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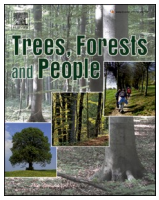

The impact of war on forest logging: Changes in logging practices in Syrian rural communities☆

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ABSTRACT

Syria has been struggling with a prolonged and brutal war for over a decade, leaving much of the country in devastation and its forests severely degraded. While many studies have identified logging for firewood as a significant driver of deforestation during the war, there is a notable absence of research specifically addressing logging behavior within the context of war. This research seeks to address this gap by examining the changes in logging behavior among local communities, the effects of violence and socioeconomic variables on wood harvesting, the contribution of wood income to people's survival during the war. To do that, we conducted survey questionnaires in two coastal villages in Syria—Blouta and Nehel al Annaze—which experienced high and low levels of violence, respectively. Our findings reveal that logging activities increased once the war began, with more people involved in forest harvesting and average days spent logging per week significantly increasing from 1.5 to 4. Additionally, the war appeared to reduce the gender disparity in logging activities: before the conflict, women engaged in logging significantly more frequently than men, but this difference became insignificant during the war. The level of violence alone did not significantly affect the amount of wood logged per month. Furthermore, income generated from wood harvesting played a substantial role in bridging the gap between the monthly income needed to cover their basic necessities and the actual income of families in both villages by 46.94 % and 84.83 % of the gap in Nehel al Annaze and Blouta, respectively. These results highlight the crucial role of forest resources in supporting rural livelihoods during times of war. Post-war effective forest management will be vital to ensure the sustainable use and recovery of forest resources, supporting both ecological restoration and economic stability for the rural communities.

1. Introduction

Mediterranean forests are highly diverse ecosystems that provide a wide range of ecological, social, and economic benefits that are crucial for the development of rural communities (Palahi et al., 2008; Scarascia-Mugnozza et al., 2000). According to Croitoru (2007), the average monetary value of non-timber forest products (NTFPs) such as firewood, cork, mushrooms, and others in the Mediterranean area was about €39 per hectare in 2005. This study also found that the collection of firewood was the most common practice in the forests of eastern and southern Mediterranean countries, accounting for 80–100 % of the total wood collected in countries like Tunisia, Morocco, and Lebanon, with a significant portion (69 % in Morocco) being collected illegally. The reliance on firewood as an energy source is not only prevalent in the Mediterranean area but also vital for the survival of rural communities globally. Furthermore, it is considered the most important product from local forests for rural populations in the developing world (Timko and Kozak, 2016). In Sub-Saharan Africa, over 70 % of rural communities depend on fuelwood to meet their energy needs for cooking and heating due to the absence of affordable alternatives (Matsika et al., 2013; Pereira et al., 2011). Similarly, in northern rural China, despite the country's economic growth, firewood consumption still accounted for 47.2 % of total energy consumption in 2005 (Démurger and Fournier, 2011). Consequently, the high demand and reliance on firewood as a

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primary source of energy could lead to unsustainable forest use, causing significant forest degradation that can negatively reflect on the well-being of poor rural communities (Kyaw et al., 2020). Globally, unsustainable wood fuel harvesting contributes to deforestation, forest fragmentation, loss of biodiversity, and increased greenhouse gas emissions (Bailis et al., 2015; Kyaw et al., 2020; Specht et al., 2015). The effects of unsustainable wood harvesting are well-documented, with a large body of literature identifying poverty and the lack of alternative energy sources, such as liquid gas, as the main drivers of this unsustainable use of forests (Agoramoorthy and Hsu, 2008; Cerutti et al., 2015; Soe and Yeo-Chang, 2019). During times of war, the demand for energy resources becomes critical as wars often lead to rising oil prices and limits its availability for local populations (Asif and Muneer, 2007), This issue is especially true in rural areas, where access to services and energy is already limited (Cabello-Vargas et al., 2021).

The impact of warfare on natural environments is evident across various global examples. In Kosovo, extensive forest degradation occurred due to logging activities during and after the 1998–99 war, leaving protected areas severely damaged (Bouriaud et al., 2014). Similarly, South Korea's mountains suffered severe defoliation before, during, and after the Korean war, driven by bombing, shelling, and illegal wood harvesting due to fuel shortages (Martin, 2023). In the Democratic Republic of Congo (DRC), two decades of violent conflict and increased mining activities have significantly contributed to deforestation in one of the world's largest tropical forests (Butsic et al., 2015). The rapid expansion of refugee camps in Sudan led to drastic depletion of local vegetation (Hagenlocher et al., 2012), while in Pakistan, the influx of Afghan refugees caused extensive deforestation due to the demand for agricultural land, fuelwood, and construction materials (Allan, 1987).

The war induced environmental degradation can also be seen in Syria, which has been grappling with armed conflict since 2011. The effects of this war have been catastrophic on the Syrian population, resulting in thousands of deaths, millions of displacements, and widespread destruction (UNHCR, 2024). The conflict has also caused extensive damage to the energy sector, depriving Syrians of the means to meet their basic energy needs (Alhaj Omar et al., 2023).

The critical demand for energy during the war in Syria forced people to use firewood as an alternative source, which had a negative impact on the forests. Numerous studies have been conducted to evaluate the war's effects on Syria's forests (Aldakhil et al., 2023; CEOBS, 2021; Daiyoub et al., 2023; Mohamed, 2021; PAX, 2023; STJ, 2023). The results of those studies showed a dramatic decline in forest area since the onset of the war. For instance, Daiyoub et al. (2023) found that around 20 % of the forests in the western region of the country were lost from 2010 to 2019. Additionally, a report by the Dutch peace organization PAX for peace in 2023 showed that the governorates of Latakia, Hama, Homs, and Idlib witnessed deforestation of over 36 %, with deforestation rates doubling in 2020 and tripling in 2021 (PAX, 2023). This deforestation is thought to be driven mainly by legal and illegal logging by forest communities and refugees, in addition to the impact of forest fires (CEOBS, 2021; Mohamed, 2021; PAX, 2023). The logging of forests was in demand for domestic and commercial firewood and charcoal for cooking and heating (Daiyoub et al., 2023; STJ, 2023). Access to fuel by locals and refugees was severely limited, with gas prices unaffordable for most of the population. This situation was worsened by the monopolization of the fuel and energy sectors and the fragmented control of the country (PAX, 2023). Many oil fields are not under the control of the Syrian government, further complicating the energy supply for Syrians (Alhaj Omar et al., 2023).

Although firewood logging is a significant contributor to deforestation in Syria during the war, there is a lack of research addressing this specific issue. The existing body of literature primarily focuses on broader deforestation trends like the change of forest area without isolating the specific role of firewood harvesting. Additionally, comprehensive, quantitative data on the extent of firewood harvesting in Syria is scarce to non-existent, even from the period prior to the war. For these reasons, this study aims to understand the changes in logging behavior of forest communities during the war in Syria and focuses on two villages that experienced different levels of violence.

The primary objective of this research is to examine how the war has influenced changes in forest logging behavior among two villages and to determine variables of impact. Concretely, we address the following questions: 1) Did the frequency of logging changed during the war? Are gender and violence intensity levels related to the frequency of logging days? 2) Do socioeconomic factors, such as gender, education level, age and others affect the amount of harvested wood? 3) How do people harvest wood during the war? 4) What is the economic contribution of forest harvesting to people's survival during times of war?

2. Materials and methods

2.1. Study area

The study area includes two villages: Blouta and Nehel al Annaze (Fig. 1). Blouta is located about 50 km from the city of Latakia in the Latakia governorate. The village sits at an altitude of 750 m above sea level, has an average annual temperature of 17 °C, and an average annual precipitation of 1058 mm with the coldest month's minimum temperature at 3.8 °C (Fick and Hijmans, 2017). The natural vegetation of the village is predominantly a Mediterranean *Maquis,* that is very rich in plant species, mainly composed of oaks such as *Quercus calliprinos (*Al-Sindiyan Al-'Aadi*)*[1] *and Quercus infectoria (*Al-Sindiyan Al-Balluti*)* as dominant species, and associated with shrubs including *Pistacia palestina (*Al-Butm Al-Filastini*), Myrtus communis (*Al-Ās*), Phillyrea media (*Az-Zurud*), Rhamnus palaestina (*As-Suwayd*),* and *Styrax officinalis (*Al-Istirak*)* (Nahal and Zahoueh, 2005). Village residents mainly practice agriculture and cultivate crops, namely tobacco, olive trees, citrus trees and others (Y. Maarouf, personal communication, June 22, 2024). We encountered challenges in determining the village's total population number due to the violent terrorist attacks that led to significant loss of lives and displacement of residents. As a result, accurate data on the current population is unavailable.

The second village is Nehel al Annaze, located about 18 km from the city of Baniyas in the Tartus governorate. It is situated at 620 m above sea level and shares Blouta's average annual temperature of 17 °C but receives slightly more precipitation at 1081 mm. The minimum temperature during the coldest month in Nehel al Annaze is 3.9 °C (Fick and Hijmans, 2017). The population in 2020 was around 2000 inhabitants that work mainly with agricultural crops including tobacco, olives, legumes, and vines (SANA, 2020). The natural vegetation of Nehel al Annaze is also a mediterranean *Maquis* of mainly oak species like *Quercus calliprinos (*Al-Sindiyan Al-'Aadi*)* and *Quercus infectoria (*Al-Sindiyan Al-Balluti*)* and associated shrubs like *Pistacia palestina (Al-Bitm al falastini), Myrtus communis (*Al-Ās*), Phillyrea media (*Az-Zurud*), Rhamnus palaestina (*As-Suwayd*), Styrax officinalis (*Al-Istirak*)* (Nahal and Zahoueh, 2005). The village's vegetation also includes a planted pine forest with species such as *Pinus brutia (*As-Sanawbar Al-Bruti*)* and *Pinus pinea (*As-Sanawbar Ath-Thamri*)*, which had burned in the 2020 forest fires. The fires resulted in the removal of a significant part of the forest area and cultivated olive groves in the village (SANA, 2020).

We chose those two villages to obtain data from different safety levels during the war (site status variable or SS). Blouta experienced a high intensity level of violence (HLV); in 2013 this village was attacked by armed terrorist groups that belong to the Islamic State of Iraq and Sham (ISIS) and Jaish al-Muhajireen wal-Ansar. This resulted in deaths and hostages of a number of the inhabitants, of which those violent

[1] The common Arabic names are listed following the Latin (scientific) names throughout this paper.

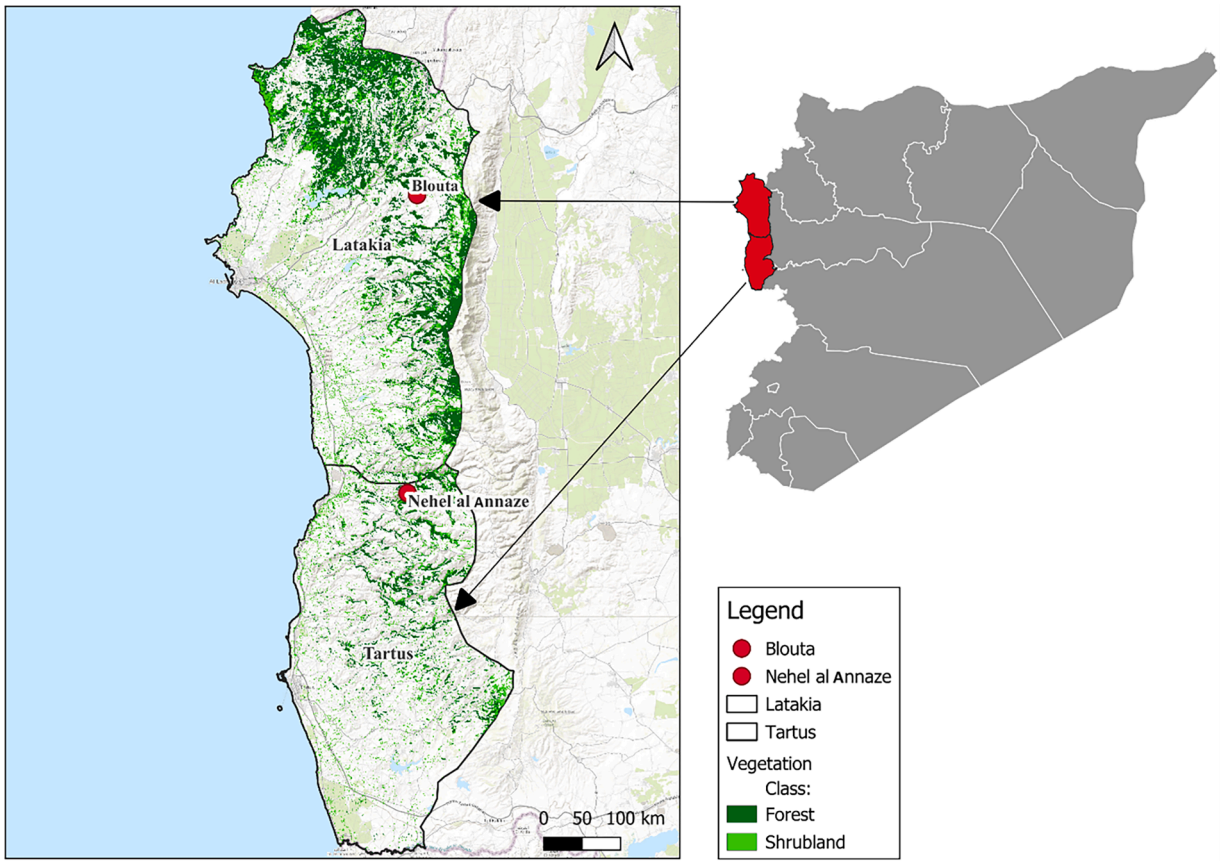

Fig. 1. The study area. Vegetation classes were adapted from the global map of terrestrial habitat types (Jung et al., 2020).

events rose to the level of war crimes according to the Human Rights Watch report (Human Rights Watch, 2013).

Nehel al Annaze, however, wasn't directly affected by the war. The effects here are mainly represented by the economic hardship and the lack of essential resources for survival, such as gas, electricity and fuel. We consider this village as an area with low intensity level of violence (LLV).

2.2. Data collection

The experimental design for data collection included 80 participants, consisting of 20 men and 20 women from each site, identified through snowball sampling. Initially, we contacted key individuals within our network, who then referred others involved in logging activities. This approach ensured a gender-balanced representation and maintained confidentiality due to the sensitive nature of logging activities during the war. The design of the questionnaire included information on the socioeconomic data like gender (GR), age (AG), monthly income (MI), number of household members (NM), and education level (EL). The second part of the questionnaire focused on logging activities. We asked participants first if they practiced logging before the war and if they practice it now, we also asked them about the number of days per week they go logging before and during the war (DL), the amount of wood harvested each month (LAT), the price per ton of harvested wood they sell, and the uses of the harvested wood.

The final part of the questionnaire focused on logging methods. We asked participants how they cut trees and what tools they used, whether they allowed time for tree regeneration, the species of trees harvested (conifers or broadleaved), and the transportation methods used for the logged wood. We conducted the questionnaires during three-month period, from March to May 2021.

2.3. Data analysis

For the statistical analyses, we considered two response variables for the logging activities: the amount of logged wood, represented as our response variable: logged amount per month in tons (LAT) and the number of logging days per week (DL). The data for the LAT variable was only available for the during-war period because the war has been ongoing for >13 years and the respondents did not remember their pre-war amounts of logged wood.

2.3.1. The descriptive statistics of sampled population and harvesting methods

Firstly, we summarized the socioeconomic data of the participants by calculating frequencies, percentages, means, and standard deviations for age, gender, income, education level, and number of household members. Using the descriptive approach, we calculated the percentages of responses for each logging method identified in the questionnaires. These percentages were then visually represented in stacked bar plots to illustrate the frequency of the various logging methods reported by respondents.

2.3.2. The analysis of logging behavior in the war context

Participants were asked whether they engaged in logging activities before and during the war, with response options of "Yes" and "No." Descriptive analysis was conducted on these responses, calculating percentages for each category. The results were then visually represented using bar plots to illustrate the distribution of logging practices before and during the war among the respondents.

2.3.2.1. Number of logging days (DL) analyses. We used the Wilcoxon rank sum test for paired samples test for nonparametric data analysis to examine differences in the number of wood logging days per week (DL)

before and during the war among all participants. This test was chosen due to its suitability for non-normally distributed data.

To explore the relation between the number of days per week spent logging among sites, gender, and their interactions we used Generalized Linear Models (GLMs) with a Poisson distribution. This model allowed us to examine the combined effects of different variables and their interactions, considering the number of days per week spent logging as a predictor across both periods (before and during war (DLB and DLD, respectively)), gender, and site status (HLV, LLV). Analysis was conducted using the glm function from the stats package in R.

2.3.2.2. Amount of logged wood analysis. We examined the relationship between the amount of logged wood per month in tons (LAT) and socioeconomic variables (such as age, income, and household members) and site status (HLV, LLV). For this analysis, we also used GLM models with a Gaussian distribution, considering LAT as the response variable.

In both GLM analyses, for the logged wood and days of harvesting we used the Akaike Information Criterion (AIC) to compare and select the best-fitting models. The emmeans package was used to perform pairwise comparisons of the estimated marginal means, providing insights into the interactions between socioeconomic variables and site status. The statistical analysis was performed using R version 3.6.3 (2020–02–29) and RStudio version 2022.02.0 + 443 ("Prairie Trillium").

2.3.3. Measuring the economic contribution of forest harvesting to poverty alleviation

We conducted a descriptive analysis to determine monthly wood income by multiplying the amount of wood harvested each month by the price per ton. This monthly income from wood was then compared to the average salary needed to meet basic needs, as specified in the 2021 United Nations report (OCHA, 2021). To convert both salaries and wood income into US dollars, we used the official exchange rate between Syrian pounds and US dollars for 2021 (UN, 2024).

3. Results

3.1. Socioeconomic information of the sample population

The analysis of socioeconomic data from 80 respondents showed an average age of 43.96 years. The largest age group was between 45 and 59 years, comprising 41.2 % ($n = 33$) of the participants, while those aged 60 and older made up just 11.2 % ($n = 9$). In terms of education, 25 % ($n = 20$) of respondents had no formal education, and 55 % ($n = 44$) had received basic education. Regrading monthly income, 60 % ($n = 48$) earned less than US$30, whereas only 7.5 % ($n = 6$) earned more than US$90. (See Table 1).

Table 1
Summary of the socioeconomic data of the sample population.

Variable	Items	N	M (SD)	%
Gender	Man	40	50	50
	Woman	40	50	50
Education level	None: No formal education	20	25	25
	Basic education: 9 years duration, from age 6 to 15	44	55	55
	Secondary education: 3 years duration, from age 15 to 18	8	10	10
	University education	3	3.8	3.75
	Vocational education	5	6.2	6.25
Monthly income (US $)	< 30	48	60	60
	30–60	21	26.2	26.25
	60–90	5	6.2	6.25
	> 90	6	7.5	7.5
Number of household members	80		3.92 (1.90)	
Age (years)	80		43.96 (12.36)	
Age Group	15–29	10	12.5	12.5
	30–44	28	35	35
	45–59	33	41.2	41.25
	60+	9	11.2	11.25

3.2. Forest logging practising before and during the war among sites and gender

Before the war, 46.2 % ($n = 80$) of the respondents did not participate in logging, while 53.8 % ($n = 80$) were already involved in it. When comparing pre-war logging activities by site and gender, the data shows that in Blouta, women made up 54.5 % ($n = 40$) of those involved in logging before the war. While in Nehel al Annaze, a higher proportion of women (57.1 %) ($n = 40$) engaged in logging compared to men (Figs. 2 and 3).

3.3. Logging frequency before and during the war in relation to gender and violence intensity

The results of the Wilcoxon rank sum test for paired samples showed a significant increase in the average number of logging days ($p = <0.0001$), rising from 1.5 days per week before the war to 4 days per week during the war (Fig. 4).

We fit six models and selected the best one using the corrected Akaike Information Criterion (AICc) and AICc weights (Table A.1 and A.2 in appendices). The model *interaction.mod2 (~ Period + SS + GR + GR*SS*Period)* was chosen because it had the lowest AICc value (686.71) and the highest AICc weight (0.54) which suggests that it has the best fit and highest performance among all the other fitted models.

Results from the selected model showed that the effect of gender alone, the interaction between gender and site status, as well as the interactions between period and gender were statistically significant ($p = <0.05$). The site status effect alone was marginally significant with ($p = 0.0618$), (Table 2). To further understand those significant interactions, we used the emmeans pairwise comparisons of the different combinations of the variables.

We found that before the war, women significantly logged more days than men in Blouta (HLV), while in Nehel al Annaze (LLV) there were no significant differences in logging days between men and women. In contrast, during the war there was no significant differences in logging days among men and women in both villages (Fig. 5). For full interactions values refer to (Table A.3 in appendices).

3.4. Amount of harvested wood in relation to socioeconomic variables

To explore the relationship between the amount of harvested wood and socioeconomic factors, we evaluated 28 models (that include the combination of the variables and their interactions) and identified the most suitable ones based on their AIC scores (full models detailed in Table A.4 appendices). Our findings highlighted significant relation between the amount of harvested wood and gender. The emmeans analysis showed that during wartime women harvest an average of 0.47 tons less wood than men. Additionally, age was found to significantly influence wood harvesting, with the 30–44 age group harvesting 0.7 tons more compared to those aged 45–59. Generally, wood harvesting tends to decrease with age. Notably, variables such as monthly income, number of household members, and education level did not demonstrate a significant impact on the amount of harvested wood (Table 3).

3.5. Methods of forest logging

Our results show variations in logging methods (LM), revisiting the logged site (RLS), and type of exploitation (TE) across both sites and gender. In Blouta, the predominant logging method among women was cutting all the branches and leaving the trunk (55 %), whereas half of

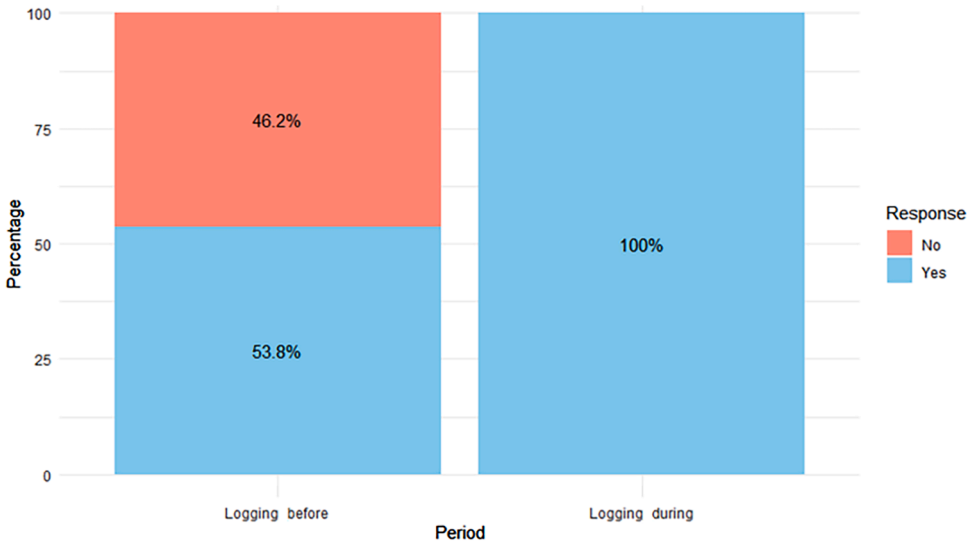

Fig. 2. Logging practice reported before and during the war periods.

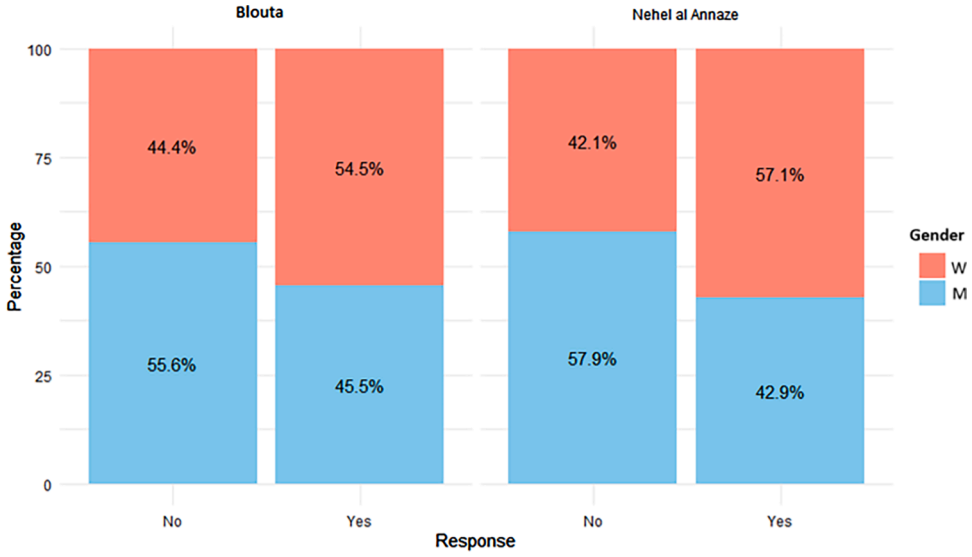

Fig. 3. Logging practise among gender and sites.

men cut the main trunk (50 %). In Nehel al Annaze, we sound that women (50 %) and men (65 %) engaged in cutting a few branches (Fig. 6).

Regarding the practice of revisiting logged sites (RLS) in Blouta, a higher percentage of women (65 %) gave trees time to regenerate compared to men (45 %), who tend more towards harvesting without allowing regeneration. Whereas in Nehel al Annaze, both women and men (70 %) predominantly gave trees time to regenerate. The type of exploitation (TE) also showed notable differences: in Blouta, women largely engaged in selective cutting (55 %), while men showed more balanced distribution between selective cutting (45 %) and clear cutting (35 %). Conversely, in Nehel al Annaze, men preferred selective cutting in a higher percentage (85 %) compared to women (55 %) (Fig. 6).

Our results showed distinct patterns in the use of logging tools (LT) and transportation methods (TM). In Blouta, the primary logging tools for women were the axe and handsaw (55 %), whereas men utilized a wider variety of tools, but also preferred axe and handsaw (40 %). In Nehel al Annaze, both women (90 %) and men (70 %) predominantly used the handsaw and sickle (Fig. 7).

Regarding transportation methods (TM) in Blouta, women predominantly used animals (80 %), while men have a more diverse range of methods, with (35 %) using animals, motorbikes (25 %), and a combination of motorbikes and animals (20 %). In Nehel al Annaze (90 %) of men relied on motorbikes for transportation, and (50 %) of women responded that they did not use any type of transportation to move the harvested wood (Fig. 7).

When we asked the respondents about their preferred species for wood harvesting between broadleaved species (mainly oaks), or pines. Clear patterns emerged between the two villages. In Blouta, both women (100 %) and men (95 %) predominantly logged broadleaved species, with women exclusively logging broadleaved species. In Nehel al Annaze, the majority also preferred broadleaved species, with 90 % of women and 75 % of men logging these species. However, a higher proportion of men (25 %) in Nehel al Annaze logged both broadleaved and pine species compared to women (10 %).

3.6. Economic contribution of forests to sustaining people during the war

In 2021, the average price per ton of wood was US$100 in Blouta and US$63 in Nehel al Annaze, with average wood harvests amounting to

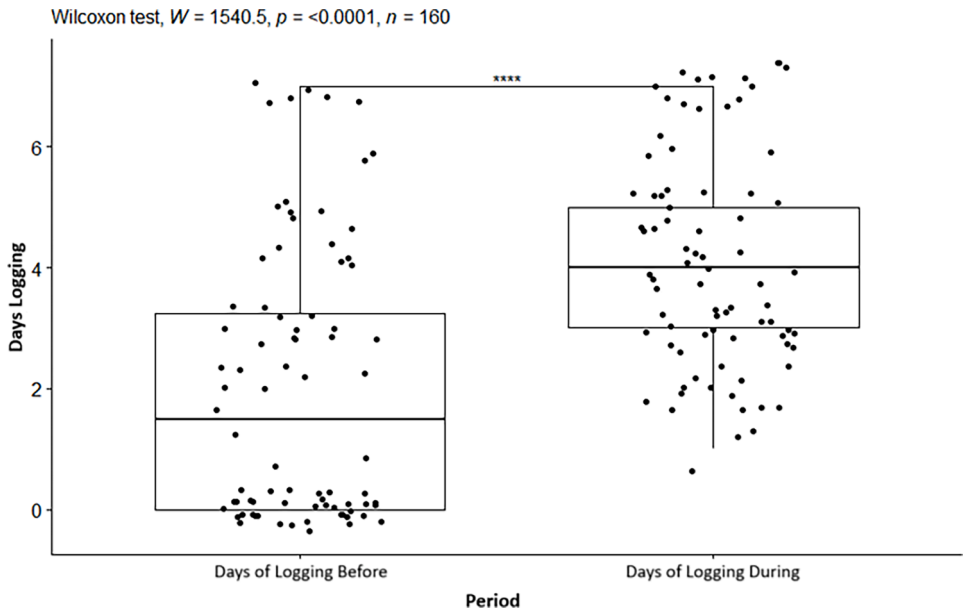

Fig. 4. Boxplot displaying the results of the Wilcoxon test, illustrating the distribution of Days of logging (DL) before (DLB) and during the war (DLD).

Table 2
Results of the Generalized Linear Model (GLM) interaction analysis for logging practices (interaction.mod2), showing coefficient estimates, standard errors, z-values, p-values, and significance levels.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)	Significance
(Intercept)	−1.8293	0.9338	−1.959	0.05011	.
PeriodDLD	3.3544	1.0834	3.096	0.00196	**
SS	1.0625	0.5689	1.868	0.0618	.
GR	1.6633	0.5327	3.122	0.00179	**
SS:GR	−0.7142	0.3323	−2.149	0.03163	*
PeriodDLD:GR	−1.5992	0.6334	−2.525	0.01157	*
PeriodDLD:SS	−1.2435	0.6709	−1.854	0.06379	.
PeriodDLD:SS:GR	0.7411	0.3993	1.856	0.06349	.

1.48 tons in Blouta and 1.44 tons per month in Nehel al Annaze. We assessed the income from commercial wood harvesting and compared it to the average monthly income required for a family to meet basic needs, which was US$180 according to 2021 UN estimates. Interviewees reported an average monthly salary of US$31.80, excluding wood income, while their average earnings from wood amounted to approximately US $150.60. Combining both sources, their total average monthly income was around US$182.40. Among the 16 interviewees (20 % of the sample) who depended solely on wood profits, the average monthly earnings from wood were US$191, with half working full-time as loggers. In Blouta, the average income from wood was US$152.70, compared to US $84.50 in Nehel al Annaze. Salaries averaged US$31 in Blouta and US $33 in Nehel al Annaze. Income from wood harvesting helped reduce the income gap by 46.94 % in Nehel al Annaze and 84.83 % in Blouta.

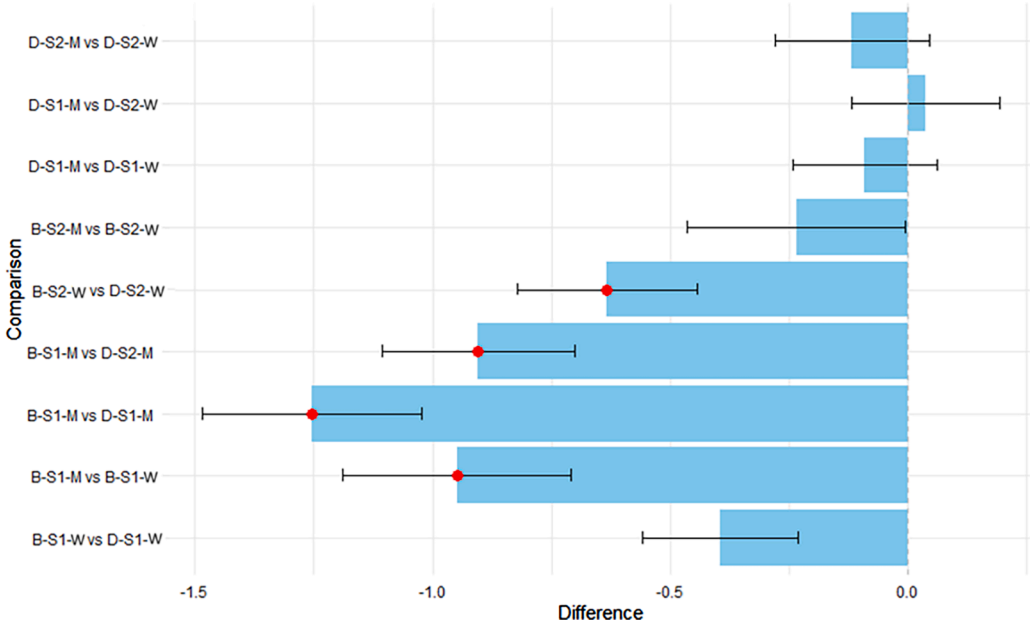

Fig. 5. Graph of estimated marginal means showing interaction effects of gender and sites on logging practices before and during the war (B-D: Before, During; M-W: Men, Women; S1-S2: Blouta Site, Nehel al Annaze Site).

Table 3
Summary of Generalized Linear Model (GLM) results for various predictors of amount of logged wood in tons (LAT).

Variable	Model	Estimate	Std. Error	t value	Pr(>|t|)
Number of household Members (NM)	LAT ~ NM	0.03547	0.06288	0.564	0.574
Age (AG)	LAT ~ AG	−0.02248	0.008956	−2.51	0.0142*
Gender (GR)	LAT ~ GR	−0.4698	0.2225	−2.111	0.0379*
Education Level (EL)	LAT ~ EL	0.09624	0.11812	0.815	0.418
Monthly Income (MI)	LAT ~MI	−8.429e-08	1.468e-06	−0.057	0.954

4. Discussion

4.1. The change in forest logging behavior during war

4.1.1. Logging before and during the war - general trends

The earliest instance of anthropogenic deforestation in history was recorded in Syria, with evidence of deciduous forest clearing in Al-Ghab valley by pre-pottery neolithic people around 9000 years before present (BP) (Yasuda et al., 2000). Since then, forested areas have steadily declined, from 35 % of the country's land cover at the beginning of the last century to just 3 % in 2010 (Meslmani, 2010). Before the war, rural Syrians relied on firewood as source of energy, driven by minimal public services, harsh winter conditions, and high poverty rates (Meslmani and Ali, 2009). Firewood was used for heating, cooking, and producing charcoal. Annually, 3239 tons of firewood were extracted from Syrian forests (Nahal and Zahoueh, 2005). This demand led to significant forest degradation (Meslmani and Ali, 2009).

Our results confirm this pre-war reliance on forests, with more than half of our respondents (53.8 %) reporting logging activities before the war, averaging 1.5 days per week of wood logging. However, during the war, logging increased significantly, with more people engaging in this practice and the average logging days rising to 4 days per week. Notably, 46.2 % of those who started logging after the war began had not logged before. This change can be attributed to the war-induced poverty, which increased poverty rates in Syria to 90 % of the population by 2021 (OCHA, 2021). Additionally, limited access to energy resources such as electricity, diesel, and butane gas exacerbated the situation.

The war caused extensive damage to the power infrastructure and oil pipelines throughout the country due to attacks, sabotage, and vandalism, severely restricting electricity supplies. Although the electricity sector in Syria was already struggling before the war, the conflict drastically worsened the situation, reducing per capita consumption to <10 % of pre-war levels (Hatahet and Shaar, 2021). Furthermore, the Syrian government lost control of oil fields, which were captured by various militant groups and foreign states (Alhaj Omar et al., 2023).

In 2021, Syrians received less than eight hours of electricity per day, with some areas getting only three hours. Rural areas, in particular, had even less access since the war began, making cooking and heating using electricity as unavailable solution (UNDP, 2022). The villages where interviews were conducted, located at elevations of 750 and 620 m, deal with harsh winters and had an average January minimum temperature of 4 °Celsius in 2021 (Fick and Hijmans, 2017). Thus, firewood remained

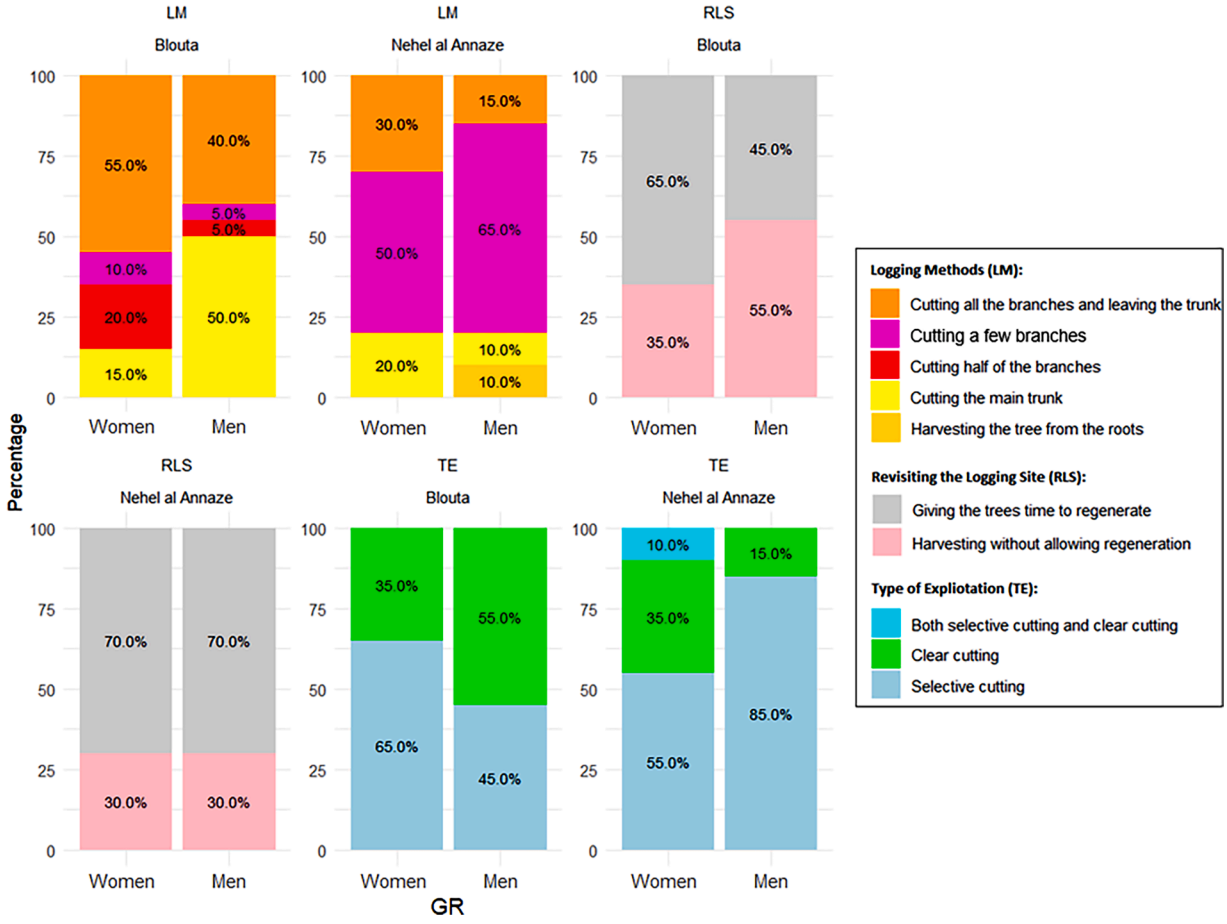

Fig. 6. Stacked bar plot showing the percentages of logging methods (LM), revisiting the logged site (RLS), and type of exploitation (TE) among respondents in Blouta and Nehal al Annaze.

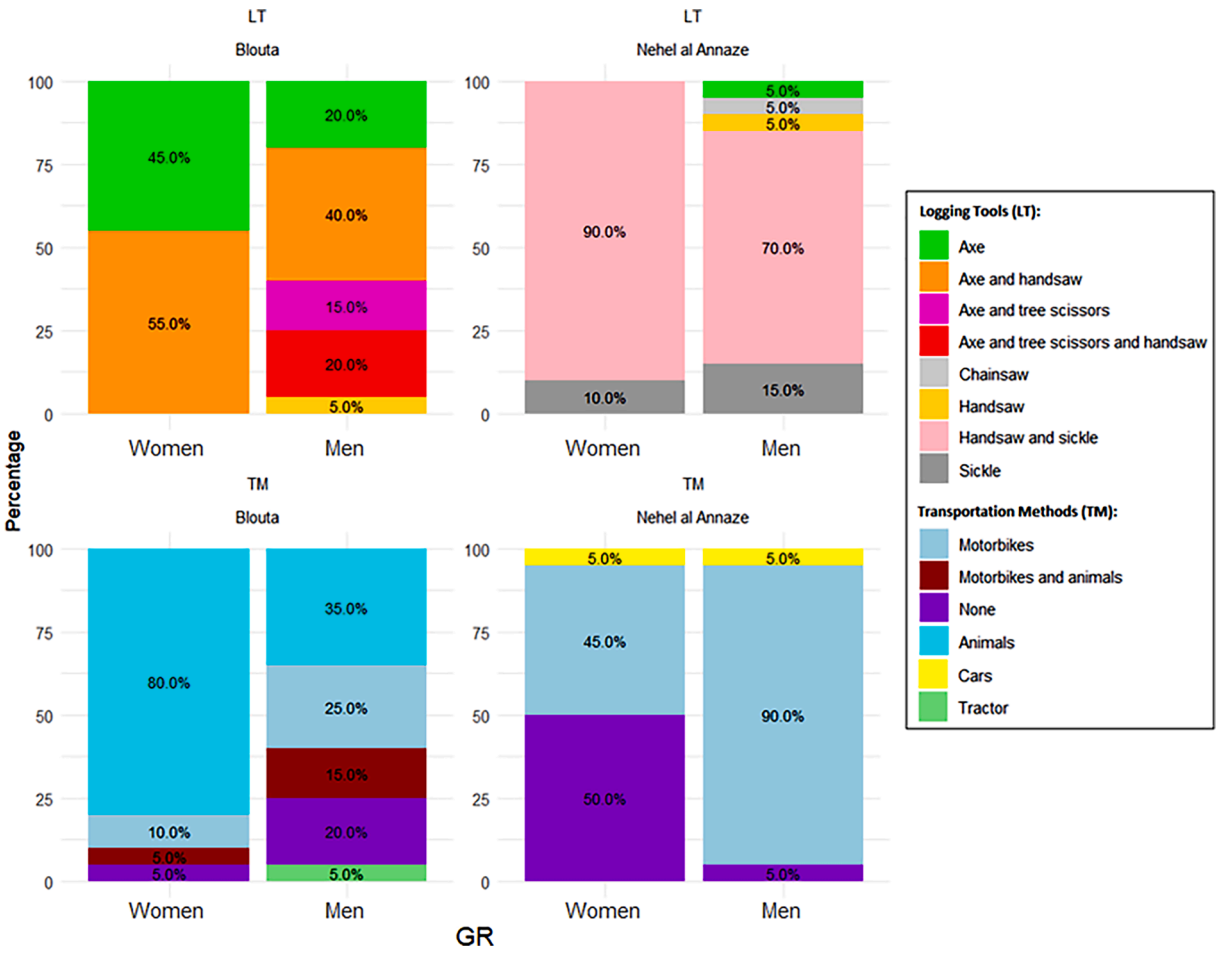

Fig. 7. Stacked bar plot showing the percentages of logging tools (LT) and transportation methods (TM) among respondents in Blouta and Nehal al Annaze.

the cheapest, and most accessible energy source for them.

Similar patterns of increased reliance on firewood and consequent forest degradation during conflicts can also be observed globally. In the Democratic Republic of Congo, the civil war led to greater dependence on forests for firewood, exacerbating forest degradation (Draulans and Krunkelsven, 2002). Another example can be drawn from the Gishwati forest reserve in Rwanda, which suffered a significant loss of forest cover due to extensive logging activities during the armed conflict. The conflict led to a decline in conservation efforts in the reserve and increased use of forest resources near refugee settlements, leading to forest degradation (Ordway, 2015). The armed conflict in Tigray (Ethiopia) caused severe ecosystem disturbances, reversing restoration efforts and increasing dependence on natural resources such as firewood and charcoal due to service suspensions like electricity, especially in areas with many internally displaced persons (Negash et al., 2023). Angola's woodlands within the miombo ecoregion have faced major changes over the driven by increasing urban demand for agricultural products, firewood, and timber. The Angolan civil war intensified these pressures leading to deforestation and canopy opening, with widespread unemployment forcing many into informal jobs collecting firewood and trading in small markets (Andrews et al., 2024).

4.2. Logging behavior change among gender and violence intensities

4.2.1. Pre-war logging

In both villages we surveyed, women accounted for more than half of the "Yes" responses regarding logging activities before the war. Our results also showed that the average number of logging days was significantly higher for women than for men in Blouta village. This indicates that women were more involved in logging activities before the war. This trend can be attributed to the traditional role of women in collecting wood for cooking and heating. Collecting firewood is a gendered issue in many developing regions, where women are responsible for household chores, including firewood collection (Njenga et al., 2021; Tabuti et al., 2003). For instance, women in Kenya work more days and longer hours collecting wood compared to men (Njenga et al., 2021).

4.2.2. Logging during the war

During the war, we found no significant differences between women and men in the number of days spent logging in both villages. It seems that the war narrowed the gap in gender roles, with more men becoming involved in logging activities. Increased economic difficulties for rural communities during the war drove both men and women to collaborate in supporting household survival. This was evident in Syria, where not only did men take on more responsibilities, but the war also pushed women to adopt new roles and challenge long-standing gender norms. Women began participating more in various economic activities, often becoming the breadwinners for many households during the war (Buecher and Aniyamuzaala, 2016).

4.2.3. Violent intensities and logging activities

The differences of logging days between the were marginally significant, suggesting that the violence itself wasn't enough to trigger changes in logging activities. We conclude that the primary driver of forest use was economic motivation rather than the intensity of violence. In Blouta, the village that was under armed attack, residents were forced to flee to other areas. Upon their return, they resumed using the forest.

We also found no evidence of forest use by militant groups in Blouta after it was recaptured.

4.2.4. Amount of harvested wood and socioeconomic variables during the war

The results of our model estimating the amount of logged wood (LAT) and the socioeconomic variables, only gender and age was found to have significant impacts on the amount of the harvested wood. Although the differences in logging days between men and women weren't significant during the war, women harvested significantly less wood (0.47 tons) than men. One explanation of this could be that women in rural areas are in charge of the domestic work at home in addition to the collection of the wood, which gives women less time to harvest wood than men. Studies show that women in rural areas especially in developing countries carry the burden of the domestic housework in addition to collecting firewood and agricultural activities, and they spend approximately about (14–16) of working hours everyday (Nagbrahmam and Sambrani, 1983). Unfortunately, our study didn't consider wood collection per hour, only the frequency of visiting the forest every week. This factor could help elucidate wood collection comparison by hours harvesting between men and women and help explain the result described above.

The gender is not the only variable affecting the amount of harvested wood, age also has a significant relationship to the amount of harvested wood. We found that LAT decreases by 0.02 tons for each additional year of age, suggesting that older individuals harvest less wood. Among age groups, the difference between the age groups of 30–44 and 45–59 years was statistically significant. These results suggest that younger individuals are more likely to harvest larger amounts of wood than older ones as younger people are more physically fit to carry out the logging and also capable of walking longer distances (Godoy et al., 1997; Mushi et al., 2020).

4.3. Wood harvesting methods during the war

4.3.1. Preferred tree species for logging

The majority of respondents reported a preference for broadleaved species in logging, particularly oak trees (*Quercus calliprinos and Quercus infectoria*). Oaks are a popular choice for forest loggers because they regenerate well after harvesting and they also have excellent combustion properties making them ideal for firewood and producing charcoal (Aguilar et al., 2012).

4.3.2. Logging methods

In Blouta, women primarily used a logging method where they cut all the branches and left the trunk, while half of men cut the main trunk. In Nehel al Annaze, both women and men mainly engaged in cutting a few branches. Larger trunks are typically sold as firewood, while smaller branches are preferred for charcoal production (Bahhah, 2022). This charcoal is used for cooking and shisha consumption, especially with shisha smoking becoming increasingly popular among younger generations since the onset of the war in Syria (Bahhah, 2022; Kakaje et al., 2021).

Most respondents in both villages preferred selective cutting for harvesting wood, the practise decreases tree species biodiversity, tree density and basal area, leading to potential long-term ecological impacts (Lulandala et al., 2023; Ndegwa et al., 2016).

A smaller percentage employed clear cutting, mainly for land conversion to crops, a similar pattern that also can be found among rural communities that practise logging Africa (Kutsch et al., 2011; Zulu and Richardson, 2013). This method, involving the removal of most or all trees in an area, can have varying negative effects based on the cleared area size, with large-scale forest removal significantly reducing soil organic content and affecting hydrology more than smaller cleared areas (Lulandala et al., 2023).

Most respondents, except for men in Blouta who favour clear cutting, indicated they would allow trees time to regenerate after harvesting. However, the lack of data on the harvest rotation period makes it difficult to determine whether these trees can mature or will be maintained as coppices for firewood. Given the ongoing conflict in Syria, it is more likely that trees will be maintained as coppices, potentially harming the sustainability of oak forests. (Nocentini et al., 2022) found that intensive use of oak forests for firewood in Mediterranean areas could lead to soil degradation and a decline in landscape quality.

4.3.3. Wood transportation methods and logging tools

In Blouta, women predominantly used animals (80 %), while in Nehel al Annaze 50 % of women said that they didn't use any type of transportation to move the harvested wood. The wood transportation methods can be controlled by the social and cultural traditions and vary in every country, for example, in Kenya it is normal for women to transport wood carrying them in bundles on their back, a practise which is considered feminine and opposed to men who usually use donkeys and wheelbarrows to transport the wood (Njenga et al., 2021). In Syria it is uncommon for women to ride motorbikes which and considered a masculine transportation method (UNFCCC, 2018). We see this reflected in our results where 90 % of men in Blouta use motorbikes for transporting the harvested wood.

Using motorbikes is not only influenced by the cultural norms but it is also affected by the availability of the fuel during the war. We found that men in Nehel al Annaze use a mix of transportation methods and which could and explanation due to the high cost of motorbikes and fuel and their limited availability. The average price for the subsidized diesel in 2021 for transportation was 376 SYP /litre (or 0.15 US$) while the informal (black market) average price was 1612 SYP /litre (0.6 US$) (UNDP, 2021). While the minimum wage in 2021 was 71.515 SYP per month (28.6 US$ at the current official exchange rate of 2.500 SYP to the US dollar).

4.3.4. Logging tools

Our results show a preference to using traditional logging tools like, handsaw, axe, sickle by both gender and in both sites. These results are similar to a study conducted in rural Nepal where informants found the traditional logging tools more familiar and easier to use, while modern tools like chainsaws were costly and more complex to use (Pahari and Bhattarai, 2020). Also, the use of modern tools like chainsaws although more effective but it requires sources of energy that are scarce and unaffordable by the rural communities, especially during the war.

4.4. Wood income and alleviating poverty

The war in Syria has led to a significant economic collapse, with 90 % of Syrians living below the poverty line compared to pre-war poverty overall rates in 2007 of 3.6 % (Hamati, 2019; OCHA, 2021). The value of the Syrian pound plummeted against the US dollar (from 1 US$ = 46 SP in 2010 to 1 US$ = 2500 SP in 2021) (UN, 2024) . War also caused the collapse of key sectors like industry, agriculture, and tourism that were essential for the economic stability of the country (World Bank, 2017). It is important to note that, although Syria was not an oil-rich country, its oil demands were met by refining crude oil domestically, with the surplus being exported to Türkiye and other European countries (Alhaj Omar et al., 2023). After the war began, the government lost access to the oil and natural gas fields primarily located in eastern Syria. This loss severely impacted the country's energy supply, increasing energy poverty and leaving the population with limited to no access to energy resources due to high costs and scarcity (Alhaj Omar et al., 2023; Nofal, 2023; Seifan and Alhosain, 2021). Energy poverty is defined as a 'situation where a household is unable to meet its domestic energy needs', often due to low income, high energy costs, and inefficient energy use in buildings (Agnieszka, 2023). Wars can significantly exacerbate the energy poverty, as seen in countries like post-war Lebanon, where the conflict severely damaged energy infrastructure, leading to daily power

outages of up to 8 h (Abi Ghanem, 2018). Similarly, post-war Sri Lanka faced significant challenges in reducing poverty and providing affordable energy, with the lack of access to modern cooking fuels contributing to around 57 % of the Multidimensional Energy Poverty Index (MEPI) (Jayasinghe et al., 2021). Beyond physical destruction, factors such as international economic sanctions, particularly by the USA, Europe, and the UN, can also exacerbate energy poverty in developing countries like Syria by reducing energy consumption and limiting access to clean cooking energy (Moteng et al., 2023).

These economic and political struggles made firewood an invaluable alternative energy source for rural communities, not only for meeting their energy demands, but also to generate extra income. Our results showed that income from wood harvesting reduced the gap between the required monthly income and the actual income by 46.94 % in Nehel al Annaze and 84.83 % in Blouta. People in Blouta earned more from wood harvesting by primarily selling it as charcoal, which commands higher prices compared to Nehel al Annaze where people sold the wood without any processing for lower prices. Revenues from firewood have become an essential source of income, especially when 20 % of interviewees had no other sources of income, and firewood became a critical for their survival.

In the Mediterranean countries, notably the southern Mediterranean, forests play an important role in poverty alleviation and development of rural communities (Bleu, 2018). This role also extends beyond the Mediterranean area to form as an essential source of income for rural communities all over the developing world. Many studies show how forests help reduce poverty by providing vital support to poor people, as they became a safety net for communities especially during emergencies like natural disasters and wars (Miller et al., 2022; Soaga and Kolade, 2013; Sunderlin et al., 2003; Wiersum and Ros-Tonen, 2005).

Despite the significant findings, this initial study is intended to establish a baseline for future research and has several limitations. The sample size was limited to two villages, affecting generalizability. Data collection using the snowball sampling method poses limitations for statistical inference due to its non-random nature and inherent biases. The study's limited timeframe may not capture seasonal variations in logging practices. The lack of comprehensive ecological data and detailed information on harvest rotation periods limits the assessment of logging's environmental impacts. Additionally, the study did not fully explore broader economic and social factors influencing logging practices.

Future research should expand the sample size, use mixed-method approaches, conduct longitudinal studies, include detailed ecological assessments, and explore socio-economic dynamics to address these limitations.

4.5. Recommendations

Reliance on forests is crucial for rural Syrian communities to meet their energy needs and alleviate poverty during the war. However, this dependence poses significant risks to the health and integrity of the forest ecosystem. If unsustainable logging continues at current rates, the long-term consequences could be irreversible, especially with the imminent threat of climate change. The depletion of forests in Syria during the war could increase the risk of desertification, soil erosion, loss of biodiversity—particularly among endemic and threatened species—and the loss of water security and carbon sequestration, along with changes in microclimates (IPCC: Summary for Policymakers, 2023). Deforestation also has socioeconomic and cultural impacts on the wellbeing of the Syrian rural communities by depriving them of forest products and diminishing their sense of place and cultural heritage (Christiawan, 2018; Hoelle, 2018). To address these issues, it is imperative for local governments and authorities to support forest communities in finding alternative and clean energy sources for cooking and heating. They should also educate communities on sustainable forest management practices, create jobs, and improve services in rural areas to combat poverty and reduce the pressure on forest resources. International bodies should consider integrating strategies that address energy poverty into their humanitarian and post-conflict reconstruction plans. This could involve ensuring access to affordable energy sources, rebuilding energy infrastructure, and creating policies that prevent the over exploitation of energy resources during wars and crises. Addressing these issues can help stabilize communities, support economic recovery, and reduce long-term energy poverty in conflict-affected regions.

5. Conclusion

Our study underscores notable shifts in logging behavior during the Syrian war, driven more by economic hardship and energy shortages than by the direct impact of violence. During the conflict, logging activities increased significantly, with a marked rise in both the number of individuals involved and the frequency of logging days. This period also saw a narrowing of the gender gap in logging, as more men took part in wood harvesting compared to the pre-war period when women were more actively engaged in these activities.

Interestingly, the amount of wood harvested was not significantly related with the intensity of violence. Instead, gender and age were the primary factors influencing the amount of wood collected. Forests emerged as a vital resource for rural communities during the war, offering critical income that enabled households to meet their basic needs. Forests have become a crucial lifeline for rural communities in Syria amid the significant economic collapse caused by the war.

To ensure sustainable forest use in the post-war period, it is essential to implement effective forest management strategies. These strategies should focus on the conservation of the remaining forests, in particular, restoring and regenerating the degraded ones. Promoting sustainable logging practices that balance economic requirements with ecological recovery is also an important aspect to effective management strategies. Adopting these approaches will be vital for fostering both environmental sustainability and economic resilience in affected communities.

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CRediT authorship contribution statement

Angham Daiyoub: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sandra Saura-Mas:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Yakzan Maarouf:** Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tfp.2024.100668.

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