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**Deforestation and Resource Conflicts in Papua New Guinea**

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**Working Paper in Economics 2/20**

March 2020

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## **Abstract**

Conflicts over natural resources are common in developing countries, due to poorly defined property rights and limited state capacity for preventing conflict and because environmental incomes matter more to livelihoods than in rich countries. In Papua New Guinea (PNG), for example, the subject of the current study, almost one-quarter of households had land disputes in the previous 12 months, with disputes over agricultural and forestry resources, over development projects, and tribal fighting also frequently experienced. About seven percent of the land disputes and 40 percent of the tribal fights resulted in deaths. In this paper, geo-referenced household survey data on disputes and conflicts, and remote sensing observations on forest losses in the local area over the prior ten years are used to show the frequency of conflict over natural resources, the distributional incidence of this conflict – whether rich or poor areas are more at risk – and the effect of large-scale environmental change, specifically deforestation, on the subsequent risk of conflict. A sharp increase in log exports, which saw PNG become the largest exporter to China as other countries withdrew from the tropical logs trade, represents an exogenous shock that helps to identify effects of deforestation on conflict rather than the reverse relationship.

## **Keywords**

conflict  
deforestation  
household survey  
land resources  
Papua New Guinea

## **JEL Codes**

Q34, Q56

## **Acknowledgements**

I am grateful to Geua Boe-Gibson for GIS and mapping support, to Hari Sharma for research assistance, and to Susan Kilby and AARES conference audiences for helpful comments. This paper was written while Gibson visited the Centre for the Study of African Economies, Department of Economics, University of Oxford and he acknowledges their hospitality. The views expressed here are those of the author alone.

## 1. Introduction

The focus of many empirical studies of conflict in developing countries is on organized group conflict, such as civil wars. It is undoubtedly true that more intense conflicts, whether defined in terms of battle-related fatalities or by the challenge posed to government power, have many adverse economic consequences, such as endangering food security (Brück and d'Errico 2019) and more generally disrupting labour market activity and human capital investments (Verwimp *et al.* 2019).<sup>1</sup> It is also true that the study of such conflicts has been greatly aided by the creation of multi-country databases, such as from the Uppsala Conflict Data Program.

Yet there is also a range of less intense conflicts that may be more widely experienced but that are potentially neglected by this research focus on intense conflicts. These less intense conflicts may be especially prevalent in developing countries, where conflict often arises over scarce natural resources, which are more important to livelihoods of the poor and for which property rights are often poorly defined and poorly enforced (Reuveny and Maxwell 2001). The evidence for these less intense conflicts over natural resources like land, forests and water is drawn from a variety of sources, such as from reports by community leaders in periodic national inventories of villages (Barron *et al.* 2009), from administrative data that record land-related conflicts at the municipality level (Fetzer and Marden 2017) and from household surveys (Deininger and Castagnini 2006).

There are several advantages of the household survey approach. First, hundreds of household surveys are carried out each year, most typically for measuring household income and expenditures but many also have a broader focus on living standards. Adding questions on disputes and conflict to these surveys would provide a rich micro-level database that could help to improve understanding of the causes and consequences of conflict. Secondly, the surveys are already used to measure poverty, inequality and hunger (for example, Beegle *et al.* 2012, De Weerd *et al.* 2016) and so they provide a basis for examining the distributional incidence of conflict. Thirdly, these surveys are increasingly geo-referenced (Gibson and McKenzie 2007) and so data on resource conflicts could be linked to remote sensing data, such as measurements of large-scale environmental changes like deforestation (for example, Hansen *et al.* 2013) or linked to satellite observations of night-time lights to proxy for local economic activity (see Gibson *et al.* 2020 for a recent survey). A further benefit is that household-level respondents may report on a wider range of conflicts than is covered by other sources. For example, in the household survey data described below, the *annual* total of conflict-related

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<sup>1</sup> One concern with this evidence is that some studies relate spatially aggregated data on conflict rates to more spatially disaggregated survey data on outcomes of interest (for example, Chamarbagwala and Morán 2011) use conflict rates for Guatemala's 22 *departamentos*, which is the first sub-national level, and Menon and van der Meulen Rodgers (2015) use conflict rates for Nepal's 75 districts, the second sub-national level). Using these aggregated data as a proxy for the local conflict rate (either real or perceived by individuals) creates a mean-reverting measurement error that is likely to exaggerate regression estimates of the conflict impacts (Sharma and Gibson 2020).

deaths is about five times higher than the 30-year total of deaths recorded by the Uppsala Conflict Data Program, suggesting that many deaths from low-level conflict are missed in cross-country databases.

In this paper, household survey data on disputes and conflicts in Papua New Guinea (PNG) are used to show the frequency of conflict over natural resources, the distributional incidence of this conflict – that is, whether the rich or the poor are more at risk – and the effect of large-scale environmental change, specifically deforestation, on the subsequent likelihood of conflict. I use a nationally representative database of 3500 households which shows that almost one-quarter of households had been involved in land disputes in the previous 12 months, with disputes over agricultural and forestry resources, over development projects and tribal fighting also frequently experienced. About seven percent of the land disputes and 40 percent of the tribal fights resulted in a death (or deaths) during the previous year. A sharp increase in log exports, that saw PNG become the largest tropical log exporter to China as other countries withdrew from the trade, represents an exogenous shock to help identify effects of deforestation on conflict rather than the reverse relationship.

The rest of the paper is set as follows: Section 2 reviews relevant bodies of literature, Section 3 covers how the measures of conflict and deforestation are derived, Section 4 reports on the frequency of conflict and compares to other times and places, describes the distributional incidence of conflict, and estimates the relationship with deforestation. Section 5 concludes.

## **2. Review of Relevant Literature**

I draw on several relevant strands of the literature, as no single body of research fits all research questions studied here. One strand of the literature examines effects of natural resource rents on conflict but this is typically looking at more intense conflict like civil wars and tends to focus on the incentives for elites, either at the national level or among rebels and outsiders, rather than on the actions of local populations (Steinberg 2016). For example, six mechanisms are proposed by Humphreys (2005) for a link between natural resources dependence and the onset of civil war but only the weak states mechanism and perhaps the grievance mechanism would apply to the less intense conflicts that are the subject of this study. These less intense conflicts are typically confined to the third sub-national level (for example, counties, villages or other local-level government areas), and usually neither escalate nor spill across regions (Barron *et al.* 2009).

Instead, it is an older literature that gives guidance on how these less intense conflicts may arise as the pressure on potentially excludable resources, like land, and on common pool resources, like forests and waterways, rises with rapid population growth, especially in places where limited structural change means that environmental incomes remain a key component of livelihoods. Writing almost 60 years ago, about a rural setting with rapid population growth and traditional customs over land use rights, Gulliver (1961, pp.25-26) notes:

No system of land distribution and concomitant social relations can adequately meet the dilemma that, as is almost ubiquitously the case, each man is thought to have the right to land to live on and cultivate and from which to improve his living standards, while at the same time the stage is being reached when there simply is not enough land for that right to be properly and economically exercised...Many or most must go short; many feel aggrieved...[and]...conflict is virtually inevitable.

This quotation is very applicable to Papua New Guinea, where the population growth rate at the time of the 2011 census was 3.1% per annum (NSO, 2013), a rate placing it in the 20 fastest growing populations in the world, and where 97% of the land remains in customary tenure.<sup>2</sup> Writing about parts of PNG almost 40 years ago, but still applicable today, Brown (1982, p.526) notes that ‘battles, ..., personal fights, raids, ambushes, [and] attacks on individuals or small groups are quite common.’ A precipitating factor in many of these actions is disputes over land and other resources like forests because of the importance of these to most people’s livelihoods and because these resources are becoming increasingly scarce. More generally, cross-country analysis shows that rapid environmental changes such as deforestation, land degradation and water scarcity increase the risk of low intensity conflict (Hauge and Ellingsen 1998).

In terms of weak state mechanisms, one indicator is that Papua New Guinea has probably the world’s highest rate of linguistic diversity, with about 850 languages spoken in the country. Most are from the island of New Guinea (some of which is in Indonesia), which is the most linguistically diverse place on earth, with more than 900 languages (Greenhill 2015), but multiple languages are also spoken in the New Guinea Islands region of PNG. With so many languages spoken amongst a relatively small population (5.1 million at the time of the data used in this article), the average size of a group speaking the same language is around 6000. Thus, a *wantok* (which is ‘one talk’ in neo-Melanesian pidgin, meaning someone from the same tribe or clan speaking the same language) is someone who will typically be from a fairly small group. In this respect, not only tribes but also clans and sub-clans can be considered as autonomous groups (Brown 1982) and so much of the inter-personal conflict that occurs in PNG is also a form of inter-group conflict. The linguistic diversity reflects PNG’s difficult topography, which in turn limited development of pre-colonial trading networks, and these factors, along with the ethno-linguistic fractionalization, contribute to weak state capacity.

Another literature that is relevant concerns the local consequences of deforestation. While earlier studies of forest loss concentrated on the global and intertemporal consequences, which reflects the role of forests in the global carbon cycle, some recent studies focus on local

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<sup>2</sup> Papua New Guinea is notable for having only a small share of alienated land, held either by the state or privately. In other Melanesian countries less than 90% of land is in customary ownership (Mohamed and Clark 1996).

costs of deforestation. For example, Gibson (2018) finds that a higher rate of local forest loss in the Solomon Islands leads to higher local inequality and poverty, even as there is a rise in average local income. It seems that some people get richer but more get poorer, most likely because resource rents from logging go to only a small tribal elite, and also because the poor depend more on environmental incomes that are disrupted by deforestation. A related literature on local impacts of forest loss studies health, Garg (2019) for example, finds that deforestation increases the local incidence of malaria in Indonesia. Potentially, an increased risk of conflict is another local consequence of deforestation, due to disruption to environmental incomes that puts pressure on other resources and could lead to more land disputes, and also potentially due to conflict over how logging rents are distributed.

### **3. Data**

The data on conflict come from a dispute resolution module that was included in the Papua New Guinea Household Income and Expenditure Survey (HIES). This survey was fielded from July 2009 until December 2010, with more than two-thirds of the sample surveyed in 2010 so it is referred to as the 2010 HIES from here on. This was the first national household survey since the 1996 PNG Household Survey, which was a multi-topic living standards survey that did not collect data on disputes. In general, dispute resolution modules are not included in HIES in other countries, and few multi-topic living standards surveys include them, despite the rich data that they can provide which may directly inform about distributional incidence of conflict, given the other living standards indicators collected for the same households.

For each of 20 types of disputes (some of which may be considered as forms of criminal victimization) the respondent was asked: ‘Have you or anyone in your household experienced a dispute in the past year?’ After the preliminary screening question was asked for all 20 types of disputes, a set of follow-up questions were asked. These follow-up questions asked whether the dispute resulted in property damage, in injury or in death. Then a further set of in-depth questions were asked about the single dispute that had the most impact on the household, in terms of the type of dispute (using the same 20 categories as in the screening question), a brief description of the dispute, whether help was sought in resolving the dispute, and if so, from whom, whether compensation was awarded and how much money the dispute had cost and how much time it had taken. A typical description of the most impactful dispute would be something like: ‘fighting over land which belongs to us, but the other village claims it’.

A multi-stage sample was used for the survey, with a stratified selection of just over 300 communities (census units) made first, and then a quota of households surveyed in each of the selected communities, giving an initial sample of just over 4000 households. In rural areas a community may be a village or a set of hamlets, with a quota of 18 households to survey. In towns the community may be part of a squatter settlement or of an urban village (where original landowners tend to live), or in more upscale parts of the town it may correspond to two or three

blocks.<sup>3</sup> The quota was six households per selected community in towns, as the transport cost of getting to town communities was less than for the rural communities (that is, given the expense of getting to a rural community it makes sense to see more households once there).

About 200 surveyed households lacked GPS details on their geographic coordinates (needed for merging with remote sensing data on deforestation), and another 400 lacked full expenditure data due to dropping out of the 14-day diary reporting; we omit these. The household-level sampling weights for the final estimation sample of  $N=3477$  are recalculated to account for these omissions. The conflict rates reported below are given for all households, for the sub-set with complete geo-referencing, and for the further sub-set with geo-referencing and expenditure data. It appears that the sample drop-out was not related to the reported conflict rates and so should not be a source of any bias.

The deforestation data are from remote sensing, and include baseline forest cover data for year 2000 and annual forest loss estimates thereafter. These are from a database provided by Hansen *et al.* (2013) where trees are defined as all vegetation taller than five metres in height, and the percentage of each pixel covered by trees is estimated from Landsat Enhanced Thematic Mapper (ETM) images during the growing season (which is more appropriate than assessing forest cover in seasons of dormancy or senescence).

The Landsat images have a resolution of one arc-second, which is a variable measure in terms of longitude (getting smaller further from the equator), but as PNG is very close to the equator each pixel is approximately 900 square meters. These pixels can be aggregated to any sized spatial unit to create measures of forest loss, which may be either the complete removal of the cover canopy for vegetation taller than five meters or from stand-replacing disturbance. Figure 1 shows that the forest loss from 2000 to 2010 was spread through all areas of PNG, although with a higher rate of loss in the New Guinea Islands and north coast regions and considerable heterogeneity.<sup>4</sup>

In some countries, the apparent rate of deforestation depends on how ‘forest’ is defined but this is not so for PNG, where mainly dense primary forest (that is, areas not subject to current or past logging or other human intervention) has been lost. This is shown in Figure 2, in terms of the cumulative percentage of the baseline forested area lost each year, under four

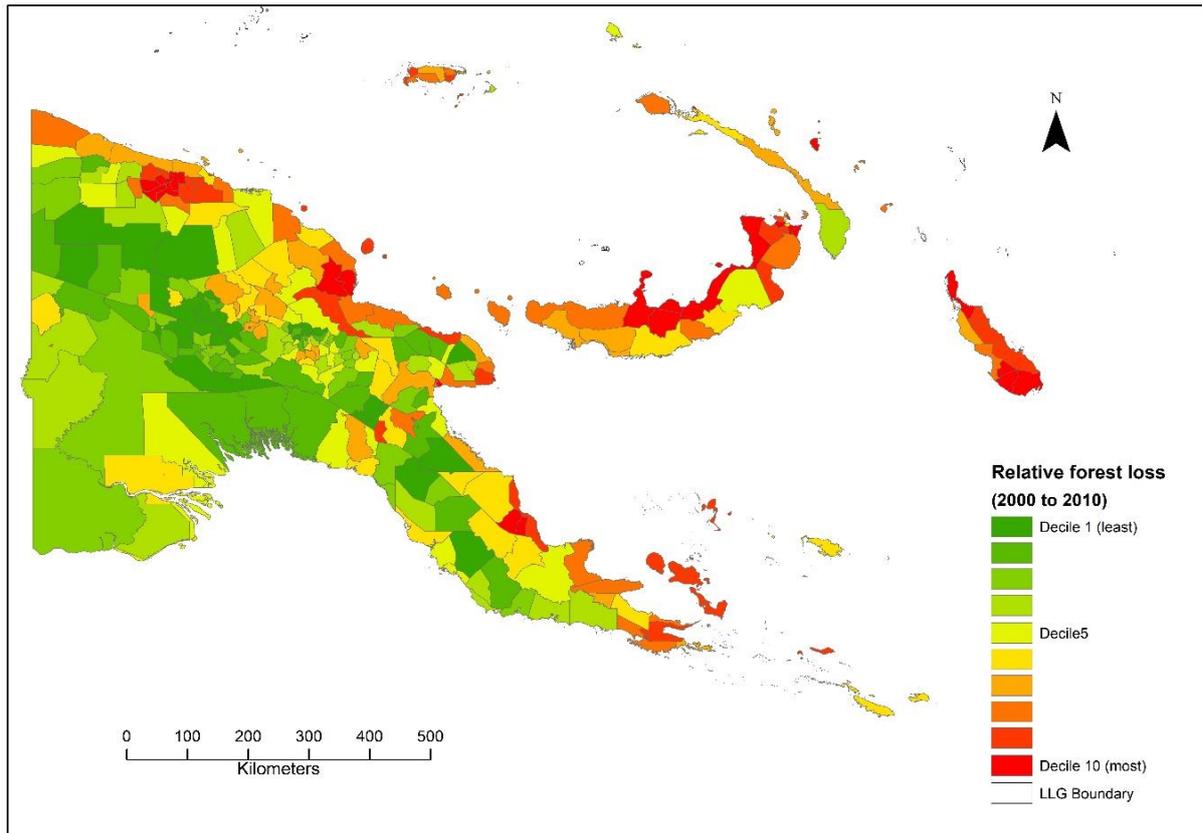
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<sup>3</sup> There is a lot of urban agriculture in the towns, growing crops like sweet potato and peanuts on urban hillsides, and also tree cutting as firewood is the main cooking fuel. People in coastal towns also rely heavily on reef and other in-shore fisheries. Thus, land disputes and other resource conflicts also occur frequently in the towns.

<sup>4</sup> The units shown in the figure are Local Level Government (LLG) areas, which are the third sub-national level. The average LLG is about 1450 square kilometers, which is slightly less than the area of Greater London.

different definitions of forest: more than 10% of the pixel is covered by trees, more than 25% is covered, more than 50% is covered or more than 75% is covered. The percentage losses are almost the same under all four definitions, with 1.2% of the area that had been tree-covered in 2000 no longer tree covered by 2010.<sup>5</sup> There was a fairly constant rate of loss between 2000 and 2013 but the rate of forest loss has accelerated since then, with about 0.4% of baseline forested area now lost per year, compared to around 0.1% per year prior to 2013.

**Figure 1: Spatial Variation in Forest Loss in Papua New Guinea: 2000 to 2010**

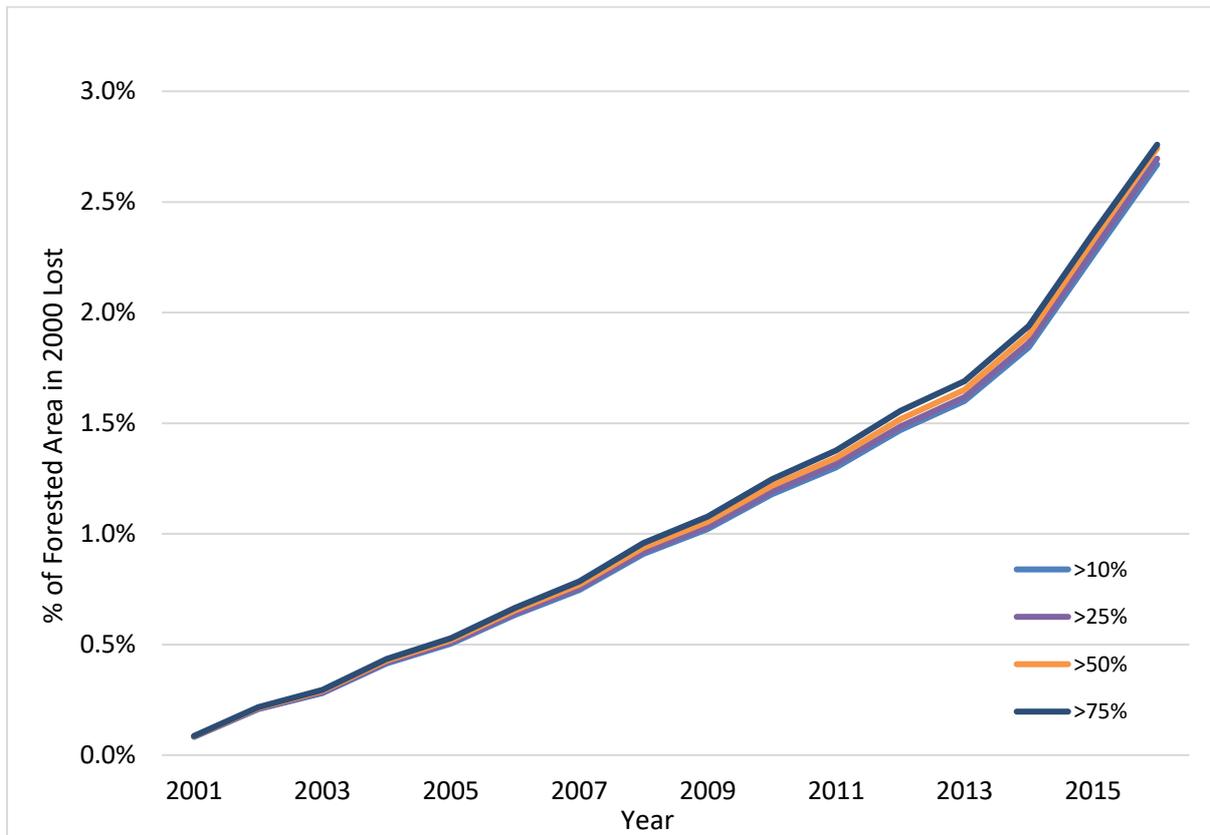


Some of this deforestation in Papua New Guinea comes from land under customary tenure that has been designated by the PNG government as Special Agricultural Business Lease (SABL) land. In principle, the SABL requires the consent of the customary landowners to lease the land to the state, who in turn classify the land as alienated land that can be leased to third parties (for up to 99 years). The SABL allows logging operations to be undertaken prior to the start of the proposed agricultural activities, which are predominantly new oil palm plantations. The SABLs are controversial because many are obtained without consent of the traditional

<sup>5</sup> The Food and Agriculture Organization (FAO) suggest a higher rate of loss, with the area of primary forest in PNG falling from 25.8 million hectares (m ha) in 2000 to 20.3m ha in 2010 and 17.6m ha in 2015 (FAO, 2015). That the record of forest loss derived from satellite remote sensing is different to what FAO report is a pattern seen in many countries (Hansen *et al.* 2013).

landowners, and much of the proposed oil palm is not planted and is simply a front for logging operations. Approximately 12 percent of the total land area of PNG has been placed under this SABL designation, leading to rapid growth in log exports, almost all of which are destined for China, for whom PNG is now the largest supplier of tropical logs (Schaap and Canby 2018). However, there are also other pressures on forests, including local demand factors from slash-and-burn shifting agriculture and from walk-about sawmills that do small-scale timber harvesting.

**Figure 2: Cumulative Percent Forest Loss by Baseline Cover  
PNG 2001-2016**



#### 4. Results

The risk of conflict for households in Papua New Guinea in the last 12 months, as reported in the 2010 HIES, is shown in Table 1. Just under one-quarter of households were involved in land disputes, three percent of households were involved in either disputes over agricultural production, or over forestry, or in tribal fighting. These four types of disputes, plus disputes over water and development project resources and compensation are defined as resource conflicts.

**Table 1: Risk of Resource Conflict:  
Frequency of Experiencing Disputes (and Disputes with Fatalities) in the Last 12 Months for Households in Papua New Guinea in 2010**

Type of Dispute	All Households			Households with GPS Data			Households with GPS & Expenditure Data		
	# exposed	# with death	exposure %	# exposed	# with death	exposure %	# exposed	# with death	exposure %
<b>Land</b>	<b>746</b>	<b>40</b>	<b>22.8%</b>	<b>699</b>	<b>38</b>	<b>22.5%</b>	<b>609</b>	<b>34</b>	<b>24.2%</b>
<b>Water</b>	<b>25</b>	<b>1</b>	<b>0.4%</b>	<b>22</b>	<b>1</b>	<b>0.4%</b>	<b>20</b>	<b>1</b>	<b>0.4%</b>
<b>Forestry</b>	<b>112</b>	<b>3</b>	<b>3.3%</b>	<b>98</b>	<b>3</b>	<b>2.9%</b>	<b>85</b>	<b>2</b>	<b>3.1%</b>
<b>Agricultural production</b>	<b>98</b>	<b>3</b>	<b>3.3%</b>	<b>84</b>	<b>3</b>	<b>2.9%</b>	<b>73</b>	<b>3</b>	<b>3.1%</b>
Child custody	115	1	2.5%	104	1	2.4%	98	1	2.7%
Inheritance	62	3	1.6%	58	3	1.5%	49	3	1.6%
Domestic violence	349	2	9.0%	337	2	9.3%	303	1	10.2%
Bride price	141	0	4.2%	132	0	4.2%	124	0	4.5%
Business agreement	19	1	0.3%	15	1	0.2%	13	1	0.3%
Loan repayment	55	0	1.4%	51	0	1.3%	48	0	1.6%
Physical assault	278	4	7.3%	253	3	7.0%	228	3	7.6%
Theft	256	0	8.5%	241	0	8.6%	220	0	8.1%
Distribution of aid	45	0	1.2%	41	0	1.2%	33	0	0.9%
<b>Access to development resources</b>	<b>63</b>	<b>0</b>	<b>1.1%</b>	<b>56</b>	<b>0</b>	<b>0.9%</b>	<b>45</b>	<b>0</b>	<b>1.1%</b>
<b>Compensation for project</b>	<b>34</b>	<b>1</b>	<b>0.8%</b>	<b>28</b>	<b>1</b>	<b>0.6%</b>	<b>23</b>	<b>1</b>	<b>0.6%</b>
Village decision making	81	1	2.2%	77	1	2.2%	64	1	2.3%
Government decision making	56	0	0.8%	54	0	0.8%	45	0	0.9%
Elections	49	3	1.7%	45	3	1.7%	38	2	2.1%
<b>Tribal fighting</b>	<b>87</b>	<b>35</b>	<b>3.0%</b>	<b>76</b>	<b>33</b>	<b>2.8%</b>	<b>41</b>	<b>29</b>	<b>2.9%</b>
Other	60	2	1.2%	56	2	1.1%	48	2	1.2%

*Note:* The numbers of households exposed to each type of dispute (and number exposed to disputes involving deaths) relate to the sample, while the exposure rate is weighted to be nationally representative. There are n=4073 households answering the disputes questions, of which n=3864 have GPS data and n=3477 have GPS data and valid total expenditure data.

The disputes in **bold** are classified as resource disputes.

A household may be involved in multiple disputes so I calculate an overall resource conflict rate, for whether a household was involved in any of these types of resource disputes, and this was the situation for 35.4% of households in Papua New Guinea (with a standard error of 2.9%).<sup>6</sup> Looking across the columns of Table 1, for different sub-samples that depend on data availability, it seems unlikely that the households without complete geo-referencing or without complete expenditure data experience different conflict rates than the subset of  $N=3477$  households with complete data available, given the similarity of the conflict rates for all three samples. Thus, there should be no issues of selective survey compliance causing bias in the results based on the final estimation sample.

Two other features of the conflict rates in Table 1 are worth comment. Several of the land disputes and the tribal fights lead to fatalities, with 75 reports of a death (or deaths) within the full sample. In terms of population proportions, about seven percent of the land disputes and 40 percent of the tribal fights resulted in deaths. There are also several other types of disputes and criminal victimization that occur frequently according to the figures in Table 1, including domestic violence, disputes over bride price (a reverse dowry system) and child custody, and thefts and physical assaults. The frequency of some of these crimes reflects the fact that Papua New Guinea is known to have a high crime rate with limited state capacity for law enforcement (Dinnen 2001).

There is further evidence that these conflicts are likely to be very costly, over and above the likelihood that a dispute involves a death as shown in Table 1. The survey asked for details on the dispute that had the most impact on the household, and most typically this was a land dispute. When asked about the amount of money that the land dispute had cost the household to date, an average of K1000 (approximately US\$400) was reported, which is equivalent to about six percent of total household expenditure for the year. There is no breakdown of this figure, so it is unclear if it reflects costs of accessing courts and other legal services, or the costs of documenting customary land ownership claims.

In about two-thirds of the land disputes the respondent had sought help from others to resolve the dispute, and in about half of the cases this involved going through police, court, or government channels, with the other approaches to resolving the dispute relying on potentially lower cost channels such as community leaders, NGOs, churches and so forth. The overall picture provided by these survey data is that these small-scale resource conflicts in Papua New Guinea are both frequent and costly.

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<sup>6</sup> All statistical results reported account for the weighted, multi-stage, sample design.

#### **4.1 How Does the Conflict Rate in Papua New Guinea Compare to Other Places and Times?**

It is difficult to compare the frequency of resource conflicts in Papua New Guinea with the situation in other countries because similar dispute modules have not usually been included in household surveys. One potentially illuminating comparison is with neighboring Indonesia, where a nationwide village inventory indicated that seven percent of all villages had a conflict incident in the prior year (Barron *et al.* 2009). This reporting was done by the village head (or their urban equivalent) and there is no counterpart to this role in Papua New Guinea. Moreover, it is unclear whether a single person reporting for the whole village has the same (collective) information as is held by all the households that are surveyed in a village. Yet given that 85 percent of surveyed communities in PNG have at least one household reporting involvement in a land dispute in the previous 12 months (and 28 percent of surveyed households within those communities report involvement), there would need to be a lot of under-reporting by the village head in Indonesia in order for the conflict rate in Indonesia to exceed that in Papua New Guinea. Instead, it is more likely that the conflict rate in PNG is substantially higher than in Indonesia.

Another way to put the PNG conflict rate in context is to compare it with records from the agrarian past of the currently developed countries. The data for homicide provide the most reliable evidence because, from the 13<sup>th</sup> Century onwards, coroners records are available for various towns and counties in England, several centuries before the formation of police forces and modern forms of crime reporting. A review by Stone (1983) shows that medieval English society was twice as violence-prone as early modern English society (the 16<sup>th</sup> to 18<sup>th</sup> Century), which, in turn, was at least five times more violence-prone than contemporary English society. Moreover, in medieval England most homicides occurred in village fields, especially during plowing and harvest when conflict over land and crops was most intense (Hanawalt 1986).

In one area with reliable data from manorial courts, it was property disputes – especially land disputes, because land was the basis of the peasant economy – that occupied most court cases (Westman 1974). Furthermore, violent crimes were primarily inter-household rather than intra-family, compared to the pattern in the modern era; for example, just eight percent of English homicides were within the biological family in the 14<sup>th</sup> Century rising to 20 percent within the family in the 17<sup>th</sup> Century and about 50 percent now (Stone 1983). Relatedly, Hatcher and Bailey (2001) note that most medieval conflicts involved individuals or small groups and were typically inter-peasant conflicts rather than class-based conflicts between larger social strata, such as peasants and lords, and in this respect they resemble some of the inter-personal conflict observed in contemporary Papua New Guinea.

The highest homicide rate in the seven centuries of data for England that Gurr (1981) assembled was 110 death per 100,000 population in Oxfordshire in the 14<sup>th</sup> Century, with the next highest being London in the same era with a rate of 44 per 100,000 population.<sup>7</sup> The data for Papua New Guinea are reported in a different way, being household-based rather than victim-based, so it is possible that several households in the same village report on the same conflict-related death. Out of the 301 communities that were surveyed, 42 of them have at least one household reporting a death due to conflicts such as land disputes or tribal fighting in the previous 12 months. While this is only 14% of the sampled communities, they account for 23% of the population (due to the unequal community-level population sampling weights).

With over 25,000 communities (census units) across all of Papua New Guinea, even if there is just one conflict-related death in 14% of them (the unweighted sample proportion) it would amount to 3500 deaths per year, or a death rate of about 70 per 100,000 population. If multiple deaths per community were allowed, because the sample had several communities where up to nine surveyed households reported that a death resulted from the conflicts they were part of, or if allowances is made for the sample villages with deaths having a larger share of the population than their share of the sample, then the death rate would be even higher. Thus, compared to the agrarian past of the developed countries, the contemporary homicide rate from resource conflicts in Papua New Guinea appears very high.

#### **4.2 Are Land Disputes and Resource Conflicts More Likely in Richer or Poorer Communities?**

The results of ordinary least squares (OLS) regressions of the community level conflict rate in 2010, on indicators of community level income or wealth are reported in Table 2. There are results specifically for land disputes, and also for the broader category of resource conflicts that includes land disputes and the other types of disputes noted in Table 1. For all of the regressions, the results suggest that conflict rates are higher in poorer areas, with the statistical significance of these effects at the  $p < 0.01$  level in all cases.

The first indicator considered is mean per capita consumption, which is obtained for each household in the 2010 HIES using a two week diary of all acquisitions (from purchases, own-production and non-market transactions like gifts) of food and frequently purchased items, plus the value of consumption for infrequently acquired items based on six month and 12 month recalls, and the calculated value of service flows from durables and own-occupied dwellings. The values of consumption are put in real per capita terms, by deflating by the regional poverty lines, and then population-weighted averages are formed for all 301 communities in the survey. The data on conflict rates and on the indicators of how rich is each community are all in logarithms, to enable interpretation of the regression coefficients as elasticities. The local

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<sup>7</sup> The data for Oxford were originally collected by Hammer (1978) but rate-based calculations and comparisons are due to Gurr (1981).

conflict rate has an elasticity of -0.081 ( $t=3.54$ ) with respect to mean per capita consumption, for the broad category of resource conflicts, and an elasticity of -0.078 ( $t=3.58$ ) for the more specific category of land disputes, according to the results in columns (1) and (4) of Table 2. Another way to interpret this relationship is with standard deviation changes: the community-level resource conflict rate has a mean of 0.19 and a standard deviation of 0.22. A standard deviation increase in the mean value of real per capita consumption for a community would reduce their resource conflict rate by 0.23 of a standard deviation (or by five percentage points).

**Table 2: Conflict Rates for Land Disputes and Resource Disputes Are Higher in Poorer Areas**

	<u>Land dispute conflict rate</u>			<u>Resources dispute conflict rate</u>		
	(1)	(2)	(3)	(4)	(5)	(6)
ln (mean per capita consumption)	-0.078*** (3.58)			-0.081*** (3.54)		
ln (District poverty rate, 1996)		0.118*** (4.92)			0.122*** (4.85)	
ln (District development index)			-0.269*** (5.13)			-0.291*** (5.30)
Constant	0.275*** (17.06)	0.373*** (12.24)	1.009*** (6.66)	0.313*** (18.49)	0.415*** (12.93)	1.109*** (6.98)
R-squared	0.041	0.075	0.081	0.040	0.073	0.086

*Notes*

Dependent variable is logarithm of conflict rate (for either land disputes or for resource disputes) in 301 primary sampling units ('villages' or 'blocks') in 2010. Inverse-hyperbolic sine transformation used to allow including zeros. All results use population sampling weights. The absolute value of  $t$  statistics is in parentheses, and \*\*\*, \*\*, \* denote statistical significance at the 1%, 5% and 10% level. District development index is from Hanson et al (2001).

One concern with relating conflict rates to contemporaneous measures of community wealth or income is that there may be effects of conflict on these wealth measures, due to property damage from conflict, due to death or injuries from conflict, due to diverting of family labour from productive tasks to security duties or fighting, and also by potentially deterring investment in local development projects.<sup>8</sup> If this reverse relationship is important, it might seem natural that poorer areas appear to have higher conflict rates, but it would be because the conflict caused them to be poorer rather than poverty contributing to the risk of conflict.

This concern can be mitigated by using lagged measures of community income or wealth, because it is harder to see how contemporary conflict can affect historical wealth and so lagged measures help to rule out the reverse relationship. While there is no previous income or wealth survey that was fielded in the same 301 communities as used for the 2010 HIES, the prior national survey of living standards, from 14 years earlier, in 1996, has estimates of the poverty rate for each of the 87 Districts in PNG (Gibson *et al.* 2005) and 78 of these Districts are included in the 2010 survey. Moreover, this 1996 poverty rate has a lot of variability, ranging from nine percent in the richest Districts to 65% in the poorest. The results reported in columns (2) and (5) of Table 2 show that the elasticities of the contemporary conflict rate with

<sup>8</sup> For example, one-fifth of the land disputes resulted in damage to property.

respect to the poverty rate from 14 years earlier are 0.12, which are precisely estimated with standard errors of about 0.025. Thus, poorer areas seem to have higher conflict rates.

Another historical indicator of whether areas are richer or poorer comes from a District Development Index, which is based on five components; land potential, agricultural pressure, access to services, income from agriculture and child malnutrition (Hansen *et al.* 2001). These components rely on data obtained over about a 20-year period from 1980 (for example, the 1982/83 National Nutrition Survey) and so well predate the conflict estimates from 2010. The places in Papua New Guinea that were poor in the 1980s, and earlier, have tended to remain poor over time (Allen *et al.* 2005) which is why an index assembled from data of differing vintages can still reflect the major spatial patterns of disadvantage at a particular point in time. The results reported in columns (3) and (6) of Table 2 show elasticities of the local conflict rate with respect to the development index (where higher values reflect better conditions) of -0.27 for land disputes and -0.29 for resource disputes and these are precisely estimated effects.

One can interpret the results in Table 2 as showing that resource conflicts are more likely to be experienced by people living in poorer areas of Papua New Guinea. The people living in these poorer areas are likely to have greater dependence on environment incomes, from forests, rivers, lakes and the ocean. With the system of customary tenure in PNG, where property rights are not formally defined and are often disputed, there is scope for rising pressure on land and other natural resources, driven both by high population growth and by large-scale and rapid environmental change, such as occurs with deforestation, to exacerbate conflict. The evidence for this effect is examined in the next sub-section.

### **4.3 Does Deforestation Exacerbate Conflict?**

The results of ordinary least squares (OLS) regressions of the community level conflict rate (for resource conflicts) in 2010, on the cumulative percentage of the nearby forest lost in each year from 2000 to 2010 are reported in Table 3. The focus is on the broader category of resource conflicts, that includes land disputes, because the results in Table 2 were so similar for both resource conflict rates and land disputes.<sup>9</sup> For the results in this table, nearby forest is defined as that within any pixel within ten kilometers of the center of the community, where this circle around each community covers just over 300 km<sup>2</sup>, and the forest loss data are at the pixel level for each year, from the Hansen *et al.* (2013) database. The baseline forested area, used for calculating the percentage loss, is for pixels with at least ten percent tree cover in the year 2000 that is the start of the period covered by the database of Hansen *et al.* (2013). A double logarithmic specification is used, to aid interpretation of the regression coefficients as

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<sup>9</sup> The regression results for land dispute conflict rates that match the specifications in Table 3 are available from the author.

elasticities.<sup>10</sup> In addition to the results for the relationship between these two variables, three other regressions whose results are shown in columns (2) to (4) successively add a control variable. These additional regressions are designed to show if the relationship between forest loss and conflict is serving as a proxy for the effects of some other, omitted, factors.

The regressions suggest that the higher the cumulative forest loss within the vicinity of a community, the higher the subsequent rate of conflict over resources. The effect is precisely estimated, with statistical significance at the  $p < 0.01$  level for all four regressions in the table. The estimated value of the elasticity ranges from 0.3 to 0.4, depending on the covariates included, so if there was a ten percent increase in the cumulative rate of forest loss, the local conflict rate would be expected rise by between three to four percent.

**Table 3: Effects of 2000-2010 Forest Loss on the Community Level Resource Conflict Rate: OLS Estimates Using 10 km Forest Buffers**

	(1)	(2)	(3)	(4)
ln (% of forest lost, 2000-2010)	0.280*** (3.25)	0.285*** (3.36)	0.356*** (4.10)	0.395*** (4.66)
ln (baseline forested area, 2000)		0.215*** (2.78)	0.190** (2.48)	0.176** (2.36)
ln (mean per capita consumption)			-0.259*** (3.14)	-0.244*** (3.03)
District poverty rate (1996)				0.560*** (4.19)
Constant	0.321 (0.94)	-1.846** (2.17)	-1.341 (1.57)	-0.641 (0.76)
R-squared	0.297	0.316	0.339	0.379

*Notes*

Dependent variable is logarithm of the standardized conflict rate (for resource conflicts) in 301 primary sampling units ('villages' or 'blocks') in 2010. All results use population sampling weights. The absolute value of  $t$  statistics is in parentheses, and \*\*\*, \*\*, \* denote statistical significance at the 1%, 5% and 10% level. All models include 20 province-level fixed effects. Forest loss and baseline forest area are calculated for pixels with at least 10% tree cover in the database provided by Hansen *et al.* (2013).

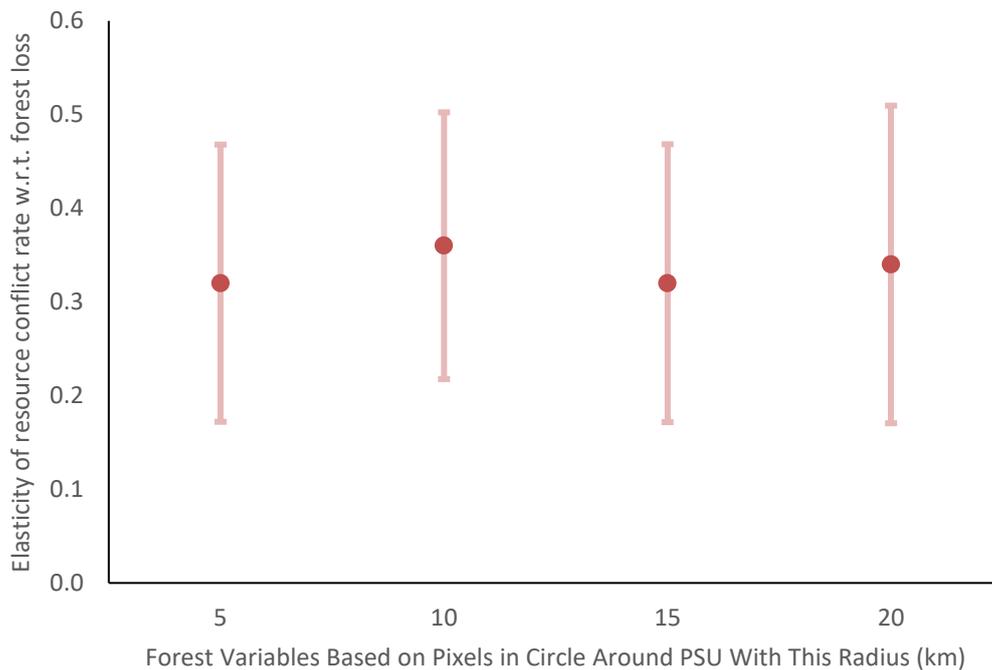
The effect of local forest loss on the local conflict rate is robust to the inclusion of the baseline forest cover, and to including measures of how rich an area is, specifically, the log of average per capita consumption in the community, or the District level poverty rate (from 1996, where this estimate from 14 years earlier serves as a proxy for long-term factors that are associated with some areas in PNG being persistently poorer than others). The elasticity of conflict with respect to forest loss rises from 0.28 to 0.40 as these control variables are added so it is unlikely to be the case that the effect of forest loss on conflict is exaggerated by the

<sup>10</sup> The conflict rate and cumulative forest loss rate in this table are standardized variables, of mean zero and standard deviation one (by construction) so to obtain logarithms of these variables, the inverse-hyperbolic sine (IHS) transformation,  $ihs(x) = \ln(x + (x^2 + 1)^{0.5})$  is used, which gives the same results as using logarithms for non-zero observations, but also lets zeros be used (Gibson *et al.* 2017).

exclusion of key control variables. Amongst the control variables, it appears that resource conflict rates are higher in more forested areas and in historically poorer areas, and are lower in communities with contemporaneously higher average per capita consumption levels.

In order to check on the robustness of the relationship between forest loss and conflict rates, the area over which the forest loss was calculated was varied. Specifically, the baseline forested area and the cumulative percentage forest loss was measured for areas with radii of 5km, 10km, 15km and 20km around the center of each community. The results of this exercise are shown in Figure 3, where the elasticity of the conflict rate with respect to the cumulative percentage forest loss varies only slightly, from 0.33 to 0.36, across these different ways to measure the severity of local forest loss.<sup>11</sup> Another robustness analysis was to measure forest loss only for the pixels that had at least 75 percent tree cover at baseline in the year 2000, and the elasticity of the conflict rate with respect to cumulative forest loss, for this more restrictive definition of forested areas, was almost identical to the elasticities reported in Table 3. Thus, it appears that the relationship between greater rates of forest loss and higher rates of subsequent conflict is robust.

**Figure 3: Robustness of Forest Loss Effect on Conflict to Varying Size of Local Area**  
Points are elasticities and bars are 95% confidence intervals



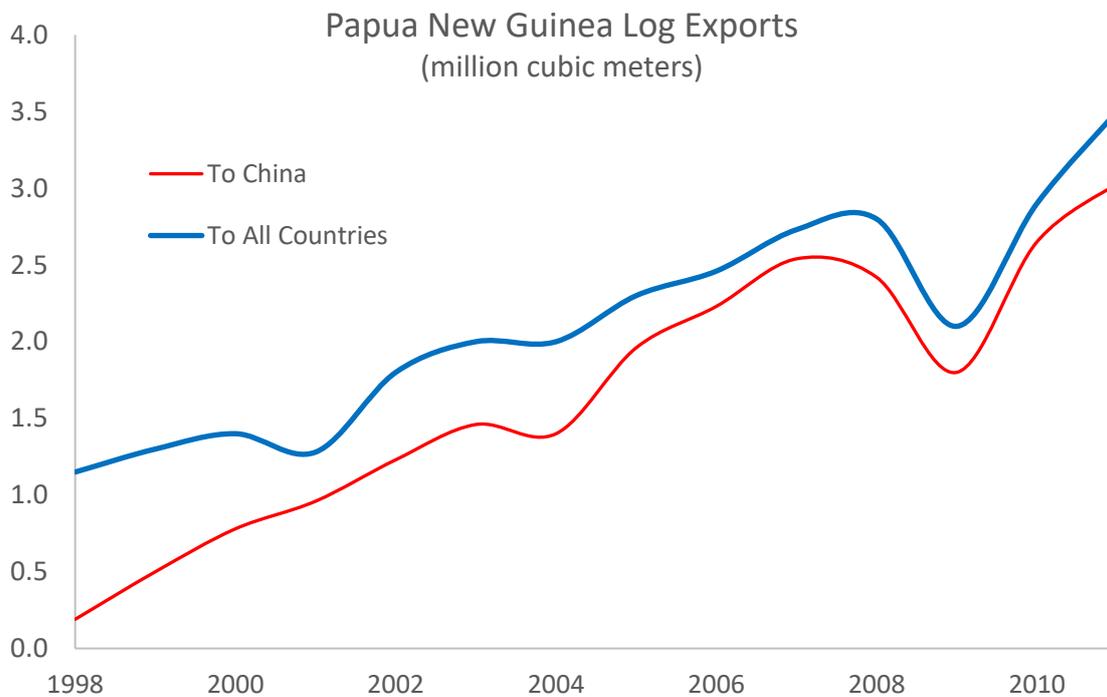
The possibility that the relationship between forest loss and conflict goes the other way, with resource conflicts leading to forest loss, can be ruled out for at least two reasons. The first is due to the lag structure of the model; it is easier to see how the prior rate of deforestation can

<sup>11</sup> The elasticities in Figure 4 are based on the regression specification reported in Column (3) of Table 3. Precision of the estimated elasticities does fall slightly as the forest loss variable is based on an ever-larger area

affect the subsequent conflict rate than how conflict in 2010 could affect deforestation occurring up to a decade earlier. Moreover, as shown in Figure 2, the percentage rate of cumulative forest loss did not show any sharp changes until about 2013, well after the conflict data were collected. Thus, even if the cumulative forest loss variables are defined to end in, say, 2008 rather than 2010, the results are very similar and thus ruling out any contemporaneous reverse effect of conflict in 2010 on deforestation.

The second factor is that there has been a dramatic shift in the volume and profile of log exports from Papua New Guinea (Figure 4). The driving force behind this has been exports to China, which have an annual growth rate of 16 percent since 1998, with China going from being the destination of just one-sixth of PNG log exports in that year to taking five-sixths of the (three times higher) exports by 2010. At the same time, Papua New Guinea has become the largest source of tropical log imports for China. The identifying assumption being made is that the sharp increase in total log exports and the change in export destinations since 2001 reflects developments outside of Papua New Guinea as other tropical countries imposed log export bans, and so is an exogenous shock. Thus, even if previous logging depended on local conflict, as might be inferred from studies in other places that suggest that conflict drives deforestation (Butsic *et al.* 2015; Landholm *et al.* 2019), any micro-level local determinants of previous logging in PNG are less relevant to the recent growth in logging. Instead, the driving force for the recent growth in logging is more at the macro level, from the sharp rise in the demand for logs by China as other supplying countries withdrew from the tropical logs trade.

**Figure 4: Growth in Log Exports to China Acts as an Exogenous Shock**



## 5. Conclusions

Much of the literature on conflict in developing countries focuses on relatively intense conflicts like civil wars, and ignores less intense conflicts that may be more widely experienced. In this paper, novel household survey data for Papua New Guinea have been used to show that these less intense conflicts are frequently experienced; about one-quarter of households experienced a land dispute in the prior 12 months and 35 percent were involved in conflicts over resources, which includes land, forestry, water, agricultural production, tribal fighting and development projects. Similar data are not available for other countries, but from the limited comparisons that are possible, the conflict rate in Papua New Guinea is higher than in other times and places.

The risk of conflict over natural resources is higher in poor areas, and one implication of this is that efforts to reduce conflict can be expected to be pro-poor. One of the driving forces for this conflict appears to be deforestation in the local area, and so the results here add to a growing literature that highlights local consequences – in terms of health and inequality – for countries involved in the export of tropical logs. In other words, there are trade-offs in the here and now for countries such as Papua New Guinea that have become important sources of log exports as other countries withdrew from this trade. In contrast, much of the previous focus of deforestation studies has been on global environmental consequences where at least some of the costs may be borne by people in other places and other times. To the extent that a higher risk of local conflict is a consequence of deforestation, that is a more immediate cost that is borne directly within the society that is making these resource exploitation decisions.

In terms of methodological issues, the results here show the value of using regularly fielded household surveys for collecting information on conflict and disputes. This approach is rarely used in conflict studies, which tend to rely on other data sources, yet it has several advantages, including an in-built ability to study the distributional impact of conflict by relating to the welfare indicators, such as income or consumption, collected for the same households in the same survey. Moreover, with the increased availability of geo-referenced household survey data, it is possible to link data on conflict to remote sensing data on environmental change. It would be useful if other household surveys included data on conflict and disputes, not only to compare to the results of the current study but also to improve the understanding of the causes and consequences of these less intense conflicts that may be missed by other data sources.

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