the survey was used as total number of villages in the calculations.

Regarding recruitment by the armed forces, about half of the villages reported that they experienced recruitment by RUF. The major target groups of RUF were male children and youth, and the main years of the attacks were 1991, 1992 and 1993. On the other hand, CDF recruitment practices affected more than half of the villages and their peak years of recruitment attacks were 1996 and 1997. Their target groups were slightly different, affecting mainly youth and adult men. SLA recruitments affected fewer villages with the main years of attacks in 1993 and 1994. Their target groups were the same as of the SLA. RUF troops were the only one targeting children and women. These facts are summarized in table 7. Latter table is divided according to chiefdoms and groups (RUF, CDF, SLA) and prevailing years of the recruitment attacks. Recruitment variable is also not included in analyses[19].

[19] The dummy variable of recruitment was causing serious problem of multicollinearity in the models.

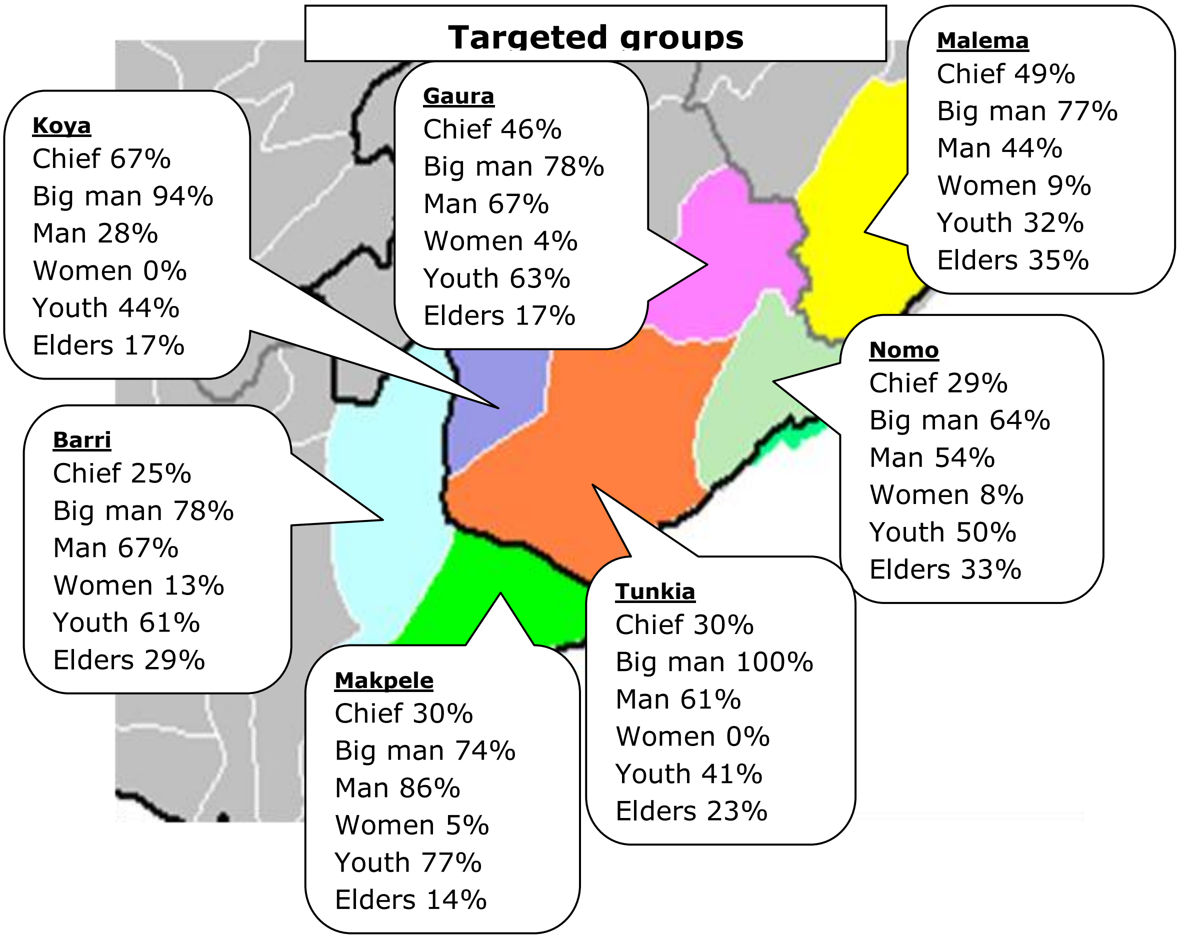


Figure 11: Targeted groups in particular chiefdoms

Figure 12, 13 and 14 show the number of attacks per chiefdom, the number of dead people and the number of wounded, respectively. This was described for every particular year. The number of attacks depicted in figure 12 is the highest in the beginning of the civil war, and then decreased in all chiefdoms. However, in the year 1993 further attacks were reported. This year, also showed the second highest average emigration rates from villages. In 1993, RUF troops were forced to retrieve into the Gola forests, where they regrouped (Peters, 2006). This is able to explain the peak in attacks in 1993.

Table 7: Armed attacks by RUF, CDF and SLA on villages during the Sierra Leonean civil war, per studied chiefdom

	Barri	Makpele	Koya	Tunkia	Gaura	Nomo	Malema
RUF	50%	44%	46%	48%	57%	69%	95%
RUF years	1991	1991	1991, 1993	1991, 1993	1991, 1992	1991, 1993	1991, 1992
CDF	60%	64%	50%	57%	78%	71%	66%
CDF years	1996, 1997	1996	1995-1997	1996, 1997	1996, 1997	1996, 1997	1996, 1997
SLA	29%	14%	14%	35%	63%	64%	40%
SLA years	1992	1993	1994	1991, 1994	1991-1994	1992, 1997	1994

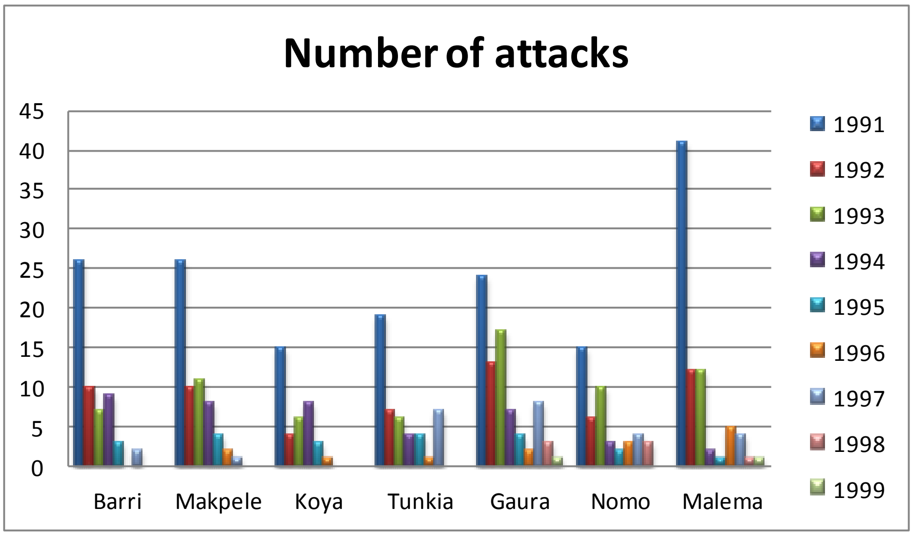


Figure 12: Number of attacks in the chiefdoms

Figure 13 shows the number of dead people during the civil war, per chiefdoms and year. The first year of the civil war had the highest number of victims. Chiefdom Nomo is the only exception. Results show exceptionally high numbers of dead people in Koya in 1991, which is in line with the previous presented data.

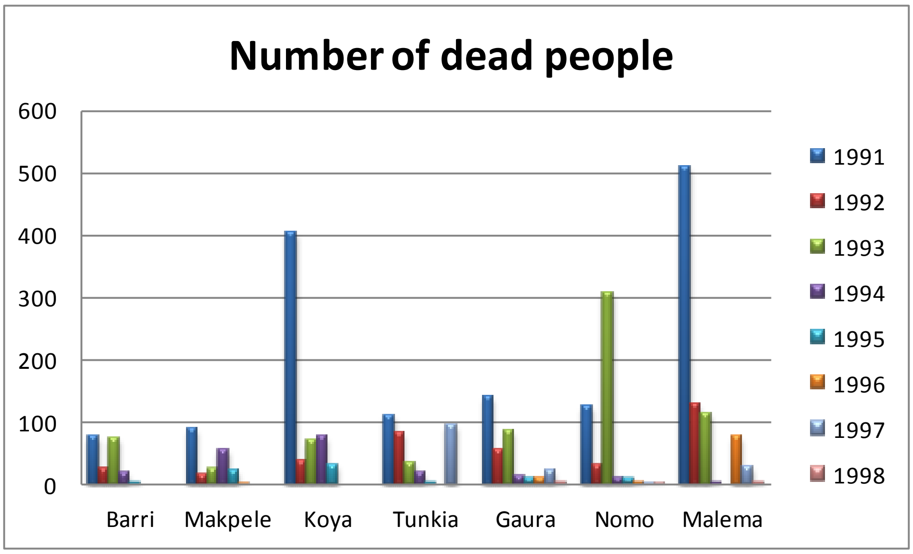


Figure 13: Number of dead people in the chiefdoms

Figure 14 depicts the number of wounded people during the civil war. This figure shows the same pattern as observed in figure 13. In the year 1991 the highest number of dead and wounded people was reported in Malema and Koya.

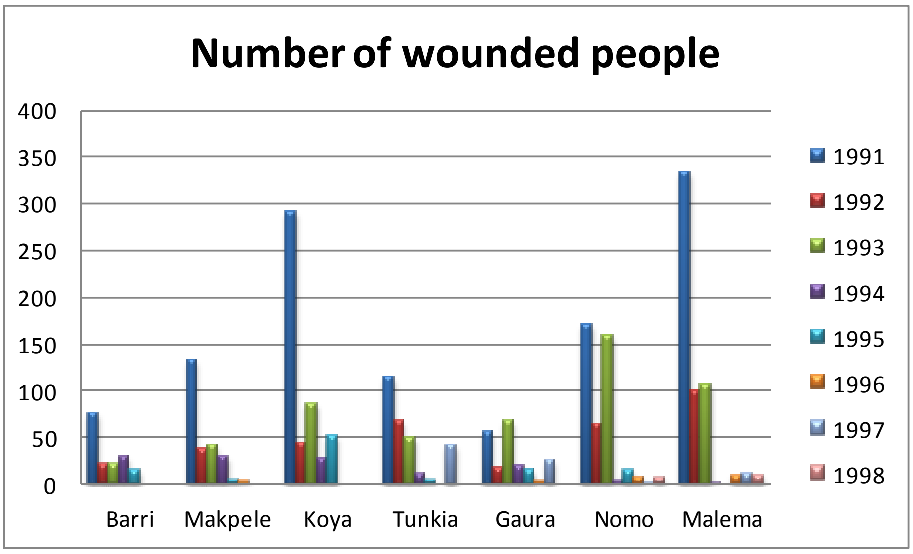


Figure 14: Number of wounded people in the chiefdoms

Figure 15 summarizes the data presented in the previous figures pooled over all villages. It clearly depicts the highest number of attacks, the highest number of dead and wounded people in the year 1991. A second peak in violence is shown in 1993 when RUF suffered from losses and backed up to Gola forests.

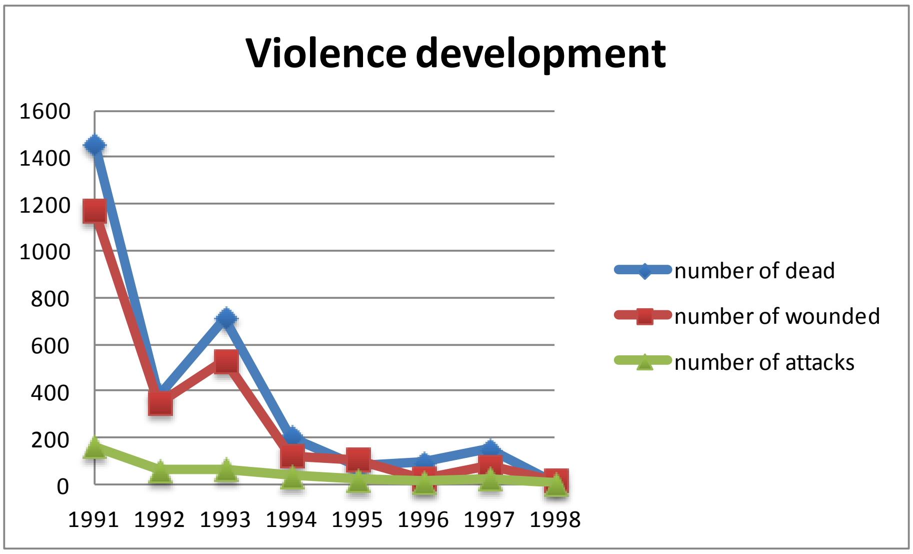


Figure 15: Violence development

5.1.3 Independent variables

This section describes all independent variables used in the analysis. Table 8 depicts the number of observations for every variable, the mean, the minimum, the maximum and the standard deviation. The first part presents variables of the main model without centring and logarithmic transformation, the second part the pre-war variables used in the model (1).

Human capital investments as a share of total expenditures range from 16.49% and 53.91%. In latter case more than half of the total expenditures are devoted to health and education. The distance to a primary school in 2010 is used as equivalent for the human capital measurement and the main model is tested for its robustness with this variable. It is expected that with increasing distance to schools there would be a decreasing level of human capital. This distance is measured on a scale of 1 to 8 ("1"=in the village, "2"=less than 30 min., "3"=between 30 min and 1 hour, "4"=1 to 1.5

hours,"5"=1.5 to 2 hours, "6"=2 hours to half a day, "7"=half a day to a full day, "8"=more than full day).

Table 8: Descriptive statistics of the explanatory variables

	Obs	Mean	Std.dev.	Min	Max
MAIN MODELS					
Channels					
HC share of total expenditure	171	35.24	6.88	16.49	53.91
Distance to primary school 2010	173	2.53	1.83	1	8
Social capital	171	0.85	0.11	0.51	1.00
Property rights	175	0.23	0.23	0	1.00
Willingness to preserve	177	0.43	0.22	0	1
Other drivers					
Soil quality	170	2.79	0.37	1.67	3.80
Slope	170	1.94	0.46	1	3.00
Total population 2010	174	351.85	344.19	10	1412
Market distance	151	5.10	1.79	1	8
PRE-WAR VARIABLES					
Number of churches and mosques 1990	175	1.11	0.47	0	2
Number of development projects 1990	176	0.22	0.49	0	2
Distance to primary school 1990	169	2.85	1.93	1	8
Distance to health clinic 1990	171	4.08	1.84	1	8
Distance to produce store 1990	163	4.66	2.37	1	8
Distance to police station 1990	169	5.31	1.85	1	8
Total population 1990	170	531.20	515.74	40	1946

Social capital is measured as trust to family, kin and neighbours and whether the households would ask for help within family, kin or neighbours. Those variables are pooled into one dummy variable, with "0" being a low level of social capital and "1" a high level of social capital. Values range from 0.51 to 1.00. The higher this value is the higher the level of social capital within the village.

The property rights variable is scored between 0 and 1. A value of 1 indicates a very high property rights insecurity. The present results suggest that villages have a high level of secure property rights.

The variable of willingness to preserve is again the average of several other variables. A value of "1" indicates a high propensity to preserve forests, while a value of "0" means a low level of pro-conservational behaviour.

The soil quality variable has values of "1" being very infertile, "2" infertile, "3" fertile and "4" very fertile. The slope of the plots variable has the values of "1" being steeply sloped, "2" moderately sloped and "3" not sloped. The household level information is aggregated to the village level. On average, the villages have rather fertile and moderately sloped farms.

Market distance 2010 and all distance variables for 1990 have the same recoding system as previously described for the distance to the primary school in 2010. On average, the total population in 1990 is higher than in 2010. On average, villages had 1 church or mosque and development projects were scarce before the war.

5.1.4 Pro-conservation behaviour

This section is devoted to the exploration of pro-conservation behaviour and attitude of the villagers. It discusses labour and land scarcity, threats for conservation and number of replantation projects in the chiefdoms.

Table 9 depicts the results for the variables labour and land scarcity. Richards (1996), Maconachie (2008) and Unruh and Turray (2006) claim that labour scarcity is a larger problem in Sierra Leone compared to land scarcity. Data are retrieved from the household survey and the table 10 depicts the percentage of households that positively or negatively answered the question: "Do you feel that labour/land scarcity is a problem in your village?" The scores are: "0"=I don't know, "1"=Strongly disagree, "2"=Disagree, "3"=Neither agree nor disagree, "4"=Agree and "5"=Strongly agree. Results show a tendency of disagreement, which is mainly driven by the chiefdoms Makpele and Tunkia, where land scarcity did not seem to be a common problem as shown in table 10.

Table 9: Land and labour scarcity

	0	1	2	3	4	5
Land scarcity	6%	17%	33%	9%	22%	12%
Labour scarcity	7%	14%	33%	9%	24%	13%

Table 10 shows the results for the same question but separated per chiefdom. The answers "I don't know" and "Neither agree nor disagree" are excluded and two possible answers on every tier (strongly dis/agree and dis/agree) are assembled into only one category "agreement" and "disagreement". Results are again expressed as percentages of the total answers.

Table 10: Land and labour scarcity in the chiefdoms

Land scarcity	disagree	agree
Barri	51%	34%
Gaura	44%	40%
Koya	47%	35%
Makpele	56%	29%
Malema	51%	35%
Nomo	49%	33%
Tunkia	53%	34%

Labour scarcity	disagree	agree
Barri	43%	40%
Gaura	45%	36%
Koya	45%	37%
Makpele	56%	31%
Malema	46%	41%
Nomo	41%	43%
Tunkia	52%	35%

The general opinion in all chiefdoms, on whether land/labour scarcity is a problem is very balanced and none of the opinions prevail. We cannot argue that labour scarcity is a larger problem than land scarcity for the questioned villages.

Table 11 depicts the threats for forest conservation and how people perceive it. There are balanced answers on whether people see the listed factors as important or non-important threats to forest conversion. The largest agreement is about agricultural conversion and 64% of all households saw agricultural conversion as an important threat to forest preserving.

Table 11: Threats to forests conservation

	Not important	Important
Agricultural conversion	36%	64%
Commercial logging	55%	45%
Logging by village members	44%	55%
Commercial hunting	55%	45%
Hunting by village members	43%	56%

Results show no evident differences between the studied chiefdoms. Commercial logging and hunting are considered a slightly lower threat for forests. The opinion on agricultural expansion, logging by the village members and hunting by the village members is again very balanced for all chiefdoms.

Table 12 shows the percentage of the villages per chiefdom, which reported the presence of forest regeneration projects. The present results suggest that most of the villages do not have any projects for forest replanting.

Table 12: Regeneration projects in the chiefdoms

	regeneration projects
Barri	29%
Makpele	11%
Koya	6%
Tunkia	23%
Gaura	0%
Nomo	15%
Malema	6%

The general opinions on land and labour scarcity are very balanced, agricultural expansion is considered the biggest threat to forest conversion, and only a small fraction of the villages have any forest regeneration projects.

5.1.5 Population

The civil war affected labour supply; many young people joined the army, were abducted or killed. In 2004, there were around 50% of female headed households as a consequence of the war (Mohammed et al., 2004). Thus, it is expected that the male and female ratio in the population was affected. In table 13, it can be observed that most of the chiefdoms have a higher number of females than males. The data is aggregated from the village level to the chiefdom level. Only one chiefdom shows a significantly higher ratio. Figure 16 shows that on average there is a prevailing number of females. Leach (1994) found a similar population composition around the Gola forests in 1994. A comparison with the pre-war situation is difficult since reliable data is lacking.

Table 13: Male/female ratio

Province	Chiefdom	Male/Female ratio
Southern	Barri	0.86
Southern	Makpele	1.01
Eastern	Gaura	0.84
Eastern	Koya	0.98
Eastern	Malema	4.06
Eastern	Nomo	0.96
Eastern	Tunkia	0.85
Total		**1.46**

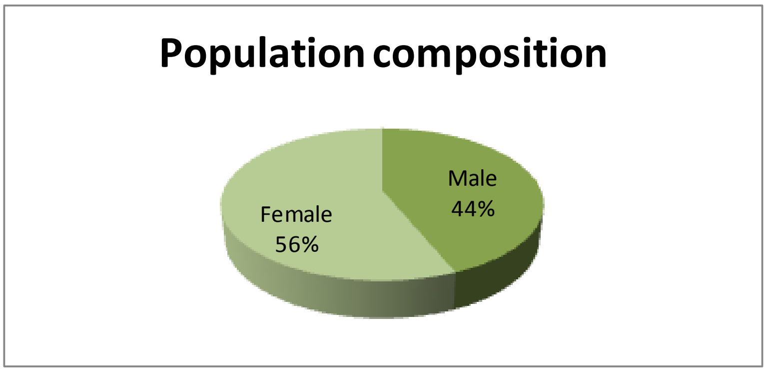


Figure 16: Population composition

Official statistics describe the impacts of the war as: 70 000–100 000 causalities (Kaldor and Vincent, 2006), 250 000 amputees (Dyfan, 2003), 4 000 abducted men (Ministry of Development and Economic Planning, 2003), 2.6 million of displaced people (Kaldor and Vincent, 2006) and 257 000 women and girls sexually abused and exploited (Dyfan, 2003). This high level of violent incidents can be expected to affect society on a population level.

Figure 17 compares total population in 1990 and total population in 2010 on the chiefdom level. It confirms a negative population growth between the years 1990 and 2010 in all studied regions.

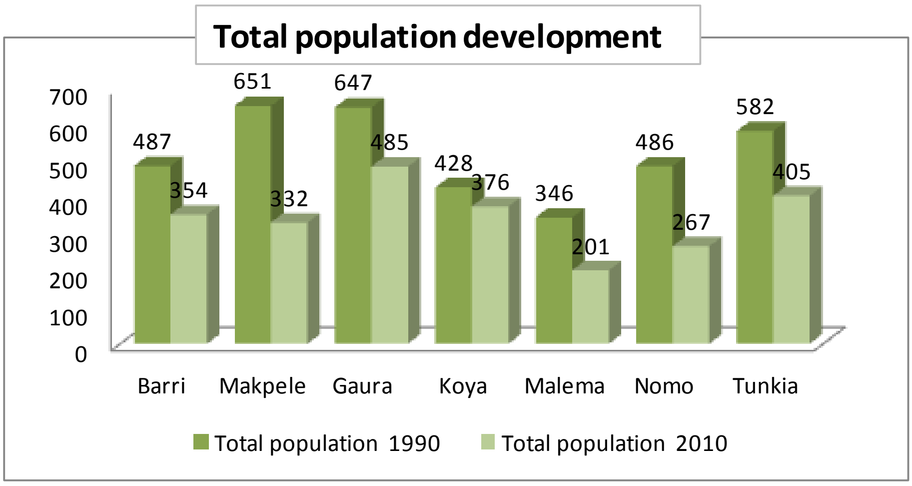


Figure 17: Population development in the chiefdoms

5.2 Estimation results

This chapter presents the results of the data analysis of four applied models the pre-war variables model, the main deforestation model, the commercial logging model and the fallow period model. Results are depicted at the tables.

The main analysis of deforestation includes the 2010 variables and the war data. The war variables are tested for endogeneity and test is presented below in section 5.2.5. However, in this model, also other data[20] suffer from the problem of endogeneity (see section 4.1). However, the survey does not contain pre-war variables for the data tested in the main analysis in order to control for endogeneity.

The first, model (1) tests the dependent variable, the war variables and the available pre-war data. Thus, this model of historical variables for 1990 is not affected by

[20] Population, soil quality, human capital, labour supply, social capital, property rights, preferences, market distance

endogeneity. Nevertheless, the tested variables, in the pre-war model, do not represent proper proxies for the drivers used in the main deforestation model. Thus the two models, the main deforestation model and the pre-war variables model, and the results cannot be fully compared. There is a trade-off between the problem of endogeneity in the main model and the proper variables chosen in the pre-war model. This report offers both approaches.

Moreover, pre-war variables model and the main model are conceptually very different. Each of them answers different question. The pre-war model allows testing conditional effects of the pre-war variables on current deforestation. The impact of the war on deforestation is assessed with a range of pre-war variables. This allowed tracing causality relationships between pre-war characteristics, war variables and current deforestation, since the chronological order of events is known. While using current variables in the main model, the correlations between the war, post-war characteristics and current deforestation, is assessed. Causality relationships cannot be established due to the endogeneity bias. Furthermore, a chronological order of events cannot be established in the main deforestation model.

Despite the facts mentioned in the two previous paragraphs, a comparison of both models is an interesting approach. This allows a complete picture on the changes in deforestation patterns and the war impacts driving those changes. The pre-war model gives us the first insight into the causal relationships of pre-war characteristics and current deforestation. Latter patterns can be compared with the main deforestation model. This main model yields only the correlation relationships, which adds additional information for other researchers to build on. All assumptions of the models are controlled for[21].

5.2.1 Model 1 – Model of the pre-war variables[22]

Data analysis starts by using pre-war variables which allowed conditional testing of a given range of pre-war characteristics and current deforestation rate. This model helps reducing the concern of endogeneity. The results are presented in table 14. The dependent variable of this model is the log ratio between farmed upland and total land owned. Selected independent variables are retrieved from the village level survey 2010: distance to primary school in 1990 (assuming that with increasing distance from the school there is a decreasing level of school enrolment and human capital), distance to police station in 1990 (distance to police station can be used as proxy for the larger villages and also as decreased safety with increasing distance), distance to produce store in 1990 (as proxy for distance to the market), number of development projects before the war (Hoffman (2004) claims that the logic of a war is partially dependent on humanitarian activities and can even increase atrocities against civilians), village population in 1990, and number of churches and mosques in 1990.

In the first column (1a)[23] only pre-war variables are tested, and war and pre-war characteristics in column (1b) to follow only their main effects. To depict their interaction

[21] Heteroskedasticity appeared to be a problem in the main analysis and in the lagged model. This was tested with Breusch-Pagan test and corrected with log transformation of dependent variable as recommended by Field (2009). Multicollinearity problem was expected due to interaction terms in the models. Huge collinearity problem was found among interaction terms. Some authors propose centring as a solution for multicollinearity (Smith and Sasaki, 1979). However, this method is considered doubtful sometimes (Tate, 1984). Centring solved the problem of collinearity in all models and did not affect the results. It was proved that this method is not always forceful and it could not solve the collinearity problem with some particular variables which had to be excluded.

[22] This model corresponds to the model (1) in section 4.2

[23] Columns' denotations correspond with denotations of the sub-models in section 4.2.

terms both of latter columns are added into column (1) together with indirect effects of the war. Column (3) shows backward logarithmic transformation of the coefficients of column (1) in order to quantify the effects. It shows the change in the dependent variable changed, when changing the independent variable by 1 unit (ceteris paribus). The effects (3) are interpreted as products between dependent and independent variables due to transformation of the log dependent back[24].

Population pressure is a significant predictor of deforestation and it increases deforestation. It is an often discussed predictor of deforestation (see section 3.1.1). This result confirms the theory of population pressure and the neo-Malthusian point of view (Brown and Pearce, 1994) and is in line with the findings of Pffaf (1999), Bhattarai *et al.* (2009), and Mahapatr and Kant (2005). Moreover, the pre-war variable of population avoids problems of endogeneity of the population measure and suggests an increasing deforestation under population pressure. However, as Palo (1994) highlights, the population pressure has to be considered in the context of its particular environment.

The circumstance of a killed village chief increases deforestation. This variable is included in the model because it is assumed that a dead chief would lead to the deterioration of institutions (Richards, 1996) and would cause "anarchy" in the village, which might increase deforestation. This fact is substantiated by the applied model. This effect is not present in column (1) where interaction terms overtake a significant effect of the killed chief.

Direct effect of dead and permanently displaced significantly decreases deforestation due to farm abandonment. It is the only war variable having direct effect on deforestation rate.

Column (1) depicts the indirect effects and three points stand out: (i) significant effects of total population, distance to primary school and distance to produce store; (ii) different signs in indirect effects of total population and distance to the school; (iii) vanished significant main effect of the chief killed.

Indirect effects of total population and dead people and total population and number of attacks are conflicting as seen in column (1). Villages which had higher population in 1990 and experienced a higher number of deaths and permanently displaced had a higher level of deforestation. Even though larger villages had numerically more dead people, the pressure on forests still prevailed. This might substantiate André and Platteaus (1998) theory that inconvenient villagers were wiped out during the war and clearing actually boomed in the post-war period. If the interaction term of scaled dead people and population in 1990 changes by 1 unit then the deforestation changes 2.872 times[25]. Therefore deforestation rate increases with the village size.

Considering the discussion of the previous paragraphs, a highly populated village experiences higher rates of clearing. But why does this not apply in the case of the villages with greater population pressure which experienced more attacks? This could mean that these two war variables have different effects on villagers and thereby on deforestation decision making. Increasing numbers of attacks might increase the uncertainty on the future and increase the risk. It is possible that uncertainty is higher with increasing number of attacks and the amount of people killed in the attack is of minor importance. Villagers might have been reluctant to invest into land clearing due to uncertainty when the next attack could come. Their preferences and behaviour might change significantly under this pressure. These effects can be persistent as claimed by McCrae (2006, quoted by Nillesen, 2010) and affect clearing decision even a long time

[24] How many times would dependent variable change if the independent variable changes by 1 unit.
[25] It is interpreted as a product due to transformation of the dependent variable back from log.

after the war. In villages with high population and high number of attacks deforestation decreases 0.866 times, current deforestation decreases by 13.4 per cent[26].

The results of the war variables and distance to the primary school are ambiguous. Indirect effects of dead and permanently and temporarily displaced people increased deforestation in the villages with a low level of human capital. On the other hand, it decreased deforestation in villages with a high number of attacks and with chiefs killed.

Remote villages, which were further from primary schools, had a lower level of human capital, and experienced more dead and displaced people, had a higher level of deforestation. The war rapidly decreased school enrolment, especially in remote areas and a decreased level of education increased deforestation in post-war periods. Furthermore, people who died or fled were likely the ones with higher levels of human capital stock. This might have left only villagers with lower levels of human capital in the village and this increased the level of deforestation rate in post-war periods.

On the other hand, the villages with low human capital and high number of attacks and killed chiefs experienced lower deforestation. This suggests that the less educated people were joining the armies, which complies with the findings of Chaveau and Richards (2008). Increasing number of attacks could have given a rise to uncertainty and risk as discussed above which discouraged any investments, also into human capital, and expansion of cultivation.

Distance to the store as a proxy for the market distance showed a similar outcome for all war variables. Remote villages which were further from the produce store and had higher level of violence showed decreased deforestation. Uncertainty of getting to the market, destroyed infrastructure and market structure, might have decreased trading and production, were likely to lead to a decreased deforestation.

We can conclude that total population, distance to the primary school and distance to the produce store are significant predictors of deforestation. Surprisingly, the effects of dead and permanently and temporarily displaced, and number of attacks and killed chief differ. All indirect effects of latter mentioned are negative and decrease deforestation. This could indicate the preferences changes, increased uncertainty and their long lasting effects. Shown model (1) does not contain variables which were gradually excluded for their redundancy.

[26] Current deforestation rate will decrease by 13.4 per cent if the independent variable changes by 1 unit.

Table 14: Model of the pre-war variables 1990

Dependent variable: Model	log ratio of farmed upland and total land owned			
	(1a) OLS	(1b) OLS	(1) OLS	(3) Effects
War variables				
Dead and displaced		-0.220*	-0.238*	0.788
		(0.167)	(0.172)	
Number of attacks		0.036*	0.029	1.029
		(0.026)	(0.025)	
Displaced temporarily		-0.155	-0.226	0.798
		(0.159)	(0.177)	
Chief killed		0.124**	0.020	1.020
		(0.070)	(0.067)	
Channels				
Log total population 1990	0.255***	0.182**	0.286***	1.331
	(0.080)	(0.095)	(0.095)	
Distance to primary school 1990	0.006	0.016	0.017	1.017
	(0.017)	(0.019)	(0.019)	
Distance to produce store 1990	-0.038***	-0.029**	-0.035**	0.966
	(0.012)	(0.014)	(0.014)	
Number of churches and mosques 1990	0.001	0.003	-0.027	0.973
	(0.061)	(0.067)	(0.064)	
Indirect effects				
Dead x total population 1990			1.055**	2.872
			(0.459)	
Dead x distance to primary school 1990			0.164*	1.178
			(0.098)	
Dead x distance to produce store 1990			-0.096	0.908
			(0.068)	
Dead x number of churches/mosques			-0.512	0.599
			(0.321)	
Attacks x total population 1990			-0.144*	0.866
			(0.073)	
Attacks x distance to primary school 1990			-0.060***	0.942
			(0.016)	
Attacks x distance to produce store 1990			0.015	1.015
			(0.011)	
Chief x distance to primary school 1990			-0.078**	0.925
			(0.035)	
Chief x distance to produce store 1990			-0.092***	0.912
			(0.027)	
Displaced x distance to primary school 1990			0.229**	1.257
			(0.090)	
Displaced x distance to produce store 1990			-0.169***	0.845
			(0.063)	
Constant	-1.744***	-1.584***	-1.225***	
	(0.249)	(0.288)	(0.079)	
FE	yes	yes	yes	
N	152	133	133	
R^2	0.232	0.262	0.437	
adj. R^2	0.178	0.174	0.306	
sign.	0.000	0.001	0.000	

5.2.2 Model 2 - Deforestation model

The main deforestation model tests the direct and indirect effects of the war and other predictors on upland cultivation rate. The results of the four sub-models are depicted in columns (2a), (2b), (2c) and (2). First three sub-models tests only direct effects (2a), (2b) and (2c), while the last model includes the indirect effects of the war (2). Changes and differences in the models were followed and patterns were identified in order to understand their impact on the dependent variable. Based on this screening step, only key variables are selected. This approach was chosen due to the large amount of variables in the full model, which had to be reduced.

This model is affected by endogeneity as discussed in section 5.2 and the results can be interpreted only as existing correlations among variables and not as causal relationships. However, these correlations give indications on the relationships among variables and yield first information on the patterns among variables.

Table 15 shows two basic models which tests the direct effects of the common drivers and the war variables separately. Column (2a) considers only fundamental variables (other drivers) which are mostly tested in deforestation literature. Basic column (2b) focuses on the direct effects of the war variables. They are not discussed in empirical studies but in spite of that, the model is included in order to examine a direct impact of the war as it is the treatment variable in the models. Column (3) shows backward logarithmic transformation of both columns (2a) and (2b), which helps quantifying the effects. The effects are interpreted as products between dependent and independent variable due to transformation of the log dependent back[27].

Table 15: Basic models of the main analysis

Dependent variable:	log ratio of farmed upland and total land owned		
Model	(2a) OLS	(2b) OLS	(3) Effects
Other drivers			
Distance to the market	-0.032** (0.017)		0.969
Log total population 2010	0.139** (0.066)		1.149
Soil quality	0.262** (0.114)		1.300
Slope of farm	-0.070 (0.129)		0.932
Rain shock 2009	0.125** (0.056)		1.133
War variables			
Dead and displaced		-0.425*** (0.162)	0.654
Number of attacks		0.010 (0.025)	1.010
Displaced temporarily		-0.221* (0.156)	0.802
Constant	-1.927*** (0.402)	-0.941*** (0.171)	0.295
FE	yes	yes	
N	137	144	
R^2	0.159	0.143	
adj. R^2	0.085	0.085	
sign.	0.021	0.012	

[27] The same interpretation as in the model (1).

Table 15 shows the results of the two basic sub-models in columns (2a) and (2b). All traditional drivers in column (2a) comply with the theoretical background previously presented. Increasing market distance decreases the ratio of farmed upland, due to increasing transaction cost. This finding confirms the previous studies of Pffaf (1999), Chomitz and Gray (1996), Vance and Geoghegan (2002). Better soil availability increases land clearing because it offers a higher yield. Column (2a) gives indications on population pressure increasing deforestation. This result is in line with the pre-war variables model, which tests the pre-war total village population. Rain shock in 2009 and deforestation have a positive relationship. An increased amount of rain in 2009 allowed higher yields and upland agriculture expansion, therefore it is considered a positive shock for the farmers. On the other hand, the possible problem of endogeneity of population pressure, soil quality and market distance, needs to be considered. Chomitz and Gray (1996) claimed that latter can be overcome by controlling for other biophysical characteristics. The results obtained for population pressure are in line with those obtained in the pre-war variables model. Therefore, only soil quality might be subjected to endogeneity bias. Results suggest that soil quality and deforestation correlate together, but any causality relationship remain unclear. On the other hand, the average fallow period in the villages is 9 years, which is considered sufficient for the soils to fully recover (Leach, 1994).

Column (2b) analyses the direct effects of the war for dead and permanently displaced and temporarily displaced people. The abandonment of farms allowed forest recovery and relieved pressure from vegetation. Leach (1994) yielded the same indications in post-war Sierra Leone in the 50s and 60s of the 19th century. The impact of dead and permanently displaced people is the dominant effect among the war variables. It confirms the conclusion of the pre-war variables model.

Table 16 shows the extended sub-models testing only direct effects of all variables (2c), and the full sub-model (2) testing direct and indirect effects of all variables. Column (3) shows quantified effects of the variables in the sub-model (2), which is interpreted in the same way as in the pre-war variables model.

The channels included in the models are not significant; therefore, there is no significant correlation with upland cultivation. This pattern is present in all models. This stands in contradiction with the findings of Geoghegan *et al.* (2001) and Godoy *et al.* (1997), who found a positive relationship between level of education and deforestation. It also contradicts the findings of scholars, who showed increasing deforestation, as result of property rights insecurity (see section 3.2.5). Maconachie (2008) and Richards (1996) detected labour constraints as the crucial factor affecting cultivation; however, this is not confirmed by the present results. The present model does not yield any indications on increased investments into sustainable natural resource management in villages with superior levels of social capital, which was indicated by Bouma *et al.* (2008) and Beekman and Bulte (2012).

The impacts of other variables (such as topography), which were examined in column (2a) are weakened by adding the additional variables. Increasing distance to the market still proposes a decrease in deforestation due to increasing costs. Soil quality is considered another very robust indicator of deforestation. A higher soil quality indicates a higher propensity for the plot to be farmed. If soil quality is increased by 1 unit, the ratio of upland land farmed increases 1.415 times.

The direct effect of dead and permanently displaced people is very robust over all sub-models and indicates the high positive impact of farm abandonment on forests recovery. This complies with findings of the pre-war variables model. The deforestation model does not have any different impact of dead and displaced people and the number of attacks on indirect effects compared to the pre-war variables model. This might be due to different measures used.

The villages which experienced more violence and had a high level of human capital (i) and high pro-conservation preferences (ii), had lower levels of deforestation. When changing these interaction terms by one unit, the deforestation would decrease 0.890 and 0.163 times, respectively[28]. It is not possible to draw conclusions on the causality relationship due to the endogeneity problem. The correlation of the scaled number of dead and permanently and temporarily displaced people and human capital with deforestation rate are highly significant. This sub-model predicts that villages which have higher levels of human capital and experienced high number of deaths and temporarily displaced people, had a decrease in the current deforestation. Human capital was an important indicator also in the pre-war variables model. It is observed, that the pre-war model confirms these results. On the other hand, a decreased deforestation might also force villagers to look for off-farm employment which increases their human capital stock[29].

The villages which have higher pro-conservation preferences with many dead people and high number of attacks still show a lower deforestation rate. Nevertheless, a higher level of deforestation could induce pro-conservation behaviour as a response to forest scarcity, and this process could have been aggravated by the civil war.

Insecure property rights can encourage cultivation via uncontrollable land clearing. Bohn and Deacon (2000) and Deacon (1994) showed that insecurity and lawlessness increased deforestation. On the other hand, deforestation can increase the number of conflicts and deteriorate property rights regime. The villages with higher number of deaths under insecure property rights regime and high social capital levels, experienced expanding farmed upland. The deforestation rate values increases 7.015 and 27.771 times, respectively, if the predictor changes by 1 unit.

The robustness of the sub-models (2c) and (2) is tested by replacing both measures of human capital and market distance by their proxies of distance to the primary school 2010 and distance to the produce store in 2010[30]. This replacement does not change the results of the column (2c). Therefore, the distance to the produce store (as proxy of market accessibility), soil quality and dead and permanently displaced are significant and robust indicators of deforestation. Also the patterns in the sub-model (2) remained the same after replacing some of the variables; however, they were weakened. The most robust result is the direct impact of the scaled number of dead and permanently displaced persons on deforestation. The robust indirect effects of the channels are human capital, property rights and willingness to preserve. Distance to primary school 2010 measuring human capital increased deforestation significantly by 4% and was the only significant main effect among the channels in robustness check model.

Summarizing the main deforestation model, the patterns across all the sub-models become evident. Topography, soil quality and market distance, are highly significant which is in line with the theoretical background. Increased market distance decreases deforestation. Increasing distance increases transaction costs and decreases profitability. Increased soil quality favours the clearing, due to higher yields. Population pressure was not significant and was therefore omitted. This could be caused by the introduction of other control variables which weakens the impact of the population. The channels are not significantly correlated with the deforestation rate.

Direct effects of dead and permanently displaced persons are in line with the theory of farm abandonment, which provides time for the forest recovery. This result is

[28] See column (3).
[29] We cannot be sure which one of those is true due to endogeneity problem.
[30] Robustness check model is presented in appendix 3.

very robust and dominated over all war variables. This indicates that the most significant measurement of the war is the scaled number of dead and permanently displaced people.

The property rights in the interaction term with all war variables, is significantly correlated to deforestation. The villages with a high level of violence and very insecure property rights experience higher deforestation. It is difficult to determine the impact of the war on property rights from the present results. Possibly the increased deforestation was due to insecure property rights which were exacerbated by the war; or the pre-war property rights regime affected by the war rather impacted the current deforestation; or deforestation actually impacted and deteriorated property rights. Willingness to preserve and human capital level have negative correlation with deforestation in interaction with the war. But again a causal relationship cannot be established. But it can be concluded, that latter are important factors in the relationship between the war and deforestation.

Regions affected by a war should pay special attention to property rights regime, human capital level and pro-conservation preferences as those are linked to deforestation when affected by the war.

Initially, five war variables were selected. However, the dummy variable for the killed chief did not bring any benefit to the model and the model improved after excluding it. It also reduced the number of variables significantly. The dummy for property destruction was assumed to have lower impact on the channels. The recovery rate of physical capital destruction was faster than for destruction of other forms of capital (Blattman and Miguel, 2010). This variable was very weakly correlated to other variables and worsened the model. Therefore, it was excluded from the analyses. A war index of all selected war variables was constructed based on the works of Bellows and Miguel (2006), Voors *et al.* (2010) and Voors (2011). However, this index did not have enough explanatory power and omitted too much information. This might be due to a cancelling out of the effects of the individual war variables.

Table 16: The main analyses

Dependent variable:	log ratio of farmed upland and total land owned		
Model	(2c) OLS	(2) OLS	(3) Effects
Other drivers			
Distance to the market	-0.040**	-0.028*	0.972
	(0.020)	(0.018)	
Log total population 2010	0.094		
	(0.081)		
Soil quality	0.325***	0.347***	1.415
	(0.134)	(0.128)	
Slope of farm	-0.143	-0.324***	0.723
	(0.149)	(0.132)	
Rain shock 2009	0.064		
	(0.062)		
Channels			
Human capital	-0.004	0.003	1.003
	(0.005)	(0.006)	
Percentage literate household heads	-0.298		
	(0.195)		
Dependency ratio	0.000		
	(0.001)		
Social capital	-0.251	-0.370	0.691
	(0.377)	(0.336)	
Property rights insecurity	-0.159	-0.318*	0.728
	(0.185)	(0.181)	
Willingness to preserve	-0.044	-0.035	0.966
	(0.159)	(0.148)	
War variables			
Dead and permanently displaced	-0.527***	-0.544***	0.580
	(0.169)	(0.163)	
Number of attacks	0.0058	0.025	1.025
	(0.028)	(0.026)	
Temporarily displaced	-0.227*	-0.263*	0.769
	(0.156)	(0.146)	
Indirect effects			
Dead x HC		-0.117***	0.890
		(0.037)	
Dead x SC		3.324**	27.771
		(1.512)	
Dead x property rights		1.948**	7.015
		(0.750)	
Dead x preferences		-1.812**	0.163
		(0.687)	
Attacks x HC		-0.004	0.996
		(0.004)	
Attacks x property rights		0.309**	1.362
		(0.117)	
Attacks x preferences		-0.452***	0.636
		(0.122)	
Displaced x HC		-0.094***	0.910
		(0.034)	
Displaced x SC		3.690**	40.045
		(1.442)	
Displaced x property rights		1.787**	5.972
		(0.719)	
Constant	-1.078*	-1.317***	
	(0.635)	(0.346)	
FE	yes	yes	
N	115	116	
R^2	0.270	0.452	
adj. R^2	0.114	0.292	
sign.	0.041	0.000	

5.2.3 Model 3 - Commercial logging model

The main assumption in the analysis above was that agricultural expansion is the main proximate cause of deforestation (Geist and Lambin, 2001); however, it is not the only one. Commercial timber logging is another important driving force of deforestation. Geist and Lambin (2001) noted that in 26% of the studied cases of deforestation in Africa, wood extraction is mentioned as the main cause of land clearing.

All models tests only the direct effects and the results of all models are presented in the table 17. Dependent variable is the presence of commercial logging within the community forests. Sub-model (2a) analyses the channels and the standard drivers. Only social capital yields a positive relationship with commercial logging; the higher level of social capital is connected to a lower probability of commercial logging. Column (2b) tests the direct impact of the war variables on the probability of commercial logging and no direct effect is detected. These predictors are not significantly different from zero. The last column (2c) tests the main effects of all variables, namely the standard drivers, the channels and the war variables.

The most robust results are obtained for the variables soil quality and social capital. Villages with higher soil quality experience a lower probability of commercial logging as they prefer to farm the land rather than to exploit it commercially for selective timbering. Better quality soils offer higher yields. High levels of social capital also decrease the probability of commercial clearing. Higher levels of social capital might increase investments into natural resources management. This complies with the findings of Bouma *et al*. (2008) and Beekman and Bulte (2012) who detected a positive relationship between the level of social capital and the investments into natural resource management. However, also commercial logging causing forest scarcity could lead to tightened relationships among villagers. Nevertheless, the villages can abolish any commercial logging in the village. So, the latter is assumed to be unlikely.

The inclusion of the interaction terms brought huge instability into model. Some of the categorical predictors violated the assumption of complete information and had to be excluded. It can be concluded that the war, channels and other drivers had some effect on commercial logging, but they are not robustly related. Logging is driven mainly by farming. Another important predictor is past logging. The war affected past logging and this affected current logging. Nevertheless, there is a lack of data to test this relationship. The commercial logging model also deals with measurement problems when villagers did not report all the logging in the community forests. Thus the model might be underestimated.

Table 17: Commercial logging model

Dependent variable:	Commercial logging present (dummy)		
Model	(2a) Logit	(2b) Logit	(2c) Logit
Other drivers			
Distance to the market	-0.078		
	(0.137)		
Distance to community forest	-0.180		
	(0.238)		
Log total population 2010	0.360		
	(0.557)		
Soil quality	-1.011		-1.631*
	(0.942)		(0.879)
Slope of farm	1.302		0.932
	(1.131)		(1.053)
Rain shock 2009	-0.125		-0.519
	(0.469)		(0.457)
Channels			
Human capital	-0.022		
	(0.038)		
Percentage literate household heads	-1.487		-1.523
	(1.490)		(1.355)
Dependency ratio	0.005		
	(0.009)		
Social capital	-4.583*		-5.003**
	(2.504)		(2.136)
Property rights insecurity	-1.393		
	(1.395)		
Willingness to preserve	-1.753		-0.769
	(1.200)		(1.093)
War variables			
Dead and displaced		0.635	
		(1.074)	
Chief killed		-0.181	-0.291
		(0.459)	(0.493)
Number of attacks		0.215	0.277*
		(0.182)	(0.187)
Displaced temporarily		-1.133	-1.464
		(1.071)	(0.954)
Constant	-0.493	-0.129	2.097
	(2.726)	(0.491)	(2.582)
FE	yes	yes	yes
N	136	147	151
R^2	0.136	0.101	0.166
sign.	0.319	0.084	0.019

5.2.4 Model 4 - Fallow period model

This model tests the impact of the war characteristics and the channels on the fallow period length. The fallow period is used as a dependent variable and the same set of variables is used as in the main analysis. However, the soil type variable was excluded from the analysis due to expected high endogeneity with the fallow period variable.

Five sub-models are tested, four of them analyses only direct effects (2a), (2b), (2c) and (3) and one examines also indirect effects of the war (2). The results of these models are summarized in table 18. The sub-model in column (2a) tests only other drivers. Population pressure is expected to decrease the fallow period as well as the rain shock, allowing a fast plot revitalization; on the other hand inaccessible plots would have longer fallow periods. None of the variables tested are significant; however, the rain shock is close to the significance level. The rain shock decreases fallow period as expected.

The column (2b) analyses only the war variables and their effects on a fallow system. Column (2c) examines all direct effects together – standard drivers, channels and war variables, while column (2) shows also the interaction terms. Rain shock significantly reduces the fallow period length. Sufficient level of rain allows a faster recovery of nutrients. Richards (1996, quoted by Ickowitz, 2006) pointed out that farmers make decisions based on soil quality of every individual plot. Soil nutrient levels are affected by the precipitations. On the other hand, the slope increases the fallow period length. Steeper plots have worse accessibility and are more costly to clear and to cultivate. Gleave (1996) found a similar trend. Willingness for forest conservation increases the fallow period. The number of armed attacks increases the fallow. The number of attacks is highly significant and robust. This outcome complies with the results of the pre-war variables model. The number of attacks might have increased the uncertainty and the risk, while it decreased the level of cultivation. In the present model an increased uncertainty could increase the length of the fallow period, as people are more reluctant to invest into land clearing and to cultivate the land.

Sub-model (2) presents the indirect effects of the war. Villages with a higher number of deaths and displaced people and with a higher dependency ratio, experience an increasing fallow period. High levels of dependency ratio indicate a lower labour supply. More dead people and low labour supply prompt prolonging of the fallow period as the labour force needed for demanding clearing is missing. Labour supply is the only significant indirect indicator of the fallow period length. However, the theory of Richards (1996, quoted by Ickowitz, 2006) with labour availability as the main factor is not confirmed. Labour supply becomes an important indicator only with respect to the war.

One more sub-model (3) is built in order to prove the previous results. This column is based entirely on the theory of Gleave (1996) and Karimu and Richards (1980, quoted by Gleave, 1996) as described in section 3.2.2. Selected variables are the rain shock 2009 indicating environmental conditions, slope as a proxy for accessibility, total population pressure, dependency ratio as a labour supply measure, willingness to preserve, human capital and the share of literate heads of households as a measure for management skills. Environmental conditions, slope, rain, and willingness to preserve are the main driving forces of the fallow period length. This complies with previous findings. Labour supply and management practices are not important indicators of the fallow period lenght, which contradicts the findings of Gleave (1996) and Karimu and Richards (1980, quoted by Gleave, 1996).

The fallow period could be shortened also due to agriculture intensification or introduction of new technologies. However, 96.7% of the households do not invest into soil quality improvements and 90% of households do not invest into soil protection.

It can be concluded that the accessibility of a plot (slope), the rain shock of the last year, the preference for forest preserving, and the number of attacks are the main predictors. Labour supply becomes an important driver in post-war conditions.

Table 18: Fallow period analysis

Dependent variable:	Fallow period				
Model	Basic (2a) Ordinal logistic	Basic (2b) Ordinal logistic	Extended (2c) Ordinal logistic	Full (2) Ordinal logistic	Full (3) Ordinal logistic
Other drivers					
Distance to the market	0.029				
	(0.090)				
Log total population 2010	-0.044				-0.162
	(0.370)				(0.346)
Slope of farm	0.992		1.438**	1.412*	1.127*
	(0.652)		(0.607)	(0.748)	(0.641)
Rain shock 2009	-0.516		-0.622**	-0.661*	-0.635**
	(0.314)		(0.297)	(0.341)	(0.299)
Channels					
Human capital					-0.023
					(0.022)
Percentage literate household heads			1.389		1.216
			(0.901)		(0.906)
Dependency ratio				-0.005	0.000
				(0.006)	(0.005)
Social capital				-0.923	
				(1.651)	
Property rights insecurity				0.517	
				(0.974)	
Willingness to preserve			1.674**	0.945	1.745**
			(0.740)	(0.829)	(0.741)
War variables					
Dead and displaced		0.024		-0.045	
		(0.797)		(0.933)	
Number of attacks		0.230*	0.234*	0.290**	
		(0.119)	(0.124)	(0.145)	
Displaced temporarily		0.274		-0.871	
		(0.742)		(0.871)	
Dead x dependency ratio				0.067**	
				(0.032)	
Dead x SC				-12.062	
				(8.100)	
Dead x property rights				-7.400	
				(5.115)	
Displaced x dependency ratio				0.067**	
				(0.030)	
Displaced x SC				-8.123	
				(7.000)	
Displaced x property rights				-3.506	
				(4.847)	
FE	yes	no	yes	yes	yes
N	137	143	159	136	158
R^2	0.093	0.027	0.164	0.173	0.146
sign.	0.202	0.273	0.003	0.212	0.015

5.2.5 Testing of the war selection bias

The underlying assumption for the main deforestation model is that the war and the violence spread were random and it can therefore be considered as a natural experiment. This means that violence was not targeted and not driven by individual preferences of the attackers. Endogeneity could have caused biased results, which could have led to an overestimation or underestimation of the real results. In latter case, the overall picture of the war and deforestation would have been falsely interpreted due to this bias. The randomness of the violence spread is tested in this chapter in order to reduce any possible bias of analysis results due to violence driven by a selection bias.

Bellows and Miguel (2006) tested whether violence in Sierra Leone was driven by the presence of diamond mines and road density. The result for both factors was insignificant. Bellows and Miguel (2009) claimed randomness of a violence spread in Sierra Leone on village level. However, on household level, families related to paramount chiefs were on average targeted more heavily. Road density and population were only weakly correlated with the violence against civilians (Bellows and Miguel, 2006). On the other hand school enrolment in 1989 was negatively correlated and the log per capita consumption expenditures in 1989 were positively correlated to the level of violence. Therefore, chiefdoms with more loot able resources were more attractive to rebels (Bellows and Miguel, 2009).

In the present study it is examined whether the location of violence represented by the four war variables was randomly assigned with the selected pre-war variables. This is performed according to the approach described by Bellows and Miguel (2006) and Voors *et al.* (2012). Voors *et al.* (2012) tested the randomness of a violence appearance in Burundi.

Selected independent variables are retrieved from the village level survey 2010: distance to the primary school in 1990 as measure of human capital; distance to a police station in 1990 as proxy to safety; distance to produce store in 1990 as proxy for distance to the market; number of development projects before the war as assumed driver of atrocities against civilians according to Hoffman (2004); village population in 1990, and number of churches and mosques in 1990. They are the same pre-war variables as in the pre-war variables model.

The test whether the exposure to violence was independent from pre-war characteristics of the communities shows that the ratio of dead and permanently displaced people is positively correlated with the distance to a primary school. Therefore, with increasing distance there is an increasing level of deaths and displaced persons. Guerrillas were targeting more remote regions with lower levels of education. This confirms the finding of Bellows and Miguel (2006) who described a significant negative correlation of school enrolment in 1989 in Sierra Leone with the conflict index. The areas with higher level of human capital would have experienced less violence. This causes an overestimation of human capital results in the models. Results are presented in table 19.

The problem of endogeneity can be avoided by an instrumental variable or using pre-war data. In the present case it was not possible to overcome endogeneity, but to reduce this problem with selected pre-war variables. Yet these were no proper measure of those variables defined for the main deforestation model.

Table 19: Endogeneity of the war variables

Dependent variable:	Dead and permanently displaced (1) OLS	Temporarily displaced (2) OLS	Number of attacks (3) Ordinal logistic
Variables			
Log total population (1990)	-0.058	0.000	0.634
	(0.056)	(0.061)	(0.458)
Distance to primary school (1990)	0.028**	0.004	-0.118
	(0.014)	(0.015)	(0.111)
Distance to health clinic (1990)	-0.022	0.010	0.097
	(0.014)	(0.015)	(0.113)
Distance to produce store (1990)	0.011	0.000	0.107
	(0.009)	(0.009)	(0.071)
Distance to police station (1990)	-0.020	-0.004	0.027
	(0.014)	(0.015)	(0.111)
Number of development projects (1990)	0.037	0.011	0.023
	(0.039)	(0.044)	(0.330)
Number of churches and mosques (1990)	-0.044	0.057	0.258
	(0.0434)	(0.049)	(0.363)
Constant	0.675***	0.473**	
	(0.178)	(0.201)	
FE	yes	yes	yes
N	138	144	151
R^2	0.156	0.095	0.192
adj. R^2	0.067	0.004	
sign.	0.057	0.41	0.004

6. DISCUSSION AND RECOMMENDATIONS

The main goal of this report was to identify the direct and indirect impacts of the war in Sierra Leone on deforestation in the region of Gola Rainforests National Park. 176 villages were surveyed in order to analyse and understand the underlying factors in the deforestation process in those regions affected by the conflict. This chapter summarizes the main findings and presents recommendations for the future research on the impacts of the war on deforestation.

The model of pre-war variables showed that market distance and human capital in post-war regions are important drivers of deforestation. The war in Sierra Leone deteriorated human capital according to Mohammed *et al.* (2004), which is in line with the present results. Individuals with lower stock of human capital possibly joined the military forces (Chauveau and Richards, 2008) and those with higher stock of human capital might have emigrated from these regions. The importance of human capital and market distance was also detected by the deforestation model, which was based on post-war village data. Both mentioned models yielded indication on a negative impact of population pressure on deforestation. However, this effect disappeared in the deforestation model once we introduced more control variables into the analysis. This suggests a complex relationship of population pressure with deforestation (Kummer and Sham, 1994, Palo, 1994). The model (1) showed surprising results in terms of different indirect impacts of the war variables, i.e. dead and displaced people and the number of attacks. It is likely that the latter increased the uncertainty and the risk in war-affected regions, which in turn decreased forest clearing due to discouraged investments. The same is shown for the fallow period model, where a direct effect of the attacks increased the probability of longer fallow periods. This result might suggest that the number of attacks changed the behaviour of people and their preferences. However, our measure of preferences did not capture this change.

The main deforestation model sheds light upon the crucial players in the deforestation process in the post-war villages. The major factors correlated with deforestation in war-affected Sierra Leone were: human capital, property rights and willingness to preserve. Even though, no causality relationship could be established, the presented results still allow drawing conclusion.

The indirect effects of the war and human capital on deforestation were unexpected and a negative relationship was detected by the model. The stock of human capital could have increased depending on the place where refugees settled, which was not part of this study. Even though Kondylis (2008) found decreased stock of knowledge among returnees compared to stayers, he did not distinguish among different refugees. Also forest scarcity or new opportunities might push farmers to acquire new practices or to look for off-farm possibilities and increase their human capital, respectively. The pre-war variables model also showed a significant relationship of human capital and the war variables with deforestation rate. However, an increased stock of human capital could be caused by recent and temporary rural-urban migration. Also, operation of NGOs in post-war regions could have affected human capital or other channels such as social capital.

Improved human capital suggests exploitation of off-farm opportunities and a decrease of deforestation. People can be forced to look for off-farm jobs by several aspects: if agricultural rents are rapidly reduced (e.g. by governmental policies) or due to forest scarcity and lack of new land (Angelsen, 2010). The consequence is the acquisition of a new knowledge stock and further decrease of deforestation. The firm conclusion cannot be drawn due to causality problem on the model and the further research is needed to fully understand the relationship among the war, human capital and deforestation.

The evidence of the war impacts and property rights was scarce and did not have a clear conclusion. The applied model showed that villages with a high level of violence and very insecure property rights experienced more deforestation. This might be due to different possible causal relationships: post-war uncertainty and insecurity is linked to high level of deforestation offering immediate yields; or high deforestation causing conflicts over the land and deterioration of property rights. The insecure property rights are positively correlated with deforestation, and improved property rights regime is one of the crucial policies to decrease forest transformation (Bohn and Deacon, 2000, Godoy et al., 1998).

Pro-conservation preferences were also without any clear direct of the hypothesis. A negative correlation between the war and preferences with deforestation was shown. Villages with a high level of violence and high pro-conservation behaviour had lower deforestation rates. The possible causality of higher preferences to decrease deforestation is clear, however, the role of the war needs to be further researched. On the other hand, land scarcity might increase the preference towards sustainable forests management. Angelsen (2010) mentioned that one of the policies for reduced deforestation is setting up protected areas with forbidden or limited farming practices. However, he added that villagers do not fully respect these areas. The question is if the willingness to preserve can be influenced by any policy or if it is rather a result of human capital possession.

Based on the above indications, we can say that war-torn regions have to pay special attention to human capital, property rights regimes and to pro-conservation behaviour, which is closely related to human capital.

The main deforestation model yielded other interesting findings. Lidow (2011) showed that the villages close to permanent bases were affected the most. This is in line with the results of this study. Koya chiefdom was the most affected by the violence and the RUF troops were the main attackers. Violence affected population in all villages and most of the villages have had negative population growth since 1990.

Scholars point out positive effects of wars on forests due to abandoned farms. The present model indicated that a direct effect of abandoned farms is very robust and the number of dead, permanently and temporarily displaced people had a significant positive effect on forests. Nevertheless, McNeely (2003) concluded that the positive effects are random and accidental.

The ratio of farmed upland and total land owned was used as proxy for a deforestation rate. There was a vivid discussion in the early stages of this research, on which proxy variables to use for deforestation. Latter mentioned ratio was used as the most appropriate, among the available ones. However, satellite pictures could help to overcome some limitations imposed by the dependent variable (Lidow, 2011). It is suggested to use remote sensing for more precise measurements of deforestation rate. Past land use change would be an important driving factor for a current land use change and data is still required. This issue could also be dealt with satellite pictures. Moreover, all three surveys (village survey 2010, household survey 2010 and village survey 2011) provided information on the ratio of farmed upland and total land owned. Surprisingly, no significant correlations were detected between them. This could mean that in every survey, interviewed people understood the question in a different way and the data regarding this question are not entirely comparable. This is another reason for using satellite pictures for the measure of dependent variable.

The fallow period length is closely related to deforestation. Mainly fallow forests are cleared for further cultivation due to very labour demanding high forest clearing (older than 20 years) (Leach, 1994). The applied model confirmed the findings of Gleave (1996), that the fallow period length is driven by biophysical characteristics, namely slope and amount of rain. Excessive rain of the last year and easily accessible plots had shorter fallow periods. Those attributes cannot be tackled by the policies unless new technologies are introduced. Irrigation systems or the adjustment of the plots' slopes by heavy machinery would allow sustainable shortening of fallow periods, for the benefit of the vegetation. An important fact for the post-war regions is that labour supply plays an important role and that lack of labour force prolongs fallow periods. This confirms the theory of labour supply importance of Karimu and Richards (1980, quoted by Gleave, 1996). However, the main effect of labour supply is not significant and is aggravated by the presence of the war. Further research is needed to investigate which other consequences follow and if it is necessary to intervene and promote agriculture intensification to again shorten the fallow periods. Soil quality is also a very important predictor on fallow length. However, causality problem is expected to hamper any definite conclusions for this factor.

The model testing commercial logging, as another driver of clearing, identified soil quality and social capital as the main predictors. Better quality plots are used for farming with higher yields, rather than for commercial logging. Improved social relationships, collective action, and reciprocity significantly decreased the probability of commercial logging. This might confirm the findings of Bouma *et al.* (2008) and Beekman and Bulte (2012) about the positive relationship of social capital and investments into natural resources management. Most of the villages did not report any commercial logging. However, the survey did not distinguish between foreign commercial loggers and village members' commercial logging activity. Also, reliable data on logged quantity are missing, which could add explanatory power to the model.

In all the tested models, biophysical factors were important, such as slope, soil and rain. This suggests the support of agricultural intensification to increase the fallow period, decrease deforestation rate and decrease the probability of commercial logging. However, Angelsen (2010) showed a reduced effect of this policy if profit from intensive production is used to clear new land as it was the case in Sulawesi. Environmental scientists claim that a good deforestation model can be based only on biophysical drivers (soil, slope, climate) but in any case it cannot be based only on human and social drivers (population, technology, economic factors).

None of the models controlled for the different stages of agricultural cycles due to lacking of data. Further research should aim to tackle the problem of endogeneity by collecting more pre-war variables.

7. CONCLUSION

This report explored the unknown indirect effects of a war on upland cultivation and deforestation. This research went into unexplored field of science. It was very first step into this field. This fact and very limited number of studies made starting position very challenging.

The initial idea was to investigate direct and indirect driving forces of deforestation in post-war Sierra Leone with particular attention to the civil war. Mainly qualitative studies helped to define the impacts of war and the drivers of deforestation. Based on this, the main direct and indirect channels through which war impacts deforestation were assessed. The survey in 2010 was not constructed to research particularly this question so different obstacles had to be overcome.

A new model was developed in order to test the hypothesis of the impact of the war on community forests in Sierra Leone. It was shown that the indirect effects of the war on changes in upland farming were significant and that they need to be considered to understand the driving forces behind changes in conflicted areas. Land use changes are the outcome of complex interactions between different factors. As Leach (1994) concluded, we cannot assume that villages with pro-conservation behaviour do not have negative impact on forests because there are other factors influencing it to a larger extent, i.e. property rights, demography or knowledge. Present results confirm that the civil war played a role in deforestation patterns and policy makers should be aware of this.

This report generates indications, which are in line with deforestation studies, of topography being an important driver. War had undoubtedly a positive direct effect on forest cover in Sierra Leone. However, according to current research, this effect was only temporary, random and minor compared to the negative effects. The main factors together with the war were identified as human capital, property rights and preferences. This study did not confirm any of the studies proving direct effects of the channels on deforestation.

Although, the present study was able to support some of the previous finding and likely contributed to our understanding of the relationship between warfare and deforestation, the uncertainties in this area are still evident and further research is required.

8. REFERENCES

ADESINA, A. A., MBILA, D., NKAMLEU, G. B. & ENDAMANA, D. 2000. Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. *Agriculture, Ecosystems and Environment,* 80**,** 255-265.

ANDERIES, J. M., JANSSEN, M. A., BOUSQUET, F., CARDENAS, J. C., CASTILLO, D., LOPEZ, M. C., TOBIAS, R., VOLLAN, B. & WUTICH, A. 2011. The challenge of understanding decisions in experimental studies of common pool resource governance. *Ecological Economics,* 70**,** 1571-1579.

ANDRADE DE SÁ, S., PALMER, C. & DI FALCO, S. 2011. Dynamics of Indirect Land-Use Change: Empirical Evidence From Brazil. [Accessed 21/12/11].

ANDRÉ, C. & PLATTEAU, J. P. 1998. Land relations under unbearable stress: Rwanda caught in the Malthusian trap. *Journal of Economic Behavior and Organization,* 34**,** 1-47.

ANGELSEN, A. 2010. Policies for reduced deforestation and their impact on agricultural production. *Proceedings of the National Academy of Sciences,* 107**,** 19639-19644.

ANGELSEN, A. & KAIMOWITZ, D. 1999. Rethinking the causes of deforestation: Lessons from economic models. *World Bank Research Observer,* 14**,** 73-98.

ARAUJO, C., BONJEAN, C. A., COMBES, J. L., COMBES MOTEL, P. & REIS, E. J. 2009. Property rights and deforestation in the Brazilian Amazon. *Ecological Economics,* 68**,** 2461-2468.

BEEKMAN, G. & BULTE, E. H. 2012. Social norms, tenure security and soil conservation: Evidence from Burundi. *Agricultural Systems,* 108**,** 50-63.

BELLOWS, J. & MIGUEL, E. 2006. War and institutions: New evidence from Sierra Leone. *American Economic Review,* 96**,** 394-399.

BELLOWS, J. & MIGUEL, E. 2009. War and local collective action in Sierra Leone. *Journal of Public Economics,* 93**,** 1144-1157.

BHATTARAI, K., CONWAY, D. & YOUSEF, M. 2009. Determinants of deforestation in Nepal's Central Development Region. *Journal of Environmental Management,* 91**,** 471-488.

BLATTMAN, C. 2009. From violence to voting: War and political participation in Uganda. *American Political Science Review,* 103**,** 231-247.

BLATTMAN, C. & ANNAN, J. 2010. The consequences of child soldiering. *Review of Economics and Statistics,* 92**,** 882-898.

BLATTMAN, C. & MIGUEL, E. 2010. Civil war. *Journal of Economic Literature,* 48**,** 3-57.

BOCKSTAEL, N. E. 1996. Modeling economics and ecology: The importance of a spatial perspective. *American Journal of Agricultural Economics,* 78**,** 1168-1180.

BOHN, H. & DEACON, R. T. 2000. Ownership Risk, Investment, and the Use of Natural Resources. *The American Economic Review,* 90**,** 526-549.

BOUMA, J., BULTE, E. & VAN SOEST, D. 2008. Trust and cooperation: Social capital and community resource management. *Journal of Environmental Economics and Management,* 56**,** 155-166.

BROWN, K. & PEARCE, D. W. 1994. *The causes of tropical deforestation : the economic and statistical analysis of factors giving rise to the loss of the tropical forests,* London, UCL Press.

BULTE, E., KONTOLEON, A., LIST, J., MOKUWA, E., RICHARDS, P., TURLEY, T. & VOORS, M. 2010. Assessing livelihood impacts of the Gola Forests Programme: Preliminary Report on Baseline Survey. Gola Forest Programme.

CHAMARBAGWALA, R. & MORÁN, H. E. 2011. The human capital consequences of civil war: Evidence from Guatemala. *Journal of Development Economics,* 94**,** 41-61.

CHAUVEAU, J. P. & RICHARDS, P. 2008. West African insurgencies in Agrarian perspective: Côte d'Ivoire and Sierra Leone compared. *Journal of Agrarian Change,* 8**,** 515-552.

CHOMITZ, K. M. & GRAY, D. A. 1996. Roads, land use, and deforestation: a spatial model applied to Belize. *World Bank Economic Review,* 10**,** 487-512.

CLOVER, J., CAIN, A. & CORNWELL, R. 2004. Conflict and Human Security. *Supporting Sustainable Livelihoods. A critical review of assistance in Post-Conflict situations.* Pretoria: Institute for Security Studies.

COLLIER, P. 1999. On the economic consequences of civil war. *Oxford Economic Papers,* 51**,** 168-183.

COLLIER, P., ELLIOTT, L., HEGRE, H., HOEFFLER, A., REYNAL-QUEROL, M. & SAMBANIS, N. 2003. Breaking the Conflict Trap: Civil War and Development Policy. Washington DC: World Bank & Oxford University Press.

COLLIER, P., HOEFFLER, A., TODD, S. & KEITH, H. 2007. Chapter 23 Civil War. *Handbook of Defense Economics.* Elsevier.

CRAMER, C. 2006. *Civil war is not a stupid thing : accounting for violence in developing countries,* London, Hurst.

CROPPER, M., GRIFFITHS, C. & MANI, M. 1999. Roads, population pressures, and deforestation in Thailand, 1976-1989. *Land Economics,* 75**,** 58-73.

DEACON, R. T. 1994. Deforestation and the rule of law in a cross-section of countries. *Land Economics,* 70**,** 414-430.

DEACON, R. T. 1999. Deforestation and Ownership: Evidence from Historical Accounts and Contemporary Data. *Land Economics,* 75**,** 341-359.

DEININGER, K. & MINTEN, B. 2002. Determinants of deforestation and the economics of protection: An application to Mexico. *American Journal of Agricultural Economics,* 84**,** 943-960.

DRAULANS, D. & VAN KRUNKELSVEN, E. 2002. The impact of war on forest areas in the Democratic Republic of Congo. *ORYX,* 36**,** 35-40.

DUDLEY, J. P., GINSBERG, J. R., PLUMPTRE, A. J., HART, J. A. & CAMPOS, L. C. 2002. Effects of war and civil strife on wildlife and wildlife habitats. *Conservation Biology,* 16**,** 319-329.

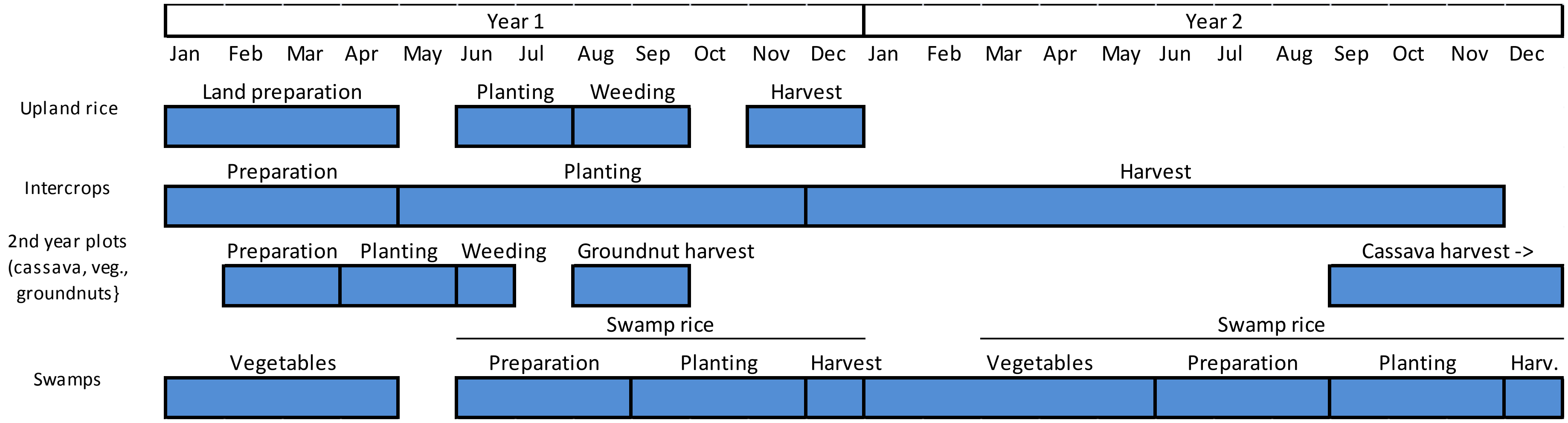
DYFAN, I. 2003. Peace Agreements as a Means for Promoting Gender Equality and Ensuring Participation of Women. Ottawa: United Nations, Division for the Advancement of Women.
EMERSON, J., ESTY, D. C., KIM, C., SREBOTNJAK, T., LEVY, M. A., MARA, V., SHREBINI, A. D. & JAITEH, M. 2010. Environmental Performance index 2010. Yale Centre for Environmental Law and Policy, Centre for International Earth Science Information Network.
ETTER, A., MCALPINE, C., PHINN, S., PULLAR, D. & POSSINGHAM, H. 2006. Unplanned land clearing of Colombian rainforests: Spreading like disease? *Landscape and Urban Planning,* 77**,** 240-254.
FIELD, A. 2009. *Discovering statistics using SPSS (and sex and drugs and rock 'n' roll),* London [etc.], Sage.
FISHER, M. & SHIVELY, G. 2005. Can income programs reduce tropical forest pressure? Income shocks and forest use in Malawi. *World Development,* 33**,** 1115-1128.
FOOD AND AGRICULTURAL ORGANIZATION 2010. Global Forest Resources Assessment 2010. Rome: Food and Agricultural Organization of the United Nations.
FREITAS, S. R., HAWBAKER, T. J. & METZGER, J. P. 2010. Effects of roads, topography, and land use on forest cover dynamics in the Brazilian Atlantic Forest. *Forest Ecology and Management,* 259**,** 410-417.
GEIST, H. J. & LAMBIN, E. F. 2001. *What drives tropical deforestation? : a meta-analysis of proximate and underlying causes of deforestation based on subnational case study evidence,* Louvain la Neuve, LUCC International Project Office.
GEIST, H. J. & LAMBIN, E. F. 2002. Proximate causes and underlying driving forces of tropical deforestation. *BioScience,* 52**,** 143-150.
GEOGHEGAN, J., VILLAR, S. C., KLEPEIS, P., MENDOZA, P. M., OGNEVA-HIMMELBERGER, Y., CHOWDHURY, R. R., TURNER II, B. L. & VANCE, C. 2001. Modeling tropical deforestation in the southern Yucatán peninsular region: Comparing survey and satellite data. *Agriculture, Ecosystems and Environment,* 85**,** 25-46.
GHOBARAH, H. A., HUTH, P. & RUSSETT, B. 2003. Civil wars kill and maim people - Long after the shooting stops. *American Political Science Review,* 97**,** 189-202.
GILLIGAN, M. J., PASQUALE, J. & SAMII, C. D. 2011. Civil War and Social Capital: Behavioral-Game Evidence from Nepal. New York: New York University Departement of Politics.
GLEAVE, M. B. 1996. The Length of the Fallow Period in Tropical Fallow Farming Systems: A Discussion with Evidence from Sierra Leone. *The Geographical Journal,* 162**,** 14-24.
GODOY, R., JACOBSON, M., CASTRO, J. D., ALIAGA, V., ROMERO, J. & ALLISON, D. 1998. The Role of Tenure Security and Private Time Preference in Neotropical Deforestation. *Land Economics,* 74**,** 162-170.
GODOY, R., O'NEILL, K., GROFF, S., KOSTISHACK, P., CUBAS, A., DEMMER, J., MCSWEENEY, K., OVERMAN, J., WILKIE, D., BROKAW, N. & MARTÍNEZ, M. 1997. Household Determinants of Deforestation by Amerindians in Honduras. *World Development,* 25**,** 977-987.
GOODHAND, J., LEWER, N. & HULME, D. 2000. Social capital and the political economy of violence: A case study of Sri Lanka. *Disasters,* 24**,** 390-406.
GROOTAERT, C. & BASTELAER, T. V. 2001. Understanding and Measuring Social Capital: A Synthesis of Findings and Recommendations from the Social Capital Initiative. Washington DC: World Bank.
HATTON, J., COUTO, M. & OGLETHORPE, J. 2001. Biodiversity and War: A Case Study of Mozambique. Washington, D.C.: Biodiversity Support Program.
HOFFMAN, D. 2004. The civilian target in Sierra Leone and Liberia: Political power, military strategy, and humanitarian intervention. *African Affairs,* 103**,** 211-226.
ICKOWITZ, A. 2006. Shifting cultivation and deforestation in tropical Africa: Critical reflections. *Development and Change,* 37**,** 599-626.
INTERNATIONAL MONETARY FUND 2011. Sierra Leone: Poverty Reduction Strategy Paper—Progress Report, 2008–10. Washington, D.C.: International Monetary Fund.
IRWIN, E. G. & BOCKSTAEL, N. E. 2002. Interacting agents, spatial externalities and the evolution of residential land use patterns. *Journal of Economic Geography,* 2**,** 31-54.
IRWIN, E. G. & GEOGHEGAN, J. 2001. Theory, data, methods: Developing spatially explicit economic models of land use change. *Agriculture, Ecosystems and Environment,* 85**,** 7-23.
JUSTINO, P. 2010. War and Poverty. MICROCON Research Working Paper 32. Brighton: MICROCON.
KAIMOWITZ, D. & ANGELSEN, A. 1998. *Economic models of tropical deforestation : a review,* Bogor, CIFOR.
KALDOR, M. & VINCENT, J. 2006. Case Study Sierra Leone: Evaluation of UNDP Assistance to Conflict-Affected Countries. New York: United Nations Development Programme, Evaluation Office.
KANYAMIBWA, S. 1998. Impact of war on conservation: Rwandan environment and wildlife in agony. *Biodiversity and Conservation,* 7**,** 1399-1406.
KEEN, D. 2003. Greedy Elites, Dwindling Resources, Alienated Youths. The Anatomy of Protracted Violence in Sierra Leone. *Internationale Politik und Gesellschaft* [Online], 2.
KLOP, E., LINDSELL, J. & SIAKA, A. 2008. Biodiversity of Gola Forest, Sierra Leone. Royal Society for the Protection of Birds, Conservation Society of Sierra Leone.
KONDYLIS, F. 2008. Agricultural outputs and conflict displacement: Evidence from a policy intervention in Rwanda. *Economic Development and Cultural Change,* 57**,** 31-66.
KONTOLEON, A. 5/1 2012. *RE: personnal communicaton.*
KOOTEN, G. C. V. & FOLMER, H. 2004. *Land and forest economics,* Cheltenham [etc.], Elgar.
KORF, B. 2003. Contract or War? An Essay on Institutional Logic in Violent Conflicts. Berghof Occasional Paper Nr. 23. Berlin: Berghof Research Center for Constructive Conflict Management.
KUMMER, D. & SHAM, C. H. 1994. The causes of Tropical Deforestation: a quantitative analysis and case study from the Philippines. *In:* BROWN, K. & PEARCE, D. W. (eds.) *The Causes of Tropical Deforestation: The Economic and Statistical Analysis of Factors Giving Rise to the Losss of the Tropical Forests.* London: UCL Press.
LEACH, M. 1994. *Rainforest Relations: Gender and Resource Use among the Mende of Gola, Sierra Leone,* London, Edinburgh University Press.
LIDOW, N. 2011. Predators or Protectors? Analyzing Liberia's Rebels Using Satellite Data.

LINDSELL, J. A., KLOP, E. & SIAKA, A. M. 2011. The impact of civil war on forest wildlife in West Africa: Mammals in Gola Forest, Sierra Leone. *ORYX,* 45**,** 69-77.
MACONACHIE, R. 2008. New agricultural frontiers in post-conflict Sierra Leone? Exploring institutional challenges for wetland management in the Eastern Province. *Journal of Modern African Studies,* 46**,** 235-266.
MACONACHIE, R. & BINNS, T. 2007. 'Farming miners' or 'mining farmers'?: Diamond mining and rural development in post-conflict Sierra Leone. *Journal of Rural Studies,* 23**,** 367-380.
MAHAPATR, K. & KANT, S. 2005. Tropical deforestation: A multinomial logistic model and some country-specific policy prescriptions. *Forest Policy and Economics,* 7**,** 1-24.
MCNEELY, J. A. 2003. Conserving forest biodiversity in times of violent conflict. *ORYX,* 37**,** 142-152.
MENDELSOHN, R. 1994. Property Rights and Tropical Deforestation. *Oxford Economic Papers,* 46**,** 750-756.
MEYER, A. L., VAN KOOTEN, G. C. & WANG, S. 2003. Institutional, social and economic roots of deforestation: A cross-country comparison. *International Forestry Review,* 5**,** 29-37.
MINISTRY OF DEVELOPMENT AND ECONOMIC PLANNING 2003. Sierra Leone Vision 2025: "Sweet-Salone". Freetown: Ministry of Development and Economic Planning.
MOHAMMED, E. A., BOEDTS, B., BASALIRWA, M., TRAORE, M. & BA, R. 2004. Agricultural Sector Rehabilitation Project: Appraisal Report. African Development Fund, Agricultural and Rural Development Department Central and West Region.
MYERS, N., MITTERMELER, R. A., MITTERMELER, C. G., DA FONSECA, G. A. B. & KENT, J. 2000. Biodiversity hotspots for conservation priorities. *Nature,* 403**,** 853-858.
NARAYAN, D. & PRITCHETT, L. 1999. Cents and sociability: Household income and social capital in rural Tanzania. *Economic Development and Cultural Change,* 47**,** 870-897.
NILLESEN, E. E. M. 2010. *Shocks, civil war and economic development in Sub-Saharan Africa.* PhD Thesis, Wageningen University.
PALO, M. 1994. Population and deforestation. *The causes of tropical deforestation : the economic and statistical analysis of factors giving rise to the loss of the tropical forests.* London: UCL Press.
PETERS, K. 2006. *Footpaths to reintegration : armed conflict, youth and the rural crisis in Sierra Leone.* Met lit. opg. - Met samenvatting in het Nederlands Proefschrift Wageningen, s.n.].
PETERS, K. & RICHARDS, P. 1998. 'Why we fight': Voices of youth combatants in Sierra Leone. *Africa,* 68**,** x1-209.
PFAFF, A. S. P. 1999. What drives deforestation in the Brazilian Amazon? Evidence from satellite and socioeconomic data. *Journal of Environmental Economics and Management,* 37**,** 26-43.
PUPPIM DE OLIVEIRA, J. A. 2008. Property rights, land conflicts and deforestation in the Eastern Amazon. *Forest Policy and Economics,* 10**,** 303-315.
RICHARDS, P. 1996. *Fighting for the rain forest : war, youth & resources in Sierra Leone,* London [etc.], James Currey [etc.].
RICHARDS, P. 2005. To fight or to farm? Agrarian dimensions of the Mano River conflicts (Liberia and Sierra Leone). *African Affairs,* 104**,** 571-590.
RICHARDS, P., BAH, K. & VINCENT, J. 2004. Social Capital and Survival: Prospects for Community-Driven Development in Post-Conflict Sierra Leone, Paper No 12. World Bank, Community Driven Development Conflict Prevention & Reconstruction.
SHEMYAKINA, O. 2011. The effect of armed conflict on accumulation of schooling: Results from Tajikistan. *Journal of Development Economics,* 95**,** 186-200.
SMITH, K. W. & SASAKI, M. S. 1979. Decreasing Multicollinearity. *Sociological Methods & Research,* 8**,** 35-56.
SOMANATHAN, E. 1991. Deforestation, Property Rights and Incentives in Central Himalaya. *Economic and Political Weekly,* 26.
SOUTHGATE, D., SIERRA, R. & BROWN, L. 1991. The causes of tropical deforestation in Ecuador: A statistical analysis. *World Development,* 19**,** 1145-1151.
SQUIRE, C. B. 2001. Sierra Leone's Biodiversity and the Civil War: A Case Study Prepared for the Biodiversity Support Program. Washington, D.C.: Biodiversity Support Programme.
STEVENS, K., CAMPBELL, L., URQUHART, G., KRAMER, D. & QI, J. 2011. Examining complexities of forest cover change during armed conflict on Nicaragua's Atlantic Coast. *Biodiversity and Conservation,* 20**,** 2597-2613.
SUTHAKAR, K. & BUI, E. N. 2008. Land use/cover changes in the war-ravaged Jaffna Peninsula, Sri Lanka, 1984-early 2004. *Singapore Journal of Tropical Geography,* 29**,** 205-220.
SUTHERLAND, W. J., ADAMS, W. M., ARONSON, R. B., AVELING, R., BLACKBURN, T. M., BROAD, S., CEBALLOS, G., CÔTÉ, I. M., COWLING, R. M., DA FONSECA, G. A. B., DINERSTEIN, E., FERRARO, P. J., FLEISHMAN, E., GASCON, C., HUNTER JR, M., HUTTON, J., KAREIVA, P., KURIA, A., MACDONALD, D. W., MACKINNON, K., MADGWICK, F. J., MASCIA, M. B., MCNEELY, J., MILNER-GULLAND, E. J., MOON, S., MORLEY, C. G., NELSON, S., OSBORN, D., PAI, M., PARSONS, E. C. M., PECK, L. S., POSSINGHAM, H., PRIOR, S. V., PULLIN, A. S., RANDS, M. R. W., RANGANATHAN, J., REDFORD, K. H., RODRIGUEZ, J. P., SEYMOUR, F., SOBEL, J., SODHI, N. S., STOTT, A., VANCE-BORLAND, K. & WATKINSON, A. R. 2009. One hundred questions of importance to the conservation of global biological diversity. *Conservation Biology,* 23**,** 557-567.
TATE, R. L. 1984. Limitations of Centering for Interactive Models. *Sociological Methods & Research,* 13**,** 251-271.
UNITED NATIONS 2004. United Nations Transitional Appeal for Relief & Recovery, Sierra Leone United Nations.
UNITED NATIONS DEVELOPMENT PROGRAMME. 2011. *International Human Development Indicators* [Online]. UNDP. Available: http://hdrstats.undp.org/en/indicators/103106.html [Accessed 22/12 2011].
UNITED NATIONS ENVIRONMENT PROGRAMME 2010. Sierra Leone: Environment, Conflict and Peacebuilding Assessment Geneva: United Nations Environment Programme.
UNRUH, J. D. & TURRAY, H. 2006. Land tenure, food security and investment in postwar Sierra Leone, LSP Working Paper 22. Rome: Food and Agriculture Organization, Livelihood Support Programme

USAID 2007. Biodiversity and Tropical Forest Assessment for Sierra Leone. United States Agency for International Development.
USAID 2010. Property Rights and Resource Governance, Sierra Leone. USAID.
VANCE, C. & GEOGHEGAN, J. 2002. Temporal and spatial modelling of tropical deforestation: A survival analysis linking satellite and household survey data. *Agricultural Economics,* 27**,** 317-332.
VOORS, M., BULTE, E., KONTOLEON, A., LIST, J. A. & TURLEY, T. 2011. Using artefactual field experiments to learn about the incentives for sustainable forest use in developing economies. *American Economic Review,* 101**,** 329-333.
VOORS, M., NILLESEN, E. E., VERWIMP, P., BULTE, E. H., LENSINK, R. & VAN SOEST, D. 2010. Does conflict affect preferences? Results from field experiments in Burundi. Brighton: MICROCON Research Working Paper 21.
VOORS, M. J. 2011. *Institutions, violent conflict, windfall gains and economic development in Africa.* PhD Thesis, Wageningen University.
VOORS, M. J., NILLESEN, E. E. M., VERWIMP, P., BULTE, E. H., LENSINK, R. & VAN SOEST, D. P. 2012. Violent Conflict and Behavior: A Field Experiment in Burundi. *American Economic Review,* 102**,** 941-64.
WALKER, R. 2004. Theorizing land-cover and land-use change: The case of tropical deforestation. *International Regional Science Review,* 27**,** 247-270.
WORLD BANK. 2011. *Country indicators* [Online]. World Bank. Available: http://data.worldbank.org/country/sierra-leone [Accessed 22/12 2011].

9. APPENDICES

Appendix 1



Farmers enter bush in December to choose next year plot. Land is cleared and brushed in the beginning of year. Cut vegetation is left to dry and then burnt. After the harvest, plot is left to regenerate Leach (1994).

Appendix 2

The model of Andrade de Sá et al. (2011) is particularly important for its focus on indirect drivers on deforestation which can be translated into indirect effect of the war on deforestation. On the other hand, the model of Fisher and Shively (2005) studies impact of a shock on forests clearing. That is why both models are important for building my own model.

The model of Andrade de Sá et al. (2011) came out of the profit maximization theory[31] where input prices are function of local parameters of forest counties and non-local parameters of non-forest counties and the same apply for output prices.

$$P_{ijt} = P_{ijt}(X_{it}, Z_{kt}) \quad (4)$$

$$W_{ijt} = W_{ijt}(X_{it}, Z_{kt}) \quad (5)$$

Where: P_{ijt} is input price
W_{ijt} is output price
X_{it} is vector of local parameters of forest counties
Z_{kt} is vector of non-local parameters of non-forest counties
i denotes forest county (local county)
k denotes non-forest county (non-local county)

Andrade de Sá et al. (2011) estimate deforestation model as:

$$\widehat{y_{it}} = \beta_0 + \beta_1 y_{i,t-s} + \beta_2 X_{i,t} + \beta_3 Z_{k,t} + \beta_4 Z_{k,t-s} + \beta_5 X_{i,t} Z_{k,t} + \beta_6 X_{i,t} Z_{k,t-s} + \mu_i \quad (6)$$

Where: $\widehat{y_{it}}$ is estimated amount of forest conversion
$y_{i,t-s}$ is past conversion
$X_{i,t}$ is vector of local characteristics of forest county *i*
$Z_{k,t}$ is vector of non-local characteristics of non-forest county *k*
$X_{i,t} Z_{k,t}$ is interaction term of local and non-local characteristics
s is number of lags
μ_i is county-specific unobservable fixed effects

Fisher and Shively (2005) studied impact of positive income shock (governmental seed assistance package) on deforestation in Malawi. They found decreasing deforestation with provision of positive income shock. Model of shock impacting deforestation is:

$$Q_{it} = \alpha_0 + \alpha_1 S + \alpha_2 \theta_{it} + \sum_t \beta_{kt} H_{kit} + \sum_k \delta_{kt} H_{kit} \cdot \theta_{it} + \varepsilon_{it} \quad (7)$$

Where: *S* is binary variable for agricultural season
θ_{it} is measure of positive income shock (weighted value of the package by the number of household members)
H_{kit} household characteristics for household *i* in time *t*

Household characteristics include dummy variables for village 1 or village 2 as well as household specific characteristics as distance to the forest, the age, gender, and education of head of household, and farm size. Interaction term between income shock and household characteristics ($H_{kit} \cdot \theta_{it}$) allows us to test different effect of shock on different households.

[31] Van Thünen bid-rent model, the traditional land use theory, predicts that a plot is devoted to the land use yielding the highest profit.

Appendix 3

Appendix 3 presents extended version of table 17. Columns (3) and (5) corresponds with columns (2c) and (2) in table 17. Column (4) represents robustness checks of two previous sub-models (3) and (5.).

Dependent variable:	log ratio of farmed upland and total land owned			
Model				
	(3) OLS	(4) OLS	(5) OLS	(6) Effects
Variables				
Distance to the market	-0.040**		-0.028*	0.972
	(0.020)		(0.018)	
Distance to produce store 2010		-0.027**		
		(0.014)		
Log total population 2010	0.094	0.108		
	(0.081)	(0.095)		
Soil quality	0.325***	0.258**	0.374***	1.415
	(0.134)	(0.129)	(0.128)	
Slope of farm	-0.143	-0.041	-0.324***	0.723
	(0.149)	(0.148)	(0.132)	
Rain shock 2009	0.064	0.096		
	(0.062)	(0.062)		
Human capital	-0.004		0.003	1.003
	(0.005)		(0.006)	
Percentage literate household heads	-0.298			
	(0.195)			
Distance to primary school 2010		0.027		
		(0.024)		
Dependency ratio	0.000	0.000		
	(0.001)	(0.001)		
Social capital	-0.251	-0.940***	-0.370	0.691
	(0.377)	(0.318)	(0.336)	
Property rights	-0.159	-0.098	-0.318*	0.728
	(0.185)	(0.186)	(0.181)	
Preferences	-0.044	-0.179	-0.035	0.966
	(0.159)	(0.154)	(0.148)	
Dead and displaced	-0.527***	-0.463***	-0.544***	0.580
	(0.169)	(0.177)	(0.163)	
Number of attacks	0.008	0.030	0.025	1.025
	(0.028)	(0.028)	(0.026)	
Temporarily displaced	-0.227*	-0.212*	-0.263*	0.769
	(0.156)	(0.165)	(0.146)	
Dead x HC			-0.117***	0.890
			(0.037)	
Dead x literacy				
Dead x distance to primary school				
Dead x dependency ratio				
Dead x SC			3.324**	27.771
			(1.512)	
Dead x property rights			1.948**	7.015
			(0.750)	
Dead x preferences			-1.812**	0.163
			(0.687)	
Dead x total population				
Attacks x HC			-0.004	0.996
			(0.004)	
Attacks x literacy				
Attack x distance to primary school				
Attacks x dependency ratio				
Attacks x SC				
Attacks x property rights			0.309**	1.362
			(0.117)	
Attacks x preferences			-0.452***	0.636
			(0.122)	
Attacks x total population				
Displaced x HC			-0.094***	0.910
			(0.034)	
Displaced x literacy				
Displaced x distance to primary school				
Displaced x dependency ratio				
Displaced x SC			3.690**	40.045
			(1.442)	
Displaced x property rights			1.787**	5.972
			(0.719)	
Displaced x preferences				
Displaced x total population				
Constant	-1.078*	-1.233**	-1.317***	
	(0.635)	(0.618)	(0.346)	
FE	yes	yes	yes	
N	115	127	116	
R^2	0.270	0.321	0.452	
adj. R^2	0.114	0.200	0.292	
sign.	0.041	0.001	0.000	

H