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Global Commodity Markets, Chinese Demand for Maize, and Deforestation in Northern Myanmar

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Abstract: This paper makes a significant contribution to understanding the logic of deforestation in Northern Myanmar and connects global trends and regional political economy with local environmental changes. Methodologically, through a combination of remote sensing GIS analysis, for which we use a newly available Myanmar Forest Change dataset produced by TerraPulse and the Smithsonian Conservation Biology Institute, as well as on-the-ground field research observations and interviews with farmers, this paper examines how the expansion of maize plantations in the northern part of Myanmar has implications for deforestation in the region. It argues that a combination of global commodity price shock around 2011–2012 plus easy market access to China generated strong incentives for local farmers to increase the cultivation of maize. The paper contributes to how we understand the environmental impacts of Chinese demands for agricultural products in Southeast Asia.

Keywords: deforestation; maize plantation; Myanmar; China

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1. Introduction

Deforestation and forest degradation are considered among the main environmental challenges facing the globe [1]. Identifying the direct and indirect causes of deforestation and forest degradation is not easy; however, such processes are often complex and involve the interplay of multiple factors, such as economic conditions, political institutions, national policies, agricultural expansion, wood extraction, and infrastructure extension [2]. With global-scale satellite studies and in-depth locally based analyses, scholars have explored how a combination of factors at different locales has led to patterns of deforestation and forest degradation [3,4].

Agricultural expansion has been identified as a particularly dominant factor driving tropical deforestation. Indeed, the economic literature on deforestation has debated different patterns of deforestation and their relationship with agricultural development. Although scholars caution that "causal relations are less direct and to empirically examine the role of underlying factors typically requires data from multiple countries and periods, which often does not exist or is of poor quality" [5], one of the main issues around which there is consensus is that agricultural expansion constitutes the main cause of tropical deforestation [6,7]. Commodity price increases in particular have been theorized as having a direct impact on land-use changes that lead to deforestation in many parts of the world [8,9]. Similar processes are taking place within Southeast Asia as well, with agricultural expansion identified as one of the driving factors of deforestation in the region, particularly in response to logging and the expansion of palm oil plantations in parts of the region [10,11]. However, differently from previous studies that look at deforestation in tropical areas using country-level metanalysis [12], we provide on-the-ground data to support the argument that deforestation is related to the expansion of commercial agriculture.

This paper specifically looks at the case of Myanmar and examines how the expansion of maize plantations in the northern part of the country has implications for deforestation in the region. The geographical focus of our paper is on Shan State, which is the largest of all 14 administrative units within Myanmar, and accounts for almost a quarter of the country's geographical territories. Bordering China to the north and Thailand and Laos to the east, Shan State, both historically and today, maintains close cross-border connections with neighboring states, particularly China and Thailand [13]. Traditionally, Shan State has been divided into three parts, with the northern part around Lashio, the southern part around Taungyi, and the eastern part around Kengtung (See Figure 1). The northern part of Shan State is more closely linked with China, the southern part to Thailand, and the eastern part is in-between the two neighboring states. Particularly, the road from Mandalay to Muse on the Chinese border goes through the northern part of Shan State, and remains the main route of bilateral trade between Myanmar and China.

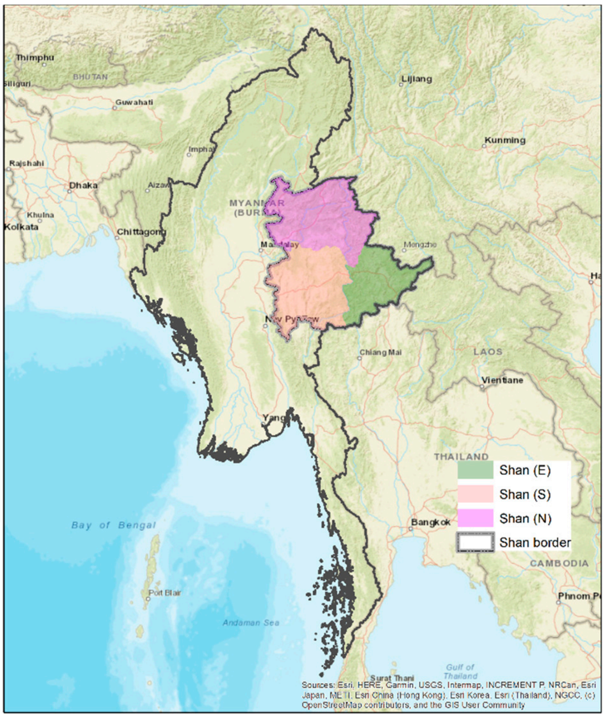

Figure 1. Shan State, Myanmar, and neighboring countries.

We argue that a combination of global and regional factors has contributed to the expansion of maize cultivation in the region. On the one hand, the global commodity price shock around 2011–2012 led to a dramatic increase in the price for maize in the years since, albeit with some fluctuations. More specifically, Northern Myanmar had easy access to the Chinese market, which coincidentally was also experiencing a big boom in demand for animal feed imports due to its rising domestic meat consumption. Thus, rising global prices, in addition to market access to China, generated strong incentives for local farmers in Northern Shan State to increase the cultivation of maize. This paper has connected these dots by arguing that the expansion of maize plantations in Northern Myanmar has accelerated the pace of deforestation in the region.

Methodologically, the paper uses a combination of remote sensing GIS analysis in addition to on-the-ground field research observations and interviews with farmers to weave together a comprehensive narrative of how the expansion of maize cultivation occurred in response to rising global prices and regional demands, and of how this expansion has led to the fast pace of deforestation. Particularly, we use a newly available Myanmar Forest Change dataset produced by TerraPulse and the Smithsonian Conservation Biology Institute [14]. In terms of field research in Myanmar, we made a series of trips to areas around Lashio in Myanmar's Northern Shan State from the summer of 2018 to the winter of 2019 to conduct interviews and collect field observation data. By combining these two methodological approaches, this paper not only presents a plausible quantitative correlation between the expansion of maize cultivation and deforestation, but also provides micro-level evidence at the village level on how decisions to expand maize cultivations are made and on villagers' actions to clear away hillsides for agricultural production. In this way, we can be more confident that our analysis demonstrates the relational dynamics across different levels of analysis of the deforestation mechanisms in Northern Myanmar.

The paper is organized as follows. It first reviews the existing literature on the relationship between agricultural transformation and environmental degradation, particularly on maize cultivation and deforestation. It situates Myanmar within this literature whilst taking into account the country's recent political and economic changes. The paper then presents the method of remote sensing and field surveying in selected villages in Northern Shan State. The survey results depicted a process of deforestation correlated with Myanmar's expansion in maize production, influenced by global commodity shocks and Chinese demand. We then utilize remotely sensed deforestation data to link the timing of maize expansion and deforestation based on our field research sites around Lashio, a major city in the northern Shan State of Myanmar. Basic village profiles at select locations with accounts of village household agricultural activities are then presented to provide a narrative to link these factors. The paper concludes with a reflection on the increasing agricultural transformation of mainland Southeast Asia and its environmental implications, and offers policy advice on how regional governments can cope with environmental externalities as a result of increasing Chinese demand for agricultural products in the region.

2. Materials and Methods

2.1. Literature Review on Agricultural Transformation and Deforestation

Studies have found that commercial and subsistence agriculture are the main drivers of deforestation in developing countries [15,16] In the Southeast Asian context, existing studies have pointed out that boom crops have strong implications for deforestation in the region [17–19]. In many parts of Southeast Asia, the expansion of palm oil has been noted for causing deforestation [11,20]. In Laos, the expansion of maize has already been noted as contributing to deforestation [21,22]. As one of the main regions in the world that still has significant tropical forest coverage, the expansion of agriculture in Southeast Asia poses a major challenge to the environment.

In Myanmar's case, it is among the most forested countries in Asia [23,24]. Its expansive forest, extending across a diverse range of ecosystems [25], harbors a tremendous number of rare and endemic species, and represents globally unique forest ecosystems and biodiversity resources [26]. According to some estimates, such as the United Nations Food and Agriculture Organization (UNFAO)'s statistics in 2015, 43% of the country's land territories are still covered by forests [27]. At the same time, Myanmar has the world's largest natural reserve of teak, one of the most valuable timber species, making its teak exports highly desirable in the international market [28]. Existing studies have indicated how such an abundance of forest resources has created a resource curse for the country's long-running civil war, because logging provided funding for various ethnic armed groups and became the target of competition between government troops and these ethnic armed groups [29,30]. In particular, the ceasefires signed between the central government and a variety of rebel groups since the early 1990s have generated an intensified process of forest resource exploitation, which has been allegedly associated with the country's fast rate of deforestation [31].

Recent satellite data have demonstrated that the country's deforestation rate accelerated even more during the past decade, although such deforestation has varied considerably across the country and appears to have heterogeneous drivers in different regions [23,24]. Through satellite remote sensing analysis, previous studies have shown that forest areas declined by 0.3% annually between 1990 and 2000 [24]. More recent work has demonstrated that deforestation rates may have doubled in the past decade [32]. Particularly, between 2000 and 2014, intact forest, the type of forest with least human disturbance and highest conservation value (defined as areas with >80% canopy cover, quantified through satellite images based on remote sensing analysis), has seen severely lost. Measured at 0.94% annually, the loss totaled more than 2 million hectares of forest within the 14-year period [23]. Our analysis, using the Myanmar Forest Change dataset (defining general forest land cover type by a commonly adopted remote sensing definition: as the areas with 30% canopy cover or larger), shows that about 8.8% of the forest has been lost. This is a total loss of 340 million hectares (or 34 thousand square kilometers) in Myanmar between 2000 and 2019, an average annual rate of 0.46% [14].

Myanmar has opened up to the outside world since the political transition around 2011, at least before another military coup occurred in February 2021. The 2010 election in Myanmar brought a civilian government to power for the first time in half a century [33]. The Thein Sein government, although heavily dominated by the military, initiated a series of political and economic reforms that put the country on track for further democratic openings [34,35]. The political and economic openings then, while generating a new momentum in integrating the country with the regional and global economy, have also opened up space for more resource exploitation. Indeed, scholars have recently identified that infrastructure development, timber extraction, and agricultural expansion are the main drivers of the country's deforestation and forest degradation [36]. As mentioned above, there are extensive studies that discuss the effect of illegal logging on deforestation in the country [28], yet few have connected regional-scale deforestation with local- and household-level socioeconomic mechanisms.

Since 2014, Myanmar's central government has imposed a national ban on cross-border timber trading [37], although, of course, it is difficult to monitor the illegal timber trade along the long and porous border areas between Myanmar, China, and Thailand. Yet, overall, it appears that the ban has had some effect on at least slowing the pace of illegal logging [38]. Therefore, in addition to the ongoing civil war and ceasefire agreements, which broke down in 2009, there are also a set of other reasons that may have contributed to the ongoing deforestation. It should be noted that in the early 2010s, another wave of agricultural reform started in Myanmar, coinciding with the country's political reform and economic opening. Since then, commercial agriculture has spread throughout the country. Indeed, scholars are already exploring the effect of commodity crops, such as maize, cassava, and rubber, on other parts of countries in mainland Southeast Asian, and have proposed that Myanmar is at the tail end of this broad land transformation taking place across the region [39]. This paper combines remotely sensed data and field surveying to untangle the relationship between maize plantations and deforestation.

2.2. Methodology

In this paper, we examine deforestation patterns in multiple spatial regions in Shan State using the Myanmar Forest Change dataset produced by TerraPulse and the Smithsonian Conservation Biology Institute [14]. This dataset was produced based on images from the Landsat satellite archive taken between the 1980s and 2019. It is the result of an algorithm that utilizes satellite measurements of electromagnetic reflectance in combination with auxiliary datasets, such as digital elevation maps and crop probability maps, to estimate the annual forest probability at each specific location and time. The forest loss and gain were then detected by examining the temporal trend of the forest probability three years prior and three years after the year of interest. It provides separate layers to quantify forest loss, forest gain, and forest detection per year, all at a 30 m $\times$ 30 m pixel resolution. The product has been tailored for detecting forest change in Myanmar by customizing the minimum percentage of tree cover to define the country's forest. It has shown high accuracy in detecting deforestation due to a variety of practices (e.g., slash and burn, forest conversion, and bamboo flowering). Additionally, compared with some of the existing products that rely on a cloud-free composite of Landsat imagery from a multi-year window, this product generates forest probability for every year with valid Landsat observations [40]. When data gaps are present (e.g., due to clouds), the algorithm will not attempt to substitute the missing data with a composite value from an adjacent year. This method will have a delayed detection of forest change events, but is less likely to completely miss change events, a side effect of temporal smoothing/substitution associated with previous products [41]. This dataset allows us to quantify the forest cover in the country in the year 2000 as the baseline so that we can calculate the annual percentage loss of forest between 2001 and 2019. The Myanmar Forest Change dataset can be accessed freely through the Smithsonian's Figshare online data repository. To maintain a consistent comparison, the annual deforestation rate in each area of interest (country, state, subregions, and village buffers) is summarized as a percentage of the changes from the baseline forest cover in 2000. We further truncated our data to look at three subregions of Shan State: Eastern Shan (Shan (E)), Northern Shan (Shan (N)), and Southern Shan (Shan (S)).

To corroborate our empirical analysis, field research was carried out in the areas around Lashio periodically from the summer of 2018 to the winter of 2019. Specifically, we conducted interviews and focus group discussions in five villages around Lashio, which was facilitated by locally recruited research assistants who have extensive experience working in the area. In total, we managed to connect with 100 local farmers and asked them a broad set of questions on their agricultural practices in addition to their household economic information. The survey methodology and questionnaire were reviewed and approved by the Smithsonian Institutional Review Board (IRB), with a Smithsonian protocol ID number of HS18042. The research was determined to be exempt research on 24 August 2018. One thing to note is that our selection of villages was not random, as there were several restrictions regarding access to different villages. In addition to difficulties in obtaining permission from local authorities, ongoing insurgencies in parts of Northern Shan State were such that it was not safe to go to certain areas, due to rebel activities [42–44]. In the end, we managed to conduct interviews and focus group discussions in five villages. For each of the five villages where we conducted interviews, we also derived quantitative data from the Myanmar Forest Change dataset by delineating three circular buffer areas using a 1000-m, 3000-m, and 5000-m radius. We used the circular buffer areas to quantify the deforestation pattern surrounding each village center where we conducted interviews. The various buffer sizes cover a range of areas where villagers might be able to travel to on a daily basis for their livelihood. We used three different buffer sizes in our analysis as a sensitivity analysis to understand how the buffer size affects the observed time series deforestation rate while also avoiding making conclusions based on a single arbitrary buffer size. It thus provides a more comprehensive picture of the deforestation pattern around each village.

We also quantified the time series deforestation data in each of the circular buffer areas around the villages from 2000 to 2019. Specifically, we imported the Myanmar Forest Change product into the Google Earth Engine [45], where the forest cover (km^2) of 2000 was calculated for each area of interest (country, state, subregions, and village buffers). The annual forest loss pixels in each area of interest between 2001 and 2019 were then summarized to quantify the annual forest loss (km^2). The percent forest loss measurement was computed as the annual forest loss divided by the total forest cover of the same area of interest in 2000. We also examined the global commodity market when seeking out supplemental data to corroborate the findings from the village-level interview survey.

3. Results

From Figure 2 we can see that Northern Shan State has experienced more deforestation than either the southern or eastern parts. Northern Shan State has lost more than 15% of its forest during 2000–2019, nearly double the national average mentioned before (Figure 2). This is the reason that we decided to carry out field research around Lashio in 2018–2019. On the other hand, we can also see that the three regions experienced deforestation differently, in that the pace of deforestation varied across years. For the eastern and southern parts of the Shan State, the peak of deforestation occurred in the mid-2000s, while for Northern Shan State, it occurred after 2010 (Figure 3). This variation might be due to transnational connections to different markets, since Southern Shan State is more connected with Thailand while Northern Shan State is more connected to China. Given the huge rise in demand for corn in China since 2010, we decided to focus our research on the Lashio area. Overall, it appears that after 2010 there has been an uptick in deforestation in all three regions, with the largest effect in Northern Shan State. There is indeed a globally related reason for this surge of deforestation—the global commodity price shock around 2010–2012.

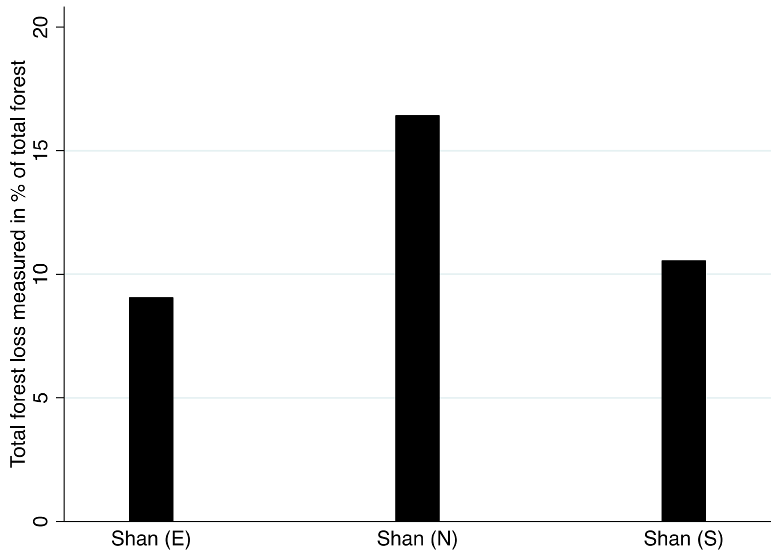

Figure 2. Total deforestation in parts of Shan State, 2000–2019.

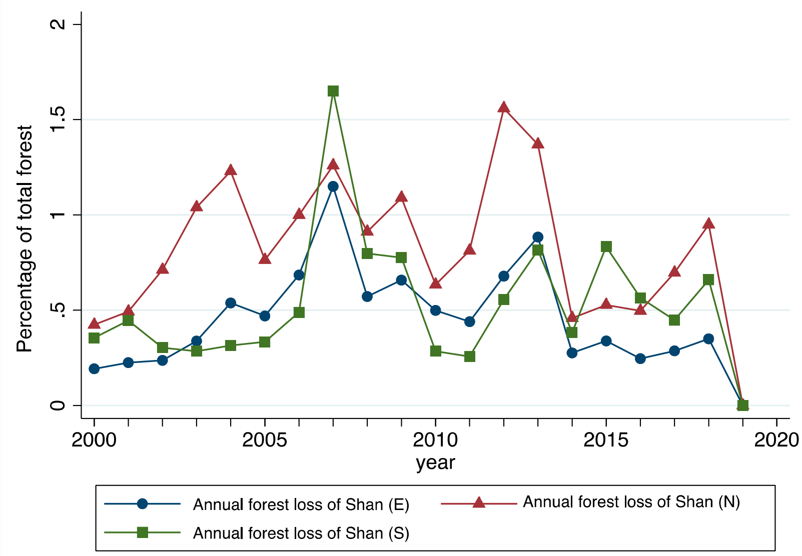

Figure 3. Percentage of yearly forest loss in different parts of Shan State.

3.1. Global Commodity Price Shock and Chinese Demand for Maize

The World Bank Commodity Price dataset provides a consistent set of data on global commodity prices over the past decades, which includes maize. According to these data (Figure 4), the global price for maize has seen surges since the early 2000s, and in fact there was a large spike in 2007–2008. More prominently, there was a further sharp increase of 57% in the price of global maize in 2010 and 2011, which pushed the price even higher than it was 3 years before. The price of maize per metric ton in 2010 was only USD 185.91, but within one year it jumped to USD 291.68 per metric ton. The price continued to increase in 2012 to almost USD 300 per metric ton. The price only recovered to previous levels in 2014, perhaps due to an increase in supply, as more producers were incentivized to join the industry by this time.

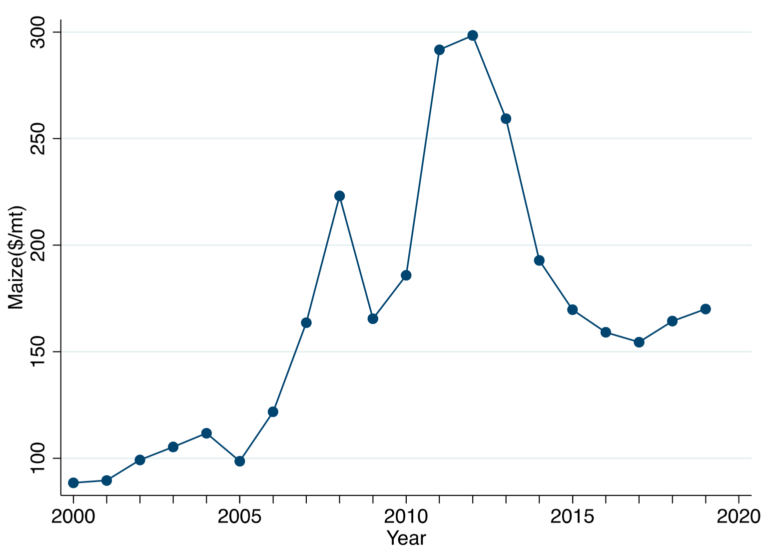

Figure 4. Global commodity prices for maize, 2000–2019 [1].

Indeed, the period between 2010 and 2012 has been known as the "2010–2012 World Food Price Crisis", during which a list of grains saw their prices soar across the globe. In the case of maize, its price surge between 2010 and 2012 was caused by an incredibly dry summer in the United States and Europe in 2011. At the same time, maize was also one of the main crops that was being heavily used in biofuel production, in part due to higher oil prices, particularly in the United States. Where Myanmar is concerned, the global surge of maize prices were coupled with increasing demand in China, as well as the political reform initiated in the country around 2010 when the then military government transitioned into a civilian one.

China remains one of the largest maize producers in the world; yet, its domestic output can no longer match rising demand, and in 2008 the country turned from being a net exporter of corn into a net importer. One of the main causes for the increase in demand for corn in China has been its fast economic development and subsequent rise of meat consumption, resulting in the rapid growth of its animal feed market. This increase, together with the industrial need for biofuel in turn, required supplies of corn that could not be satisfied by domestic production alone.

Furthermore, the domestic market price for corn in China has been consistently higher than international prices, partly due to the import quota system in place. For example, a ton of corn was worth USD 298.42 in global markets in 2012 according to data from the World Bank; however, considering the CNY–USD exchange rate on 31 December 2012, the same ton would be worth USD 385.97845 in Chinese markets. Thus, the high price in the Chinese corn market, together with the geographical proximity between the two countries that share a long 2000 km border, makes China the ideal export candidate for corn produced in Myanmar. Indeed, Myanmar's domestic production responded to such incentives. According to Figure 5, although Myanmar's corn production started to increase from 2000, the slope became much steeper from 2010 onwards. This rapid rise in corn production is possibly linked with the rise of global corn prices as well as increasing Chinese demand.

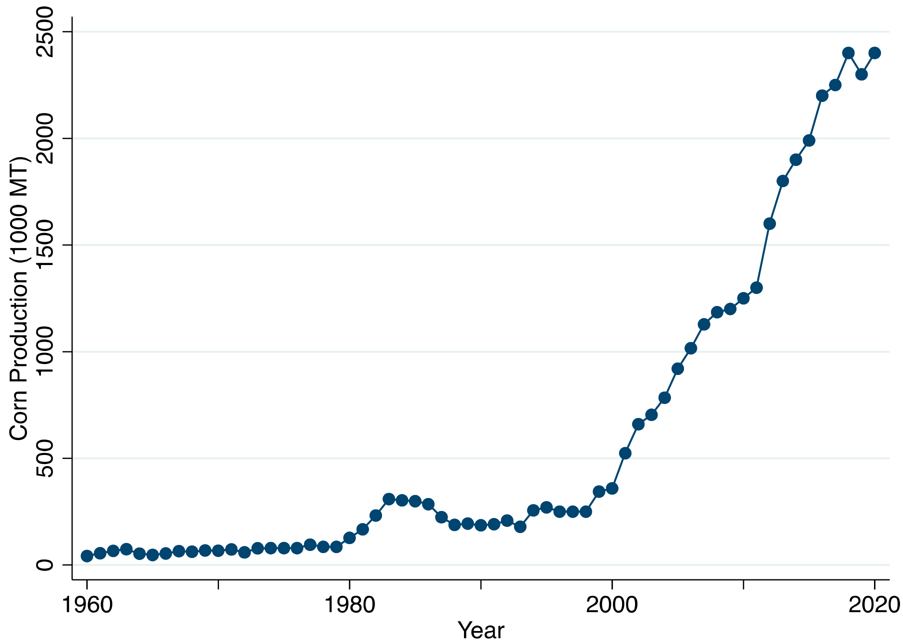

Figure 5. Myanmar maize production by year [2].

We evaluated the first-difference correlation between Myanmar maize production and forest loss in Shan State in the years between 2000 and 2019 to quantify the degree of association between the two time series datasets. We used the first-difference correlation to measure the statistical association between two series of data over time [46] to enable the calculation of the correlation with minimum impacts of autocorrelations exhibited in time series data [47]. The correlation of first-difference correlates changes in value from year to year [48]. It is commonly used to detrend (reduce autocorrelated effects) time series data, so that the correlation is based on annual changes rather than long-term changes in the variables [47].

We ran the first-difference correlation coefficient on the entire period between 2000 and 2019, and we then ran the analysis separately on the subset of data in the first (2000–2010) and the second half (2011–2019) of the study period. The correlation analysis found that the first-difference Spearman's correlation coefficient between Myanmar's maize production and the deforestation area in Shan State was the highest between 2011 and 2019 (rho = 0.22), followed by the first-difference correlation coefficient of the entire study period (2000–2019) (rho = 0.10). The first-difference correlation coefficient was negative (rho = −0.08) for the period between 2000 and 2010, suggesting that forest loss was unlikely driven by maize production in such period.

On the other hand, although Myanmar's corn production has been rapidly rising during the past decade, how much of this growth has been driven by Chinese demand or actually ended up in China is difficult to prove. This is because, in China, corn is included in the import quota system of crops to help maintain domestic food security. Thus, officially, China has established strict quality control and safety checks for imports of corn as a non-tariff trade barrier to prevent excessive amounts of foreign corn from entering the domestic market. As a result, the official statistics, especially those from China, may not accurately account for the actual inflow of maize and other products from Myanmar. However, because its domestic demand is so huge, as we can see from Figure 6, China has now become the world's largest importer of corn, and the size of its official import of corn shot up dramatically after 2010. Because of Myanmar's long and porous border with China, much of its corn thus ended up in China through smuggling and other illegal means [49]. Indeed, the scale of smuggling of corn is so widespread that it is common knowledge that the official statistics do not reflect the true scale of corn from Myanmar in the Chinese market.

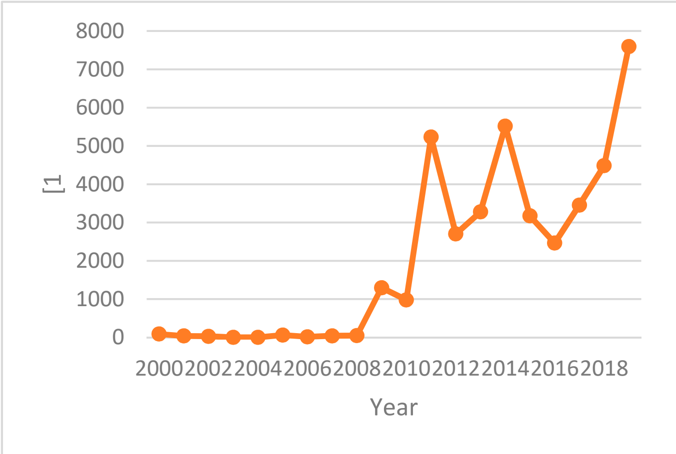

Figure 6. China's yearly import of corn, 2000–2019 [3].

3.2. *Deforestation Pattens at the Village Level*

Along the main road from Mandalay, the second-largest city in Myanmar, to Muse, a border city between Myanmar and China, which passes through Lashio, even a casual traveler would easily notice that the slow hilltops in this part of Northern Shan State are covered with rows and rows of maize. Given the hilly landscape, it was surprising that it was almost impossible to see large trees on the hill slopes around Lashio, having been replaced by the green crop throughout the year, except during harvest time. Because of its proximity to China, the areas around Lashio offer easy transport of maize produced for the Chinese market [50].

In order to understand the challenges faced by farmers as well as their decisions to enter, expand or contract maize plantations, we wanted to obtain first-hand information at the village level through interviews and focus group discussions. For this purpose, we carried out focused research with a total of five villages around Lashio in late 2019, with their locations marked on Figure 7.

Table 1 provides an overall description of the five villages and their agricultural practices during 2017–2019, with their names anonymized to be A–E. They are all located in the vicinity of Lashio and have different ethnic compositions, reflecting the general ethnic diversity and divisions within Shan State [51]. The 100 interviews we conducted were evenly distributed across the five villages. In general, there was an inverse relationship between rice and maize cultivation between 2017 and 2019, as many families had started to cultivate more rice instead of corn, perhaps reflecting an adjustment of the expectations about maize output, given the overall downward trend of the price of maize since 2015. In response, rice cultivation has been expanded and maize scaled back. Overall, however, there continues to be more acreage of maize than rice in the five villages.

As we can see from Figure 8 below, in the vicinities of the five villages, measured in buffers of 1000, 3000, and 5000 m, there have been substantial rates of deforestation in the 2000 to 2019 period. Village D witnessed the most substantial deforestation in the vicinity of its 1000-m buffer. It is also the village where the greatest amount of maize cultivation has taken place, with almost 70 percent of the forest within 1000 m of the village being lost, likely because of the need to clear land for maize expansion. We can also see that, when observing the changes from the 1000-m buffer to the 5000-m buffer, the closer the area to the village, the more forest that has been lost. Village A is an exception in this regard; this is likely attributed to its close proximity to Lashio city. Its 5000-m buffer encompassed much of the area adjacent to Lashio, which likely contributed to a large amount of deforestation within the 5000-m buffer. This indicates that villagers' agriculture activities have a more direct impact in the immediate vicinity of the villages.

Table 1. Profiles of the five villages and their agricultural activities.

Village Name	Household Number	Ethnicity	Rice Cultivation, 2017–2018 (in Acres)	Rice Cultivation, 2018–2019 (in Acres)	Maize Cultivation, 2017–2018 (in Acres)	Maize Cultivation, 2018–2019 (in Acres)	Deforestation Reasons
A	29	Lisu	2.5	28.5	78.5	27	Maize and firewood
B	22	Mixture of Kachin, Shan, and Bamar	9	12.5	143	48	Maize and charcoal
C	27	Mixture of Kachin and Chinese	3	8	135	130	Maize and charcoal
D	26	Palaung	59	61	480	469	Maize
E	22	Mixture of Lahu and Kachin	31	32.5	30.5	29.5	Maize and firewood

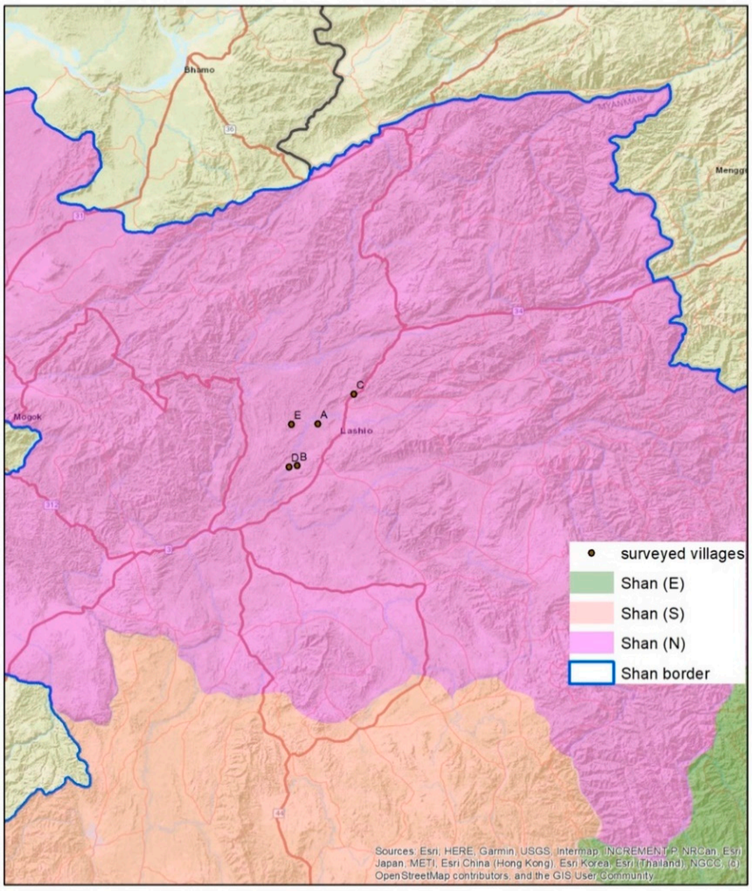

Figure 7. Locations of the five villages in Northern Shan State.

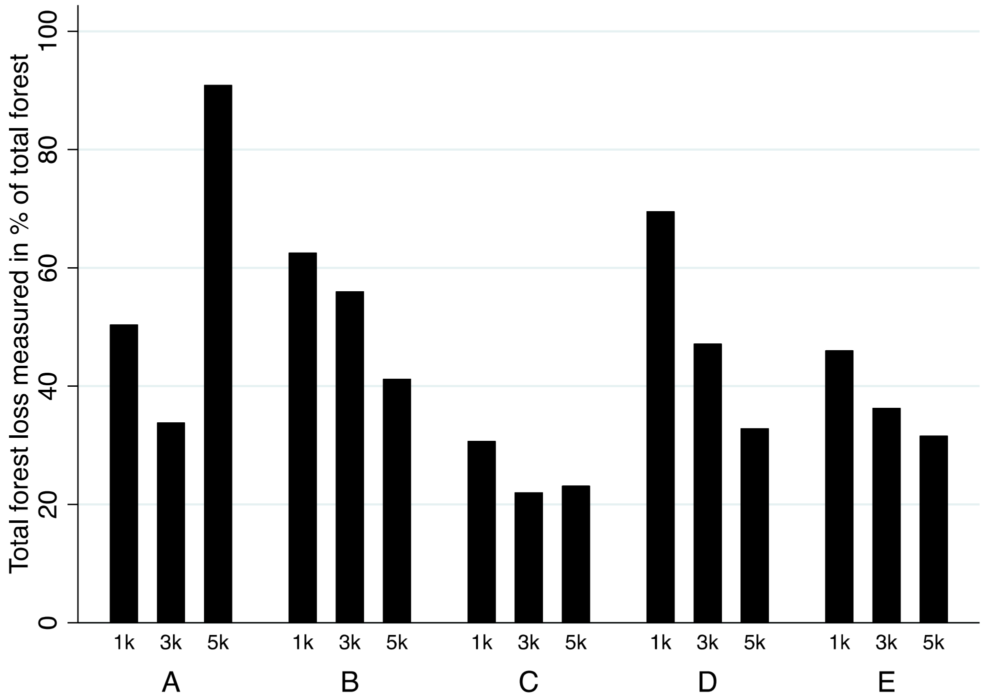

Figure 8. Deforestation rate around the five villages in 1000-, 3000-, and 5000-m buffers, 2000–2019.

At the same time, we can see that in the case of all five villages, there has been roughly two spikes in their deforestation rates during this period: one around 2003–2004 and another after 2010. In Village A, for the buffer of 1000 m, after an initial spike around 2003–2004, we can see that its deforestation rate peaked around 2013 and then had a second uptick around 2017. In Village B, for the buffer of 1000 m, the rate of deforestation surged in 2012 and then significantly declined. In Village C, for the buffer of 1000 m, a twin peak occurred between 2011–2013. For Villages D and E, for the buffer of 1000 m, it seems that the peak of their deforestation occurred much earlier, in the early 2000s, and that the second surge occurred around 2013, as was the case with the other villages (see Figures 9–13). Although not conclusive, it suggests an overall confirmation that the price shock around 2010–2012 was correlated with an accelerated pace of deforestation around the villages in the same period. Only after a few years, when the price of maize fluctuated and dropped from the peak, did they revise their deforestation practices in response to agricultural commodity market incentives. However, these changes only led to a graduated slowdown of the deforestation rate without reversing the direction of the changes in forest coverage overall. That is, after the forests had been cleared for agricultural production, the land would not be converted back to forests anymore, indicating a trend of permanent forest loss.

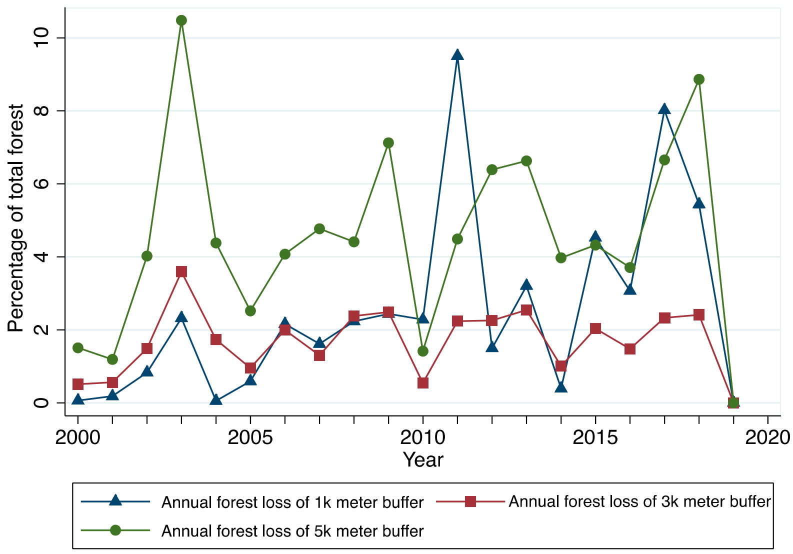

Figure 9. Yearly deforestation rate for Village A in 1000-, 3000-, and 5000-m buffers, 2000–2019.

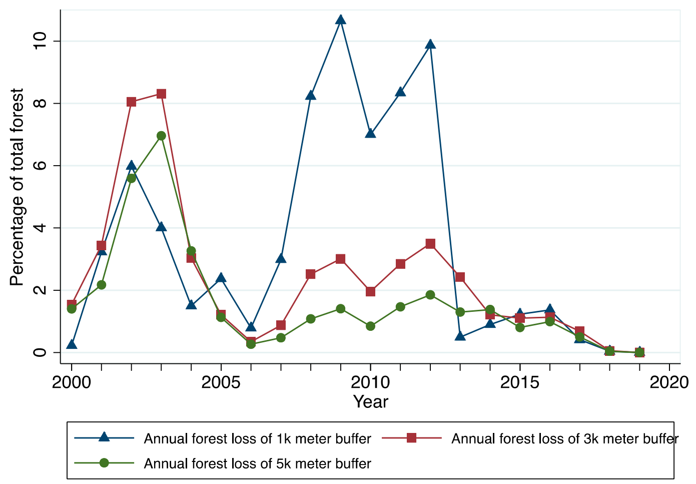

Figure 10. Yearly deforestation rate for Village B in 1000-, 3000-, and 5000-m buffers, 2000–2019.

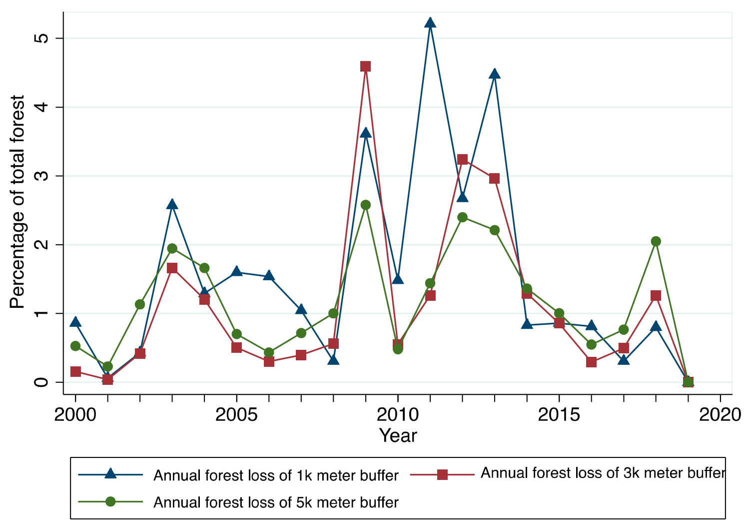

Figure 11. Yearly deforestation rate for Village C in 1000-, 3000-, and 5000-m buffers, 2000–2019.

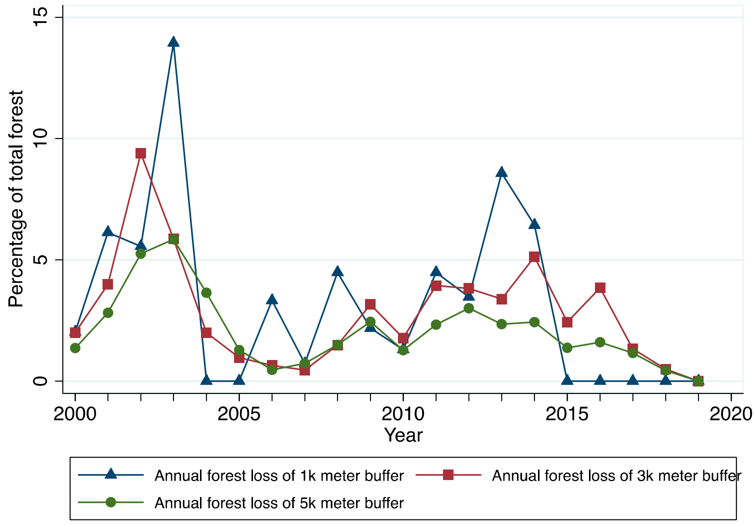

Figure 12. Yearly deforestation rate for Village D in 1000-, 3000-, and 5000-m buffers, 2000–2019.

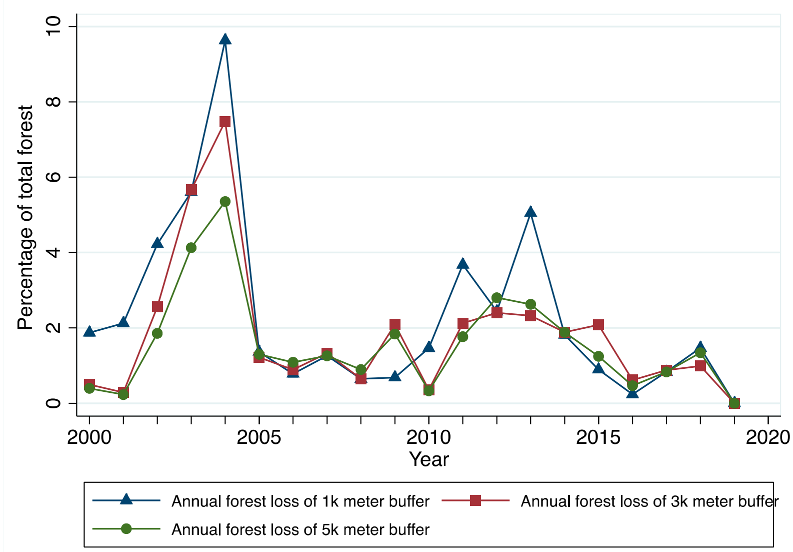

Figure 13. Yearly deforestation rate for Village E in 1000-, 3000-, and 5000-m buffers, 2000–2019.

4. Discussion

4.1. Maize Farming Practices in Northern Shan State

During our field research, we asked villagers what exactly happened during the past decade that affected their agricultural practices and what they thought the reasons were for the changes in forest coverage in the area. A general opinion across villagers was that they expanded maize cultivation because of the surge in price for maize and demand in China. For example, Sai, a man in his 40s who lives in Village B, told us the story of how maize cultivation started to expand in his village:

"All our corns are sold to China. A few years ago, the price for corn suddenly became very good, and everyone in the Lashio area started to cultivate maize. We usually buy this particular 818 brand of maize seed from the market, and they tend to grow quite well in our fields. Typically we can do three harvests of maize within one year, and the corn produced is all for the animal feed market but not for human consumption. At the time of harvest, purchasing agents in Lashio would go around to villages to buy the corn from us first, which they will later ship to China".

The 818 brand of maize seed is one of the popular high-yielding types of maize, and has been promoted by the Thai agri-business conglomerate Charoen Pokphand (CP) Group in Myanmar's Shan State for more than a decade [50]. As part of CP's regional animal feed market supply chain, much of the high-yielding maize produced in Shan State is destined for Chinese chicken farms where the CP group has a significant share of investment, instead of for food consumption within Myanmar. Since the demand in China for Myanmar's corn boomed, so did the popularity of CP's maize seed among farmers in Shan State, which came to nearly monopolize the variety of corn produced in the region. At the same time, reliance upon CP's maize seed has also directly led to debt issues among local village communities. For people who have become dependent upon loan brokers to purchase these seeds, they face financial difficulties during market price fluctuations as a result of global price changes [52].

4.2. The 2012 Vacant, Fallow, and Virgin Lands Management Law

When Chinese demand for corn was high while the selling price stayed strong, it was a natural choice for local farmers to start expanding their maize cultivation [53]. How more land would be accessed to expand cultivation became the main challenge. A piece of legislation that came out in 2012 in Myanmar indirectly facilitated this process. At that time, Myanmar's national parliament during the Thein Sein administration passed new legislation, the Vacant, Fallow, and Virgin (VFV) Lands Management Law, according to which citizens, private sector investors, government entities, and NGOs can apply to lease VFV lands for agriculture [54]. This was a significant legislative development because, in Myanmar, particularly in ethnic minority regions, there are many places where land rights are not clear and communal lands have been categorized as VFV, which then became subject to be eligible for agricultural expansion [55].

Indeed, during our fieldwork, we discovered that for most villagers the land where they cultivated maize was often leased. Even where they have their own plot of land, these are usually reserved for either rice or other vegetables for self-consumption. However, maize is often planted on hill slopes surrounding villages because such hill slopes are typically not categorized as forests but as VFV, and thus trees on these slopes can be cut. Maung, who is the head of Village A, told us how much land expansion occurred for maize cultivation:

"There is a limited supply of land within our village. Particularly the existing rice paddies have to be kept because we need the rice to survive. So when people started to look for space to expand the cultivation of maize, we would have to go to the previously bushy hillsides to clear this land. As maize is a quite tough plant, it can grow easily on hill slopes. They are also not as picky as rice, so we do not need to work on them very much. Most labors are only needed in the initial period of clearing the bushes and preparing the land for cultivation, as well as during the harvest period."

It is commonly acknowledged by villagers who cultivate maize that they have all engaged in activities that have led to the clearing of the hillsides around villages. In this part of Myanmar's Shan State, flat land for rice paddy cultivation has always been limited due to the rugged nature of the landscape. Thus, opening up the hillsides for agricultural cultivation, called *taungya* in Burmese, has been a familiar practice that local villagers have engaged in. The only difference is the scale of such practices in Northern Shan State during the past decade. People all realize how much of the forest along hill slopes has been cleared away, but for them this is inevitable; the monetary incentives from maize cultivation have been enough to make clearing these lands profitable.

4.3. Chinese Import Quota and Border Control

At least, that had been the assumption that led to the significant expansion of maize cultivation in the aftermath of the 2010–2012 global commodity price shock. At that time, profits from harvesting maize were quite handsome, and it was very easy to sell maize to purchasing agents for the Chinese market. After these corn crops were collected from the villagers, they would be shipped to the Chinese border and then redistributed into smaller portions and smuggled into China via the loose and long border. Given the huge demand for corn in China's domestic market, there were strong financial incentives on the part of these purchasing agents to bypass Chinese border inspection, which was not yet very stringent.

As we mentioned earlier, the Chinese government has tight import restrictions on corn. Because it is considered a national food security item, corn imports are subject to a yearly quota. For example, in 2020, the national import quota for corn is 7.2 million tons, of which 60% is earmarked for state-owned enterprises.[4] Obtaining import quota permission is not easy. However, even without the quota restriction, corn from Myanmar was not officially permitted to enter the Chinese market because of a lack of an agreement on disease inspection mechanisms between both governments.[5] This problem only generates discrepancies in export/import data between the two countries. Often the corn has been declared legally exported from Myanmar, for which the Myanmar customs office would make a record of, but the amount of corn would not show up in official Chinese import data on the Chinese side of border customs. Therefore, whether the corn from Myanmar can successfully enter the Chinese market ultimately depends on smuggling operations through the border and how tight Chinese border inspections are at a particular time.

Because the amount of corn from Myanmar produced in recent years has increased significantly, the amount that illegally entered the Chinese market has also grown accordingly. Chinese border patrols have increased their inspections on these smuggled corn crops in recent years, which has directly caused difficulties for local farmers in Northern Shan State to sell their harvest in time. Thus, although the smuggling of commodities along the Sino–Myanmar border has been going on for decades, periodic anti-smuggling campaigns by the Chinese state do inject occasional uncertainty for local farmers whose livelihood depends on easy access to the Chinese market [49]. During the COVID-19 pandemic, Myanmar's border with China has been restricted further, which has led to negative consequences for agricultural producers in the country [56].

5. Conclusions

As the most forested country in Southeast Asia, Myanmar's economic and political transition since the early 2010s has brought unprecedented economic development to the country. Indeed the past decade of economic openness has created opportunities for Myanmar to be integrated with regional commodity markets as a producer and supplier of agricultural products. As we have demonstrated in this paper, the global commodity price shock around 2011–2012 generated a ripple effect on Myanmar's maize production. However, a negative side effect of this expansion of maize plantations is the accelerated rate of deforestation as farmers clear away hill slopes to respond to increased incentives. This paper demonstrated, through a combination of remote sensing GIS analysis and on-the-ground field research observations and interviews, that a strong case can be made that the global commodity shock and easy access to the Chinese market, where demand has been rising, were the culprits of faster deforestation in Myanmar's Northern Shan State. At the same time, Myanmar's legal changes through the VFV law also indirectly facilitated this deforestation process. However, we also acknowledge that the expansion of maize plantations is only one of many factors, albeit a significant one, that has led to the accelerated deforestation in Northern Myanmar. Indeed, other studies have discussed the dynamics of deforestation in Myanmar within the broad political economy in the country, as part of the country's political opening and economic reform, together with the specific spatial mechanisms linking to its ceasefire and conflict patterns among various ethnic armed groups [52]

The COVID-19 pandemic and the subsequent closing of borders has, however, brought a halt to cross-border trade between the two countries. Worse still, the most recent military coup in February 2021 and the subsequent violence have generated further uncertainty for the country's future. What these major changes in the political and international context will mean for Myanmar's forests will require additional analysis. However, as this case demonstrates, as a result of China's growing appetite for agricultural products in Southeast

Asia, this will carry significant environmental imprints on forest resources throughout the region in the years to come.

The policy suggestions from our study indicate that for Myanmar, as well as other countries in Southeast Asia, governments need to be further aware of the environmental externalities that come together with further economic and trade integration with China. While understanding the economic incentives for the agricultural sectors to respond to the Chinese consumer market, they should also monitor how land-use practices could not lead to negative implications for forest coverage. Regional governments need to provide a clear mechanism with which to monitor changes in land use in rural areas and offer incentives for farmers to reforest where possible. Civil society organizations should also spend more effort in educating rural stakeholders to take on additional responsibility in their agricultural practices to make them more sustainable in the long run.

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Data Availability Statement: Our Myanmar forest change map between 1984 and 2019 can be accessed freely through Smithsonian's Figshare online data repository.

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Notes

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