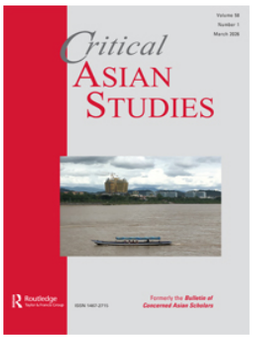

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Hidden Smoke: Air Pollution, Agrarian Change, and Governance Gaps in Luang Prabang, Laos

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ABSTRACT

Air pollution has emerged as a major public health and economic threat in Southeast Asia, yet Laos has received limited attention in scholarly and policy debates despite significant mortality and economic losses. This article analyses the drivers, lived experiences, and governance of air pollution in Luang Prabang, Laos' premier tourist destination and a UNESCO World Heritage city. Drawing on semi-structured interviews, field observations, and satellite data, our findings challenge dominant policy narratives that attribute haze primarily to traditional swidden cultivation. Instead, commercial agrarian change, particularly cassava expansion, grass cultivation, and cattle pasture expansion linked to regional and Chinese cattle demand and a prolonged urban landfill fire, drove air pollution in 2023. These sources stem from labor shortages, economic insecurity, poor urban waste planning, and a reliance on fire as a low-cost management tool. Despite significant health, livelihood, and tourism impacts, haze remains underappreciated and underfunded. Weak monitoring infrastructure, fragmented institutional responsibilities, and the absence of disaggregated health data render air pollution uncertain and socially normalized. The article argues that air pollution in Luang Prabang represents a form of slow violence, maintained by epistemic gaps and administrative silence within a development model that prioritizes expanded agriculture and tourism over environmental protection.

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Introduction

Air pollution has become the most severe environmental threat to human health worldwide. In 2025, 7.9 million premature deaths were attributed to air pollution, meaning it now kills more people annually than tobacco.[1] Air pollution is an acute problem in Southeast Asia, where it causes over 1.1 million premature deaths annually and costs US$ 432 billion.[2] Urban centers in particular suffer from smog. For example, Bangkok and Chiang Mai were among the world's top five most polluted cities at one point in 2023, with PM2.5 levels forty times higher than World Health Organization (WHO) guidelines.

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[1]Health Effects Institute 2025.
[2]Lim 2025.

Despite the severity of the problem and increased studies on this topic in several countries in the region,[3] Laos remains conspicuously absent from the literature, although air pollution is responsible for an estimated 8,000 premature deaths per year (approximately seventeen percent of all deaths) and has reduced the country's GDP by almost eight percent.[4] This figure includes both ambient and household air pollution exposure. These mortality and economic losses occur without any systematic monitoring, meaning that the true burden is likely underestimated. The Stockholm Environment Institute (SEI) states that "very little is known about the magnitude and sources" of Lao emissions and no emissions inventory existed before 2023.[5] No peer-reviewed studies so far have examined the drivers and governance of PM2.5 or NO_2 in any specific Lao city.

Luang Prabang, the country's premier tourist destination and a UNESCO World Heritage site, is an especially compelling case for investigating air pollution. Luang Prabang City relies heavily on tourism but it lies in an enclosed valley that makes it susceptible to pollutants becoming trapped. In addition, a recent Food and Agriculture Organization (FAO) report described northern Laos, which includes Luang Prabang province, as the country's "dominant fire zone" and identified 1,947 fires in the province between 2015 and 2021.[6] In March 2023, air pollution was particularly acute, with PM2.5 measured as high as 209 $\mu g/m^3$ (WHO guidelines are 15 $\mu g/m^3$). The haze that year led to schools being closed and tourists cancelling either their visits or outdoor activities in both Luang Prabang and neighboring provinces.

During our fieldwork at the end of 2023, we found that multiple development pathways have intersected to create this pollution problem. These include the expansion of cassava and maize cultivation, the growth of cattle herds linked to increased Chinese consumer demand for beef, forest fires, and chronic waste burning. These causes are driven by broader underlying political and economic trends, including accelerating commercialization of upland agriculture, labor shortages, weak regulatory enforcement, and a reliance on burning as a low-cost solution for land and waste management.

However, despite its significant harm, Luang Prabang's air pollution remains largely invisible as a public issue. The provincial environmental office owns only a single air-quality monitor which frequently does not function properly. Health departments do not maintain seasonally disaggregated respiratory illness data. Nor do national or provincial authorities possess the monitoring, modelling, or enforcement capacities found in neighboring countries. Provincial officials repeatedly asserted in interviews that resource constraints are stark. One stated that while Thailand combats haze with helicopters, "we don't even have a bicycle."

To address this gap, we present the first systematic, empirically grounded analysis of air pollution in Laos. We draw upon interviews with a wide range of actors, field observations conducted in 2023, and NO^2 satellite data to examine the production, experiences, and governance (or lack thereof) of air pollution in Luang Prabang. Based on our findings, we make three major arguments. First, Luang Prabang's air pollution is not primarily driven by swidden agricultural practices but by commercial agrarian changes and gaps in urban waste management. Second, weak institutional capacity

[3]Cf. Marks and Miller 2022; Rakholia et al. 2022; Tantengco and Guinto 2022; Varkkey et al. 2025.
[4]Sanchez-Triana 2021.
[5]Stockholm Environment Institute 2023.
[6]Tattaris et al. 2023. The report noted that 1,775 of these fires were in forests and 158 on agricultural land.

and the lack of monitoring systems render air pollution invisible, which hinders both wider public recognition of this issue and a sufficient policy response. Third, air pollution in Luang Prabang exemplifies a form of slow violence because it has become normalized, is poorly measured, and is structurally given insufficient priority even though it threatens the city's tourism industry.

To support our analysis, we first review relevant scholarship on air pollution in the region, agrarian change, tourism, risk perception, and slow violence. After describing our methods, we discuss the drivers, governance, and risk perception of Luang Prabang's air pollution. We then place our findings within broader discussions on agrarian change, Laos' governance capacity, and contradictions in Laos' development trajectory. We conclude by noting the policy implications for addressing air pollution and future research directions.

Literature review

The literature on air pollution in Southeast Asia has burgeoned in recent years, with growing scholarship on seasonal haze and the drivers of PM2.5 in countries such as Indonesia, Malaysia, Thailand, Vietnam, and the Philippines.[7] Researchers who focus on Thailand have found that air pollution worsens during the dry season, particularly in Northern Thailand, when an inversion weather effect combines with increased forest fires and agricultural burning.[8] In Bangkok, the three largest sources of PM2.5 are transportation, industry, and agricultural burning. So far, the Thai government has failed to address this problem due to regulatory and governance gaps. Consequently, Thailand's haze kills over 30,000 people per year and hurts tourism livelihoods, particularly in Chiang Mai, where tourism is central to the local economy.[9] Estimates by academics indicate that from 2020 to 2025 air pollution reduced Thailand's total gross domestic product by six percent.[10]

Research on the Philippines shows that fragmented governance structures, weak regulatory enforcement, and limited monitoring capacity hinder efforts to tackle persistent air pollution.[11] In Vietnam, rapid urban expansion, rising motorization, and shifting land use patterns have reshaped what P.D. Hien and colleagues (2020) call the "pollution landscape" and exacerbated air pollution in major cities such as Hanoi and Ho Chi Minh City. Further, scholarship on the politicization of haze in maritime Southeast Asia shows that elite-driven narratives have normalized seasonal smoke by portraying it as routine or unavoidable, obscuring the central roles of commodity-oriented agricultural burning and weak state regulation. This normalization also helps maintain the notion of haze as simply seasonal, which diffuses responsibility and leaves the structural political economic drivers of haze in countries such as Indonesia and Malaysia unchallenged.[12] These regional patterns of economic interests overriding public health, governance fragmentation preventing coordination, and political

[7]Hien et al. 2020; Marks and Miller 2022; Tantengco and Guinto 2022; Varkkey et al. 2025.
[8]Mostafanezhad and Evrard 2021.
[9]Marks and Miller 2022; Mostafanezhad 2020.
[10]Root 2025.
[11]Tantengco and Guinto 2022.
[12]Varkkey et al. 2025.

narratives obscuring responsibility offer a useful lens for understanding similar processes in understudied countries such as Laos.

A small body of literature helpfully conceptualizes haze as a form of slow violence in which harms accumulate gradually out of sight over time.[13] Danny Marks and Michelle Ann Miller (2022) illustrate air pollution's hidden and long-term consequences, including on farmers in northern Thailand who are increasingly forced to leave their homes due to deteriorating environmental conditions or to access medical treatment. Rini Astuti (2021) has shown that recurring haze in Indonesia stems from structural governance failures that allow pulp and palm oil plantations on peatland to keep using practices that make fires unavoidable. She also highlights the key role of corporate impunity and weak regulatory oversight in perpetuating these practices. Overall, using a political ecology framework, these scholars have found that marginalized populations in the region have disproportionately suffered from haze, whereas state and corporate actors have benefited from pollution-generating activities. This situation illustrates the creation of a "relational resource frontier"[14] where the Lao state facilitates ecological degradation through agricultural expansion to meet the demands of Thai and Chinese capitalists and business interests within Laos.

Despite similar geographical and economic conditions to its neighbors, such as mountainous regions, high socioeconomic inequality, and a large agricultural sector, Laos thus far has remained largely absent from peer-reviewed research on air pollution, albeit with some exceptions. For example, Kerrie Mengersen and her colleagues have investigated how house design in Laos was linked to indoor air quality problems, and pointed out that women and children are especially vulnerable to low indoor air quality.[15] Zhangwen Su and his colleagues used remote sensing to investigate the links between forest burning and air pollution in Laos, pointing to how climate change could lead to more drought and increased forest fires in the country, thus increasing air quality problems.[16] Connie O'Neil and her collaborators recently published a national scale review of air pollution issues in Laos, emphasizing that key sources of pollution vary depending on the part of the country.[17] Finally, Cameron Allen and colleagues recently published the results of a participatory modelling project in Vientiane, the country's capital, in relation to air pollution, but did not examine the drivers of haze.[18]

Several scholars have discussed a recent maize boom in the Lao uplands,[19] which has certainly contributed to haze in Northern and Northeast Laos. However, none directly address haze as a central concern. Existing references to Laos appear mostly in media reports[20] or donor assessments[21] rather than scholarly work. The lack of monitoring infrastructure and health surveillance data limits academic research and Laos' visibility in regional air pollution debates. This scant research also obscures the environmental challenges facing northern Lao provinces, where satellite imagery and media reporting

[13]Nixon 2011.
[14]Barney 2009.
[15]Mengersen et al. 2011a; 2011b.
[16]Su et al. 2022.
[17]O'Neill et al. 2024.
[18]Allen et al. 2025.
[19]Cf. Belton and Fang 2022; Cole 2022; Castella and Phaipasith 2021.
[20]Cf. Bounviseth 2020; Xinhua 2023.
[21]World Bank 2023.

indicate frequent burning, extensive fire hotspots, and hazardous AQI levels.[22] Examining Laos therefore offers an opportunity to examine whether the political-economic patterns identified elsewhere in the region operate similarly in a place with even weaker institutional capacity and less public visibility.

Understanding air pollution in mainland Southeast Asia requires examining the economic and land use changes transforming rural landscapes. Burning biomass, which is used for shifting cultivation, residue management, and land clearing, continues to be a major cause of seasonal haze. When smoke is trapped by dry-season atmospheric inversions in Thailand, Laos, Vietnam, and southern China, fire activity peaks between February and April.[23] A key driver of burning has been the commercialization of upland agriculture. Hybrid maize cultivation for livestock feed markets expanded rapidly across the region over the past few decades. Between 1993 and 2018, Vietnam, Myanmar, and Laos saw increases in maize production of 452 percent, 885 percent, and 1,961 percent, respectively.[24] The maize boom has been shaped by growing regional demand for meat and animal feed, especially from China and Vietnam.[25] This boom has been facilitated by Thai conglomerates such as Charoen Pokphand (CP), the world's largest animal feed producer. Corporations such as this have promoted industrial contract feed schemes in Myanmar and Laos and pushed the Thai government to incentivize increased feed production.[26] Requiring extensive land clearing and contributing to forest encroachment, these cultivation systems not only degrade local air quality through the burning of biomass (including crop residues, fallow vegetation, and primary forest) but also cause significant carbon emissions.[27] While causing environmental degradation, maize cultivation has lifted the incomes of many highland populations, although trapping some in incessant debt cycles.[28]

More recently, cassava has replaced maize as a high-value cash crop in many Lao provinces due to increased demand from Thailand, Vietnam and China for MSG, tapioca flour, and bioethanol.[29] Cassava's high profit margin has led to rapid expansion into upland forest areas, facilitated by shifting cultivation and open burning. Farmers frequently cultivate cassava on newly cleared land to maximize yields, which accelerates deforestation.[30] An additional source of pollution is waste burning. Further, household biomass for cooking also remains widespread and is the leading cause of both indoor and outdoor PM2.5 exposure. Household air pollution is the number one risk factor for premature mortality in Laos.[31]

These pollution drivers intersect with tourism in ways that generate sharp economic contradictions. Tourism economies depend on clean air, visibility, and outdoor mobility, yet development strategies that prioritize agricultural expansion and land conversion undermine these environmental goods. A 2021 study from Thailand shows that PM2.5

[22] *Laotian Times* 2023a.
[23] Reddington et al. 2021.
[24] Belton and Fang 2022.
[25] Jakobsen and Hansen 2020.
[26] Woods 2015; Marks and Miller 2022.
[27] Thol et al. 2022.
[28] Blake et al. 2019.
[29] *Laotian Times* 2023a.
[30] The World Bank 2023.
[31] Sanchez-Triana 2021.

has significant adverse effects on tourism flows: a five percent rise in PM2.5 reduces monthly tourist arrivals by 106,060 in Chiang Mai and 659,368 in Bangkok during the hot season months of April and May.[32] Small- and medium-sized enterprises in the accommodation, travel, and retail sectors in Chiang Mai are particularly vulnerable to haze disruptions.[33] A study of Singapore's 2015 severe haze episode similarly found losses in tourism and reduced business activity in the wider economy due to declining tourist receipts.[34]

The literature therefore reveals a broader paradox: the development pathways that national and provincial governments promote to stimulate rural incomes through commercial agriculture, forest conversion, and land commodification produce pollution levels that undermine tourism, one of the most important economic sectors in many Southeast Asian countries. This paradox therefore requires examining both governance capacity and the ways in which various actors perceive and respond to pollution risks.

Persistent contradictory development policies raise a key question: despite obvious harm, why does chronic air pollution often fail to elicit strong political or public responses in countries with chronic haze? Paul Slovic (2002) contends that because people lack clear causal chains, vivid cues, or effective public communication, they frequently underestimate slow-moving and invisible risks, such as air pollution and road safety.[35] In places with minimal environmental education or state-led risk messaging, swathes of the public perceive haze as familiar or harmless rather than dangerous. This is particularly evident in parts of the Mekong region where a long-standing reliance on burning biomass for agricultural and cooking purposes has normalized exposure and reduced perceptions of danger.[36] For tourism-dependent communities, this perceptual gap can be particularly costly. If local actors consider seasonal smoke to be normal or inevitable, they may fail to attribute economic losses to air quality when haze drives away visitors and revenue.

These perceptual tendencies align with scholarship that conceptualizes air pollution as a form of slow violence, where harm accumulates gradually and without dramatic events that would typically trigger policy responses.[37] The concept of slow violence was coined by Rob Nixon (2011) to describe long-term, gradual environmental harms that disproportionately affect the poor and marginalized and often escape public attention because their effects are less dramatic and conspicuous than those of catastrophic hazards. This framework helps explain how risk misperception and gradual harm operate concurrently. The incremental nature of health and livelihood impacts makes them politically invisible, thereby reinforcing societal tendencies to downplay the seriousness of haze.

Weak institutional capacity compounds these perceptual barriers. In Laos and parts of mainland Southeast Asia, environmental agencies face several constraints, including intergovernmental fragmentation, limited budgets, inadequate staffing and technical capacity, and a lack of emissions monitoring systems capable of generating credible

[32]Namcome and Tansuchat 2021.
[33]Srinamphon et al. 2022.
[34]Quah et al. 2021.
[35]Davies 2018; Marks and Connell 2024.
[36]Rehfuess et al. 2013.
[37]Marks and Miller 2022; Mostafanezhad and Dressler 2021.

data.[38] The enforcement of regulations is often reactive and complaint-driven since regulators lack the resources and information needed for routine oversight.[39] National strategies often articulate broad ambitions but rarely quantify expected air-quality improvements due to absent emissions inventories and monitoring infrastructure or meet these ambitions in practice. This data scarcity results in residents having little information about PM2.5 levels, further exacerbating risk misperception.[40]

Donor priorities further reinforce these gaps. International development partners typically direct funding towards climate change mitigation and adaptation or rapid onset disasters but provide limited support for addressing air pollution.[41] Between 2015 and 2021, a minuscule one percent of international development funding (US $17.3 billion) and two percent of international public climate finance (US$11.6 billion) was devoted to reducing it.[42] These governance and financial shortcomings create a feedback loop: scarce data leads to low perceived urgency, which discourages investment and perpetuates data scarcity, limited public pressure, and institutional neglect.

The reviewed literature reveals interconnected relationships. Land-use changes driven by agricultural commercialization generate air pollution that undermines tourism economies, while risk misperception and governance fragmentation prevent effective responses despite mounting evidence of harm. By applying these perspectives to the largely understudied context of northern Laos, we extend regional scholarship on this topic and provide new insights into the country's environmental, social and political-economic dimensions of haze.

Methods

We conducted fieldwork in Vientiane and northern Laos in December 2023. In northern Laos, we spent one week in Luang Prabang Province (Figure 1) and Xayaboury Province. Burning in Xayaboury is particularly relevant to Luang Prabang since the two provinces are adjacent and share the same airshed.

The city of Luang Prabang, located in northern Laos, is a UNESCO World Heritage site celebrated for its historically important and well-preserved architecture, Buddhist temples, and rich cultural traditions. It has a population of approximately 60,000 and is as an important center for tourism, government administration, and regional trade. The city's unique cultural and historical significance means it is particularly sensitive to environmental challenges, including air pollution from agricultural burning in surrounding areas, which can affect public health and tourism.

We interviewed provincial officials and farmers in the city of Luang Prabang and in the upland areas of Phonexay and Nan districts. While in Xayaboury, which has experienced rapid expansion of cassava planting, we focused on meeting with local farmers and officials in the provincial capital (Xayaboury town) and Xayaboury and Phiang districts, areas of intensive agriculture. In Vientiane, we spent a week speaking with government officials, NGO representatives, and representatives of donor agencies. In total, we

[38]Sanchez-Triana 2021; Marks and Lebel 2016.
[39]Jefferson et al. 2020.
[40]Marks and Miller 2022.
[41]Kelman 2020.
[42]Cullinan 2023.

Figure 1. Map of Luang Prabang Province.

interviewed thirty-three respondents: eleven government officials (six local/provincial and five national), eight farmers (of Hmong, Khmu, and Lao ethnicities), eight representatives from NGOs and international organizations, four professionals from the tourism industry, one grass seed company representative, and one medical doctor.

Interviews were semi-structured and focused on sources of haze, local agricultural practices, perceptions of air pollution, and governance challenges. Interview guides were structured around four key themes: agricultural land-use changes and burning practices; perceived health, livelihood, and tourism impacts of haze; attribution of responsibility for air pollution; and institutional responses and governance capacity. We mostly conducted our interviews in Lao. The few interviews which we conducted in English were with foreigners living in Laos.

We also collected and mapped satellite NO^2 data for the years between 2019 to 2024 to measure the severity of air pollution in Northern Laos. The absence of reliable monitoring infrastructure in Luang Prabang constrained our ability to directly verify pollution levels.

Findings

Comparing the month of April for the years 2019 to 2024, air pollution was worst in 2023. NO^2 data obtained from Sentinel-5P TROPOMI via Google Earth Engine confirmed this (Figure 2). This same data confirmed that air pollution was worst that year in March and April, the months when agricultural burning is the most pervasive (Appendix 1). Media reports also confirm that 2023 was a particularly bad year for

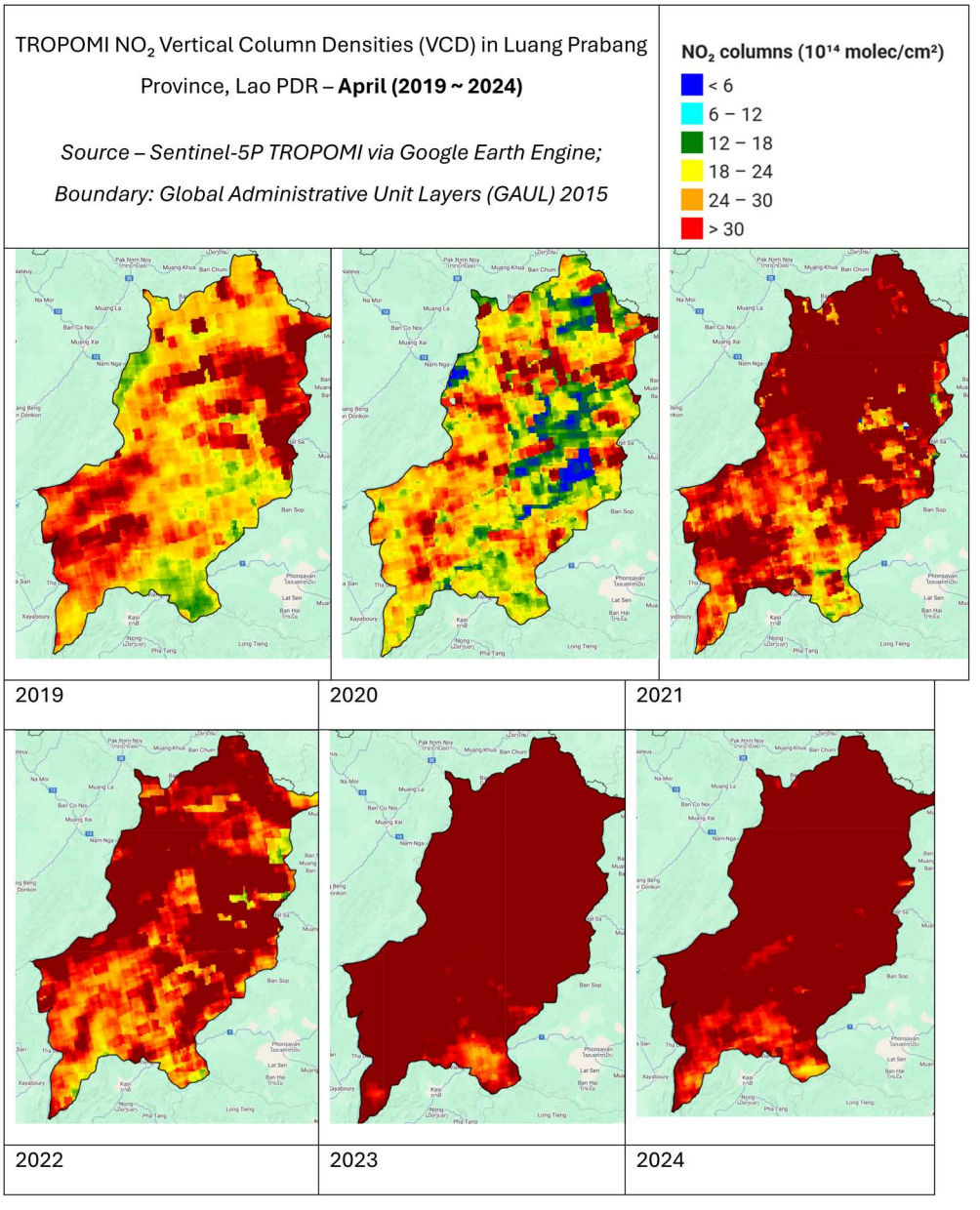

Figure 2. NO^2 data in Luang Prabang Province from 2019-2024

dry-season air quality in Laos,[43] including in Luang Prabang.[44] The NO^2 data presented are the best measure of air pollution levels, as TROPOMI is able to evenly cover the whole landscape and can also be averaged over the whole month of April, which is important for a place with very little ground data collection capacity. We could have provided hot spot data to indicate where fires had occurred, but it would not have been feasible to have provided such data over a whole month in a way that would have been visually meaningful, and hot spot data do not indicate the scales of different fires. NO^2 data is also an excellent proxy for PM2.5 data. Therefore, we chose to use TROPOMI NO^2 data to illustrate changes in air quality. The downside of TROPOMI is, however, that it only started operating in 2017.

Producing haze in Luang Prabang: agricultural burning, land clearing, and waste disposal

Across all our interviews, respondents consistently identified open burning and forest fires as the primary drivers of haze in Luang Prabang, particularly during the dry season. While fire has long been part of upland livelihoods, interviewees stressed that the scale, spatial extent, and commercial rationale of burning have changed, producing more severe and hazardous haze. National level studies confirm that vegetation fires, primarily forest fires and agricultural burning, are the primary source of PM2.5 emissions in Laos, particularly in northern provinces during the dry season.[45]

Farmers were clear that contemporary burning differs from earlier swidden practices. A Hmong farmer in Luang Prabang explained, "burning for shifting cultivation to grow rice has decreased. There is less swidden burning, but more forest fires now." Another stated that current burning is "not like swidden" and that forests are now "very dry" and increasingly degraded, which allows fires to spread more easily. Satellite fire datasets corroborate these accounts. They show that Luang Prabang Province records the highest number of fire hotspots nationally with the majority occurring in forests and cropland rather than traditional swidden fields.[46]

Farmers described burning as a necessary and routine practice. As one farmer said, "for agriculture, we burn to clear the land. There is no other way." Another noted that residues are burned because "we don't have machines and there is not enough labor to do it differently." Indeed, low levels of mechanization and limited access to residue management alternatives have been identified as structural constraints in Lao agriculture.[47] This issue is particularly evident in remote upland areas, such as much of Luang Prabang Province, where mechanized machinery is not easily accessible due to rough terrain and a lack of road infrastructure.

Reflecting the rapid expansion of export-oriented cash cropping into upland and forest areas, cassava cultivation has emerged as the most frequently cited agricultural driver of land clearing and burning, particularly before prices dropped in 2024 and 2025. Officials, researchers, and civil society organizations (CSOs) have described how cassava cultivation rapidly expanded into upland and forest areas, particularly between

[43]Meadley 2023; *The* Star 2023; *Laotian Times* 2023b; Xinhua 2023.
[44]Visapra 2023; Delgado and Siviero 2023; *Vientiane Times* 2023.
[45]Sanchez-Triana 2021; Stockholm Environment Institute 2023.
[46]Tattaris et al. 2023.
[47]The World Bank 2023.

2021 and 2023. National statistics and donor assessments reveal that cassava, driven by demand from Thailand, Vietnam, and China, has become one of Laos' fastest growing export crops.[48] During our fieldwork in 2023, a senior Ministry of Natural Resources and Environment (MONRE) official stated: "cassava is expanding very fast now. Farmers clear new land because old land gives low yields." Another official from the same ministry was more direct: "this year we need more area to grow cassava, that's why they destroy the forest." An international NGO official described cassava as "the name of the game now" in northern provinces. Interviewees explained that cassava plots are often cultivated for only a few years before being abandoned, which encourages repeated cycles of clearing and burning. In addition, several respondents directly linked cassava expansion to short term economic pressures. An international organization official declared that cassava is "bringing prosperity to rural areas" but also stated that it is "a significant challenge" because land conversion is occurring rapidly and often beyond the state's awareness. Other interviewees emphasized that cassava's cash crop nature makes it especially attractive during periods of inflation and currency depreciation, even as it accelerates land degradation and burning.

This pattern was especially pronounced in Phiang district in Xayaboury Province. Interviewees there reported widespread cassava expansion into both fields and surrounding hillsides. Several farmers explained that maize cultivation has largely been replaced by cassava, with one stating, "Last year we stopped corn, now only cassava." Respondents emphasized that expansion accelerated sharply in 2023, requiring more clearing and burning. Maize burning was described as less prominent than in previous decades but still present. Farmers explained that maize has declined in importance relative to cassava and cattle. A farmer in Luang Prabang said, "Before we burned more for maize, but now maize is less important." Nevertheless, interviewees concurred that remaining maize cultivation still contributes to seasonal smoke through residue burning. Other researchers have found that maize expansion in northern Laos still contributes to deforestation and fire use, although its relative importance has declined in recent years.[49]

Cattle raising and the growing of *ruzi* grass to feed the cattle have emerged as growing drivers of fire use and thus haze. Phonexay district and Luang Prabang provincial officials reported large and rising export volumes, with over 4,000 cattle exported from Muang Phonexay in Luang Prabang Province in 2023, much of this destined for China. One ethnic Khmu farmer whom we interviewed laughed in amusement when we asked him if he would have guessed many years earlier that he would be focused on cultivating grasses, since in the past farmers were mainly interested in suppressing grasses. He admitted that his income mainly came from cultivating grass rather than conducting traditional swidden cultivation, as he had done in the past.

One might wonder how cattle production contributes to increased air pollution. The key is pasture creation, which is done to provide grazing areas for cattle and, in some areas, to cultivate grass to produce grass seed for export to Thailand. Both government officials and farmers explained that pasture creation depends on burning. According to one Hmong farmer in Luang Prabang, "Before I burned one or two hectares a year [for swidden cultivation], now [this year] I burn six hectares [to expand pastures for raising

[48]*Laotian Times* 2023a; The World Bank 2023.
[49]Greenpeace Southeast Asia 2020; Bhandari 2023.

cattle].” The Hmong farmer further explained that he was able to expand his pasture area for raising cattle by purchasing fallow swidden land from ethnic Khmu farmers, who tend to be less oriented to commercial agriculture compared to most Hmong farmers. He was then able to clear and burn this fallow area to convert it into pasture. Other respondents explained that while maintaining existing pasture produces limited smoke, new pastureland produces heavy smoke, particularly during very dry years. Interviewees estimated that 40,000 to 50,000 hectares of grass pasture now exist in parts of Luang Prabang Province, especially in the mountainous Phonexay district, reflecting rapid conversion of former fallow and forest.

Cattle raising was repeatedly described as attractive because it requires less labor than cropping. A district planning official explained, “Cattle raising uses less labor, so villagers raise a lot of cattle now.” Household examples illustrated severe land pressure, with farmers grazing large herds on insufficient land. Although burning of pasture was formally restricted in 2023, interviewees widely doubted the efficacy of enforcement efforts, particularly in upland areas.

Rising demand from China was repeatedly cited as a key driver of cattle expansion. A third Hmong farmer in Luang Prabang proclaimed, “As long as Chinese demand beef, more and more Hmong will raise cattle.” He also explained that Hmong people in Luang Prabang have not only increased their cattle raising, but some have also become more involved as middlemen, buying cattle from other farmers and selling them to large trading companies. Recent policy initiatives have encouraged the expansion of livestock raising and trading in northern Laos. In addition, a bilateral agreement between Laos and China has set an annual export quota of 500,000 head of cattle, while efforts by the Lao Ministry of Agriculture and Forestry (MAF) to scale up cattle production in northern provinces has incentivized farmers to expand their pasture land.[50] The Lao Government also has received support from the FAO to expand cattle exports to China.[51] In addition, several interviewees emphasized that cattle now function as savings in an unstable economy. A former NGO official focusing on rural livelihoods explained, “cattle is the primary form of savings for farmers. With the currency going down, cows are an easy way to store value.”

In addition to agricultural sources, our respondents consistently identified waste burning as a significant but under-regulated contributor to haze, including in and around Luang Prabang City, despite government calls to improve urban waste management, including reducing air pollution[52] and transboundary haze in the region.[53] Respondents described municipal waste collection as irregular or absent in many areas, leaving households little option but to burn rubbish. One official declared: “People burn waste because there is no collection or the collection is not regular.” Another interviewee added, “plastic, food waste, everything is burned, especially outside the city center.” Several informants emphasized that waste burning occurs year-round, creating a constant background of smoke even outside peak agricultural burning periods. National waste assessments confirm that open dumping and burning

[50] *China Daily* 2021. Although Laos was only hoping to export 50,000 cattle in 2022 (Pongkhao 2021), the Lao government has been urging a dramatic increase in the production of cattle for export so as to meet the demand in China (*Xinhua* 2021).
[51] Putri 2023.
[52] *Vientiane Times* 2025.
[53] Meadley 2023.

remain the dominant waste disposal practices in Laos.[54] Interviewees in Luang Prabang, including one government official, reported that in 2023, a landfill fire continued for over a month, and included toxic cans and aerosols, which made it very difficult extinguish. This incident points to the role of poor solid waste management in increased air pollution. In addition, it illustrates that sometimes acts of individuals or small groups of people can often cause considerable damage.[55]

Overall, our respondents rejected the idea that haze is primarily caused by traditional swidden. While swidden cultivation is undoubtedly contributing to air pollution, they attributed the contemporary increase in haze to commercial agriculture (which has replaced some swidden cultivation), livestock expansion, and weak urban waste management (see Table 1). As an NGO official observer asserted: "It's not shifting cultivation like before. It's business now." This finding echoes a broader critique of policy discourse in Laos which has blamed swidden cultivation while underemphasizing the environmental impacts of commercial cash crop agricultural expansion.[56] For example, Chen et al. (2023) reported that the amount of shifting cultivation occurring in Laos had increased substantially between 2015 and 2020 compared to earlier periods, but without mentioning that this increase was almost certainly not due to traditional swidden cultivation of rice, but instead to an increase in maize cultivation as a cash crop during this period.

Agrarian transition, fire use, and changing rural livelihoods

Beyond identifying immediate sources of air pollution, our interviewees revealed how broader agrarian transitions shape fire use and haze production. Farmers and officials alike emphasized that burning persists not because of cultural inertia, but because economic restructuring and labor shortages, as well as geographical difficulties, leave few viable alternatives. Research in Laos illustrates this, showing that market integration, such as contract farming schemes, and export-oriented farming have shaped land use decisions and narrowed farmers' options.[57]

Labor shortages were frequently cited. One farmer explained: "There is no labor, so burning is the easiest way." Other farmers agreed, saying that without burning, they cannot prepare land quickly enough to meet planting schedules or market demand. As one declared, "If we don't burn, we cannot plant on time." This lack of labor has been exacerbated by the Lao economic crisis, which has driven a boom of outmigration to Thailand.[58]

Interviewees characterized cattle raising as both a livelihood strategy and a response to economic instability. Several described cattle as a form of savings in the context of inflation and currency depreciation, both problems that have been plaguing Laos in recent years.[59] This financial logic has spurred land clearing and burning for pasture expansion. Sarah Martin and Kai Lorenzen (2016) found that rural Lao households with higher wealth

[54]Sanchez-Triana 2021.
[55]Interviewees indicated that the fire was likely started deliberately by one man, reportedly in response to a grievance with the local government. The same individual may also have been responsible for setting forest fires in the area, although details remain unclear.
[56]Fox et al. 2009.
[57]Cole 2022.
[58]Barney and Souksakoun 2021.
[59]Barney and Souksakoun 2021.

Table 1: Drivers of air pollution in Luang Prabang

Driver	Economic Rationale	Pollution Impact
Cassava	Driven by demand from Thailand, Vietnam, and China for animal feed, MSG and bioethanol.	Rapid expansion into forests; repeated clearing/burning due to soil depletion
Cattle, ruzi grass & pasture	Acts as 'savings' against currency depreciation; high demand from China.	Initial expansion requires heavy burning to create grass pasture
Maize	Traditional regional demand for animal feed.	Residue burning remains a contributor, although its relative dominance is declining
Urban Waste	Result of irregular municipal collection	Year-round background smoke from plastics and food waste

and asset diversity are more likely to pursue diversified livelihood strategies which commonly include livestock rearing combined with other economic activities.

Many farmers we interviewed emphasized that they attempt to manage fire responsibly, describing how they time burns carefully and create fire breaks. However, these practices are increasingly overwhelmed by larger scale land use change and climatic variability. An NGO official explained, "Normally Hmong are good at managing fires, but this year there were many fires out of control." Climate variability and longer dry seasons, such as in 2023, increase fire risks across northern Laos.[60] Our findings show that fire use results from a set of economic pressures and policy incentives which constrain farmers' choices, instead of resistance to regulation or persistence of past practices.

Normalization, tourism, and the lived experience of low-risk perception

Interview data demonstrate that haze linked to cassava and cattle expansion has become normalized in everyday life. Many respondents told us they expected smoke during the dry season and rarely associated it with serious health risks, with one interviewee saying that villagers are "not worried about health" even when burning intensifies. The economic benefits of cassava and cattle were described as outweighing concerns about smoke. This suggests that haze is accepted as a necessary cost of livelihood security. This perspective was especially evident in areas such as Phonexay, where interviewees emphasized that farmers prioritize agricultural over air quality. Long-term exposure to indoor smoke has also likely contributed to this normalization, diminishing perceptions of cumulative health risks.[61] Many interviewees described smoke as something people have learned to live with. One farmer remarked that "people wear masks, but they are not really worried." Others explained they expected haze annually, and it rarely triggers behavioral change beyond minor adaptations. This aligns with risk perception research, which shows that familiar and recurrent hazards are often perceived as less dangerous even when they pose serious health risks.[62] Several interviewees stated that people rarely connect respiratory symptoms to air pollution. One provincial Health Department official confirmed that "there are no data on sickness related to air pollution," resulting in pollution being an abstract rather than embodied health risk.

Tourism further shapes risk perception and the governance of haze. Some respondents suggested that openly acknowledging haze linked to agriculture is complicating Luang

[60]Tattaris et al. 2023.
[61]Cf. Sclar and Saikawa 2019.
[62]Slovic 2002.

Prabang city's image as a clean heritage destination. Officials and residents described a general reluctance to foreground air pollution in tourism-related discussions, particularly during the peak visitor season between November and February. Several officials acknowledged that no assessment has been conducted of tourism losses from haze, despite tourist arrivals exceeding 2.3 million locally and over five million for the entire country and generating US$ 1 billion in 2024 and some news reports indicating that tourists have cancelled visits to Luang Prabang due to air quality concerns.[63] As a result, the economic implications of air pollution for tourism remain largely unexamined.

Our interviewees also indicated tensions between urbanites who rely on tourism for their livelihoods and rural residents who depend on agricultural production. which often produces smoke. Rural interviewees stressed the necessity of continuing cultivation. One stated simply: "We're living here," implying that farming must persist even if it causes additional smoke. In contrast, interviewees in the tourism industry were concerned that declining air quality would deter visitors, one asserting, "I don't want tourists to leave due to air pollution." Officials also acknowledged that tourism authorities are largely absent from air pollution governance. One MONRE official in Vientiane told us that the Ministry of Information, Culture, and Tourism is "not really working on this issue." Civil society actors interpret this absence as a reflection of broader development priorities. An NGO employee argued that raising concerns about air pollution is often perceived as conflicting with investment objectives, contending that "investors don't care about air quality." Thus, air pollution has so far remained institutionally marginal even as the health and environmental costs accumulate.

A comparable phenomenon has occurred in other tourist-dependent cities in the region. In Chiang Mai and Bangkok, officials have expressed concern about the potential economic consequences of formally acknowledging haze. Therefore, in 2025, they decided not to declare the cities national disaster zones during severe PM2.5 episodes.[64] In Chiang Mai, tensions have also emerged between local people, both farmers and wild mushroom collectors, and government officials and residents involved with tourism.[65] These cases suggest that in tourism-dependent places, the state governs air pollution through strategic silence and limited engagement instead of explicit denial. This silence enables environmental risks to persist without meaningful political intervention.

Governing haze and producing uncertainty: data gaps, fragmented authority, and risk perception

A final key finding from our interviews is that weak governance does not only limit the state's ability to address haze but also shapes how air pollution risks are understood by both officials and the public. Government interviewees concurred that the lack of reliable monitoring data produces uncertainty about air pollution sources, severity, and health impacts. This consequently hinders political prioritisation of the issue.

MONRE officials we spoke with acknowledged that air quality monitoring infrastructure is limited and unreliable. A few interviewees noted that PM2.5 stations frequently malfunction or remain offline for long periods. As one official stated, "sometimes the

[63]Ngotsyoudom 2025a; Ngotsyoudom 2025b.
[64]*The Nation* 2025.
[65]Lodge 2023; Mostafanezhad et al. 2025.

machine [government bureaucracy] works, sometimes it doesn't." Another added that even when data are collected, they are rarely used for policymaking because "we don't have enough information to explain where the pollution comes from." A national-level official admitted that air pollution data are only collected annually, thereby limiting the government's ability to respond to seasonal spikes.

This lack of source attribution strongly influences risk perceptions within the government. Pollution control officers repeatedly expressed uncertainty about the relative contribution of agriculture, transport, and industry. For example, one MONRE official admitted, "We are not sure where PM2.5 comes from. Maybe agriculture, transport, industry. We don't know specifically." The lack of accurate information on the sources makes it more difficult to govern this risk, and so far the Lao government and international donors have not invested sufficient resources into increasing air quality data collection.

Health data gaps further weaken the governance of haze as a public health problem. Officials confirmed that respiratory illness data are not seasonally disaggregated and are rarely linked to air pollution. One interviewee asserted: "We don't have data to show that people are sick because of air pollution." This reflects the limited healthcare funding available in Laos, and the fact that air pollution has not been given much attention so far within the healthcare sector, due to both the government and international donors not prioritizing this issue.

Institutional fragmentation compounds these challenges. While MONRE is responsible for pollution control, agricultural expansion is promoted by the Ministry of Agriculture and Forestry (MAF), and tourism by the Ministry of Information, Culture, and Tourism. Interviewees described weak coordination across these agencies. One official stated: "MAF focuses on cassava production, not pollution from cassava." As a result, pollution risks produced in one sector are not fully recognized or addressed in another. Vertical fragmentation also exists.[66] At the provincial level, enforcement is largely reactive and symbolic. Annual orders banning burning are issued at the national level but local officials acknowledged that they lack the resources to enforce them or offer alternatives. A Luang Prabang provincial officer admitted, "We tell people not to burn, but we cannot give them another option." Similar enforcement gaps have been found across the wider environmental sector in Laos.[67] Regulation is often complaint-driven rather than proactive.[68]

These findings show that weak institutional capacity does more than constrain state action. It produces uncertainty, obscures responsibility, and lowers the political priority of air pollution, thereby enabling chronic haze to persist without a sufficient policy response.

Discussion

Overall, our findings show that development pathways that prioritize agrarian commercialization—while rendering environmental harm politically marginal—produce air pollution in northern Laos. Additionally, our results challenge Lao policy narratives that portray haze as primarily a byproduct of traditional swidden cultivation.[69] Instead,

[66]Dwyer 2022.
[67]Wayakone et al. 2013.
[68]UNEP 2022.
[69]Fox et al. 2009.

burning ought to largely be viewed as a developmentally embedded practice influenced by labor scarcity, market integration, and agricultural incentives focused on exports. Fire often serves as a cost-cutting technology that enables farmers to respond to unstable economic conditions, such as a weak economy, and meet shortened planting schedules.[70] This point supports political ecology arguments that limited choice, not cultural or individual preferences, shapes environmentally harmful practices.[71]

Inadequate air-quality monitoring in Laos is not merely a technical limitation, but also a form of epistemic violence. Pollution becomes politically ambiguous and administratively deferrable when it cannot be accurately measured, attributed, or publicly communicated. Because it allows for institutional inaction, fragmentation, and delay, uncertainty becomes a governing condition.[72] Studies on risk perception demonstrate that invisible and poorly measured risks are less likely to generate political urgency or maintained public pressure.[73]

Institutional fragmentation further exacerbates this invisibility. The siloed responsibilities across ministries promoting agriculture, tourism, and environmental protection reveal deep-seated inconsistencies in Laos' development model where economic growth is consistently prioritized over environmental protection. Rather than resulting from coordination failures, this fragmentation is symptomatic of a system designed to shield pollution-producing sectors from environmental accountability. Consequently, the state governs air pollution through administrative silence, deferral, and symbolic regulation, rather than through any transformative interventions.[74]

Tourism sharpens these contradictions. Publicly highlighting haze risks in a heritage city like Luang Prabang may have negative economic effects, such as tourism reservation cancellations, shorter stays, and harm to the city's reputation as a peaceful and clean UNESCO destination. Indeed, in March 2023, hotel operators in Luang Prabang reported that some foreign tourists had cancelled plans to visit or shortened their stays explicitly due to air pollution problems.[75] These potential adverse effects incentivize strategic silence, whereby air pollution is not denied or addressed but is instead marginalized in tourism governance.[76] Conceptualizing haze as a form of slow violence helps explain this marginalization. While the economic benefits of tourism and commodity-driven growth remain immediate, visible, and politically prioritized, the health effects, productivity losses, and environmental degradation accumulate gradually and unevenly.

When Laos is situated in a regional perspective, commonalities and unique challenges become apparent. Thailand, Myanmar, and Vietnam also experience seasonal haze arising from forest conversion and agricultural burning.[77] However, because of its inadequate monitoring infrastructure, poor involvement in transboundary air pollution initiatives, and lack of presence in scholarly and policy discussions, Laos has a marginal position in regional haze governance. This marginality enables pollution produced in Laos to remained unaccounted for even when it contributes to broader regional haze

[70]Mostafanezhad and Evrard 2021.
[71]Astuti 2021; Marks and Miller 2022.
[72]Mostafanezhad et al. 2024.
[73]Slovic 2002; Marks and Connell 2024.
[74]McElwee 2025.
[75]Visapra 2023; Delgado and Siviero 2023.
[76]Mostafanezhad et al. 2024.
[77]Greenpeace 2023.

episodes. Therefore, addressing air pollution in mainland Southeast Asia requires greater attention to lower-capacity states, where pollution is produced but hardly measured, politicised, or effectively governed.

Conclusion

This article has provided the first comprehensive analysis of air pollution in northern Laos, with a focus on Luang Prabang and Xayaboury Provinces. It demonstrates that, rather than traditional subsistence practices, commercial agrarian change, waste burning, and governance gaps are the main causes of the current haze in northern Laos. Burning persists not because of cultural preferences but due to structural political-economic limitations ingrained in the nation's development trajectory, such as labor shortages, economic volatility, and policy incentives that prioritise agricultural expansion.

Concurrently, ongoing uncertainty exists about the sources of pollution and their effects due to inadequate monitoring systems and a lack of disaggregated health data. This uncertainty makes it more difficult to implement policy, erodes accountability, and helps normalize haze as a quotidian aspect of life. Therefore, low-risk perception is not just personal or cultural. Rather, it is socially and politically produced by a lack of data and public communication and by the state's development priorities which privilege heritage branding and tourism over environmental and public health.

This study has policy ramifications that transcend public awareness campaigns or prohibitions on seasonal burning. Long-term investments in emissions inventories, health surveillance systems, and air quality monitoring infrastructure are necessary for effective mitigation, as is improved coordination between environmental, agricultural, and tourism authorities. In the absence of these foundations, regulatory actions are likely to remain symbolic and reactive. It is also important to acknowledge that farmers' use of fire for clearing fields does not reflect an opposition to regulations, but limited options. Therefore, if mitigation efforts are to support rural livelihoods rather than worsen preexisting inequities, they must provide viable alternatives for waste management and agricultural production. Moreover, as our findings suggest, an approach that does not blame but instead enables dialogue between urban and rural communities, tourism actors, and state institutions is required. Finally, the scale of the challenge in a low-capacity, highly mountainous setting makes long-term international financial and technical support, particularly for monitoring, health surveillance, and waste management infrastructure, urgently needed.

In a broader sense, this study illustrates the importance of investigating air pollution in states with lower capacity, where environmental damage is poorly monitored and depoliticized, and where international aid donors have tended to underprioritize air pollution because the issue often acts in ways that fit Rob Nixon's notion of slow violence. Without paying more attention to the ways in which development strategies, institutional arrangements, and risk perception interact to produce pollution in locations that are largely invisible in regional governance frameworks, efforts to address transboundary haze in mainland Southeast Asia are likely to remain largely unsuccessful. Understanding these drivers, and the nuanced ways they play out in different contexts, is necessary for designing more inclusive, just, and successful strategies to reduce air pollution throughout the region and beyond.

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Appendix 1: NO_2 monthly average levels in 2023