

Trends in Wildfire Dynamics in Ghana's Transition Zone: Evidence from Dormaa and Atebubu-Amantin Districts.

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abstract

Wildfires are major ecological and socio-economic concern in Ghana, especially within the Transition Zone where forest and savanna ecosystems converge. While fire plays a natural role in maintaining ecological balance, it can also be a threat to biodiversity, soil fertility, and rural livelihoods when it is intense. This study investigates the trends, drivers, community preparedness and coping strategies associated with wildfires in the Dormaa and Atebubu-Amantin Districts of Ghana's Transition Zone. Using a mixed-methods approach, data were collected through household surveys ($n = 165$), institutional records, and key informant interviews. Descriptive statistics, chi-square tests, and binary logistic regression were employed to analyze the quantitative data, while qualitative responses were thematically analyzed. Findings reveal a general decline in wildfire incidences over the past decade, corroborated by both community perceptions and institutional records. Declines were largely attributed to sensitization campaigns, adoption of improved farming practices, expansion of cash-crop systems, and the work of fire volunteer units. Despite this progress, anthropogenic activities such as land clearing, hunting, smoking, and grazing alongside environmental stressors like prolonged dry seasons and high temperatures remain key drivers of wildfire occurrence. Community preparedness was moderate, with high awareness of preventive measures but limited access to firefighting equipment and resources. The coping strategies varied across districts, ranging from communal patrols and firebreaks to shifts from annual to perennial crops. The study concludes that effective wildfire reduction requires an integrated approach that combines community-based fire management, institutional capacity building, and climate-sensitive policy interventions, which can support Ghana's forest restoration and climate adaptation agendas.

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Introduction

Forest fires, also referred to as wildfires, bushfires, grassfires, or vegetation fires depending on the type of vegetation that is involved (Amissah et al., 2011), represent a natural disturbance that has shaped ecosystems for centuries. They play key roles in maintaining forest ecosystems by recycling nutrients, promoting flowering and seed germination, and enhancing the sprouting of fresh browse (Appiah et al., 2010; Pausas and Keeley, 2021). Fires can also reduce fuel loads and maintain species composition and structure in fire-tolerant and fire-resistant ecosystems (Dwumoh et al., 2013). When properly managed, fire can contribute positively to ecological processes and biodiversity conservation (Dahan and Kasei, 2022).

Uncontrolled wildfires worldwide have wide-ranging environmental, economic, and social impacts, including biodiversity loss, soil erosion, deforestation, damage to infrastructure, displacement, and human casualties (Richardson et al., 2022). In Europe, about 17,000 people died in 2009 alone and these deaths were attributable to wildfire-related events (Bowman et al., 2020). In the United States, the economic costs of wildfire damages exceeded 70 billion USD in 2016, in addition to fatalities and long-term health impacts (Keeley & Syphard, 2018). Similarly, Australia's 2019–2020 bushfires burned more than 18 million hectares, leaving devastating ecological and socio-economic consequences (Filkov et al., 2020).

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In Africa, wildfires are recurrent in savanna and transition zones, often linked to farming practices, hunting, and land clearing. Such fires alter vegetation composition, accelerate land degradation, and contribute to greenhouse gas emissions (Chidumayo, 2013). In Ghana, wildfires have become increasingly problematic, especially in the forest–savanna transition zone, where both ecological and livelihood vulnerabilities intersect (Amissah et al., 2011). While wildfires can maintain fire-adapted systems, studies reveal that in Ghana they frequently lead to forest degradation and deforestation as they damage timber resources, degrade soils, and destroy biological diversity (Kosoe et al., 2015).

Evidence suggests that wildfires are modifying the structure and composition of natural forests in Ghana at rates that far exceed those caused by mechanical thinning or prescribed fire (Barnes et al., 2017; Dwumoh et al., 2019). This poses significant challenges to forest landscape restoration (FLR) efforts. For instance, between 2015 and 2017, the Ankasa Forest Reserve and neighboring areas experienced repeated wildfire outbreaks, while since 2018, large sections of reserves such as Abonyere and Bonsampepo in the high forest zone have burned, alongside worsening conditions in the savanna zone (Asante et al., n.d.). These events highlight the inextricable link between FLR and fire management in Ghana. Without integrating effective fire management systems, restoration efforts risk being undermined, especially in transitional and drier northern zones (Kumi et al., 2024).

Several studies have explored the causes, impacts, and management of wildfires. For instance, Kraha and Njume (2020) investigated community-

based fire management strategies, emphasizing the role of local participation. Dahan et al. (2023) applied remote sensing techniques to analyze wildfire trends, while Kosoe et al. (2015) assessed community involvement in fire management and sustainable forestry practices. Despite this growing body of research, much of the scholarship has tended to concentrate either on ecological consequences (Santín & Doerr, 2016) or climate–fire linkages (Jones et al., 2020; Richardson et al., 2022).

In Ghana, however, there is limited empirical work on the temporal trends of wildfire occurrence and the extent of community preparedness and coping strategies in the forest–savanna transition zone (Amissah et al., 2010; Asori and Appiah, 2021). This gap is critical given that communities are both primary victims and essential actors in the management of wildfire risks. This study integrates both community perspectives and institutional data to reveal shifting patterns of wildfire occurrence, moving beyond earlier works like Amissah et al. (2011) that focused on role of wildfires in shaping farming systems in Ghana’s transition zone, and Kosoe et al. (2015), who highlighted the challenges of community participation in managing forest fires in degraded reserves. This integrative approach reveals how changes in governance, livelihoods, and community behavior interact with institutional interventions to shape declining wildfire incidences. It therefore addresses how and why wildfire trends are changing, and how communities and institutions jointly influence fire outcomes in Ghana’s transition zone. Through linking these insights to broader governance debates, the study advances discussions on wildfire management in Ghana and provides lessons applicable to other fire-prone regions globally.

Against this backdrop, the current study investigates the trends and occurrence of forest fires in the Dormaa and Atebusu-Amantin Districts of Ghana’s

Transition Zone which have been increasingly affected by wildfires in recent decades (Kosoe et al., 2015). These fires not only disrupt ecological balance but also threaten the livelihoods of communities reliant on forest resources (Amissah et al., 2011). Specifically, the study aims to: (i) analyze temporal trends of wildfire occurrence over the past decade (2015 - 2024); (ii) identify key anthropogenic and environmental drivers of fire incidence; and (iii) evaluate community preparedness and coping strategies for managing and mitigating wildfire risks. By addressing these objectives, the study fills key gaps in Ghana’s wildfire research and provides evidence to inform fire policy, strengthen community-based fire management, and support sustainable forest landscape restoration.

Methodology

The Study Area

The study was conducted in six communities across the Dormaa and Atebusu-Amantin Districts, both located within Ghana’s forest–savannah transition zone. These communities were purposively selected due to the high prevalence of wildfires in the area (Amissah et al., 2011; Appiah et al., 2010), as well as their proximity to forest reserves and active agricultural landscapes where human–fire interactions are most pronounced. In the Dormaa District, the selected communities were Twumkrom, Abonsrankrom, and Taforo. These areas have historically experienced recurrent wildfire incidents, making them particularly suitable for examining the drivers of fire occurrence, prevention practices, and the effectiveness of governance interventions.

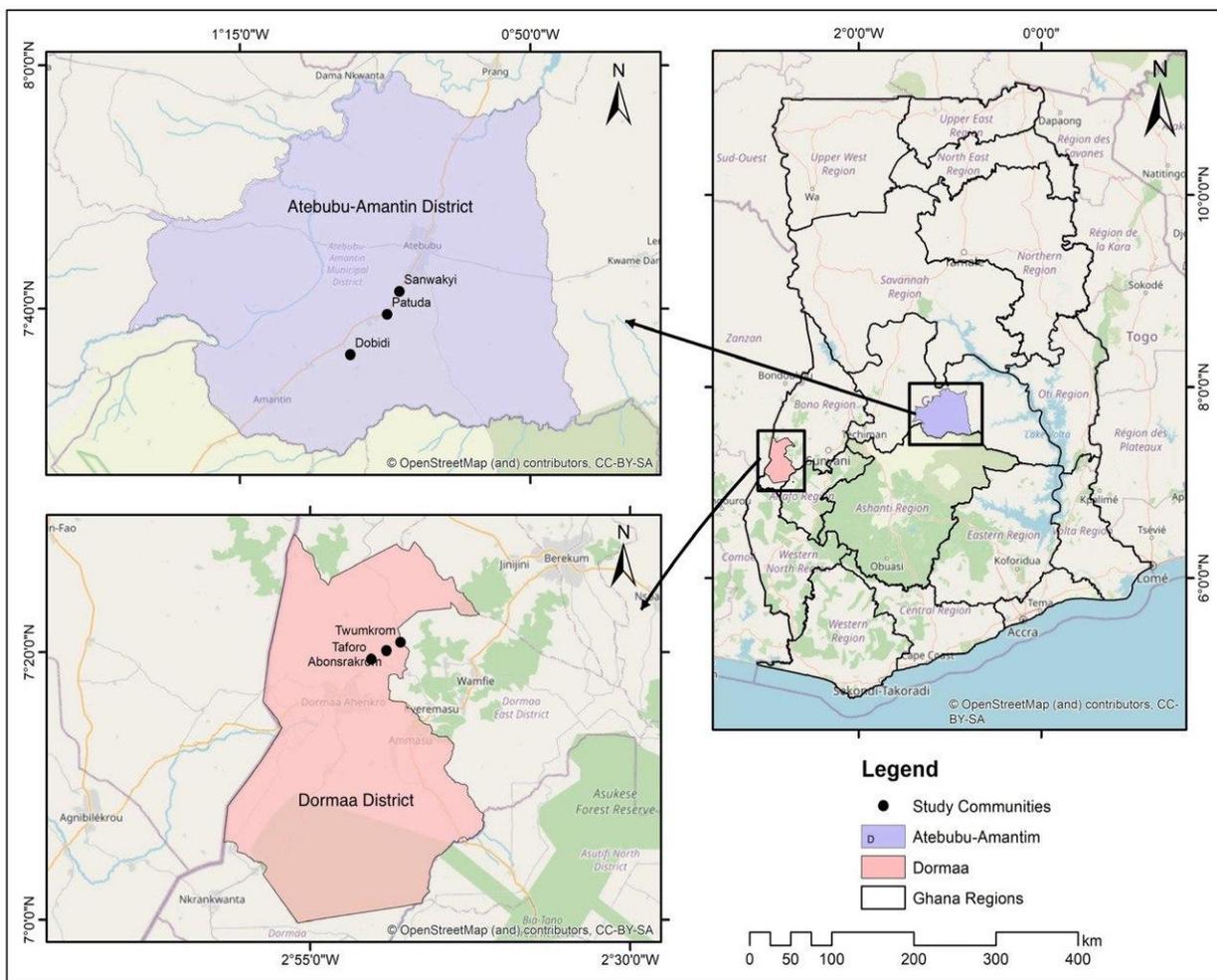


Figure 1: Map of the study area showing the Dormaa and Atebusu districts

Dormaa District is one of the 260 MMDAs in Ghana and one of twelve districts in the Bono Region (Amankwaa, 2021). Located in the western part of the region, it has Dormaa Ahenkro as the municipal capital and lies between latitudes 7°25'–7°80'N and longitudes 2°35'–2°48'W. The district is bordered by Dormaa Municipal, Berekum Municipal, Sunyani West, Asunafo North, and Asutifi Districts (Damoah-Afari et al., 2023). According to the 2021 Population and Housing Census, the district has a population of 154,209 (GSS, 2021). The study communities are situated along the fringes of the Pamu Berekum Forest Reserve, where agriculture dominates local livelihoods, with major crops including plantain, maize, and cassava, and limited cultivation of yam and pepper.

In the Atebubu-Amantin District, the study communities were Dobidi Nkwanta, Sanwakyi, and Patuda. The district, located within the Bono East Region, lies in the forest–savannah transition zone and is characterized by annual rainfall ranging between 1,400 and 1,800 mm. It covers an estimated land area of 2,605 square kilometers and according to the 2021 census, has a population of 144,947 (GSS, 2021). Although the area is wooded, tree cover is relatively sparse compared to the dry semi-deciduous forest zone (Asori and Appiah, 2021). It is one of eleven districts in the Bono East Region. It was formerly part of the larger Atebubu District until the northern portion was carved out in 2003 to create Pru District. The remaining section was renamed Atebubu-Amantin District and was elevated to a Municipal Assembly in 2018. It shares boundaries with Pru West to the north, Sene West to the east, Kintampo South and Nkoranza North to the south, and Ejura-Sekyedumasi Municipality with Sekyere East and West to the southwest, with Atebubu as the municipal capital (GSS, 2021). It lies within the interior wooded savanna, where deforestation, charcoal production, and recurrent bushfires have transformed much of the original forest into savanna vegetation. Soils range from fine sandy to clayey loams and are generally poorly drained. Agriculture employs about 70% of the population, with crops such as cassava, vegetables, cashew, cotton, and tobacco, while charcoal production remains an important secondary livelihood shaping land use and fire regimes (MoFA, 2025).

Climate and Vegetation

The study areas lie within Ghana's forest–savannah transition zone, which is characterized by a unimodal rainfall regime. Rainfall is highly seasonal, occurring mainly between April and October, followed by a pronounced dry season from November to March, during which the Harmattan winds intensify fire risks. Mean annual temperatures range between 24°C and 32°C, creating warm conditions that, when combined with prolonged dry spells, contribute to high wildfire susceptibility (Amissah et al., 2011).

Vegetation in the zone is a mosaic of forest and savanna species, reflecting both climatic conditions and human disturbance. While remnants of dry semi-deciduous forest are still present, much of the area has been degraded into wooded savanna due to repeated burning, agricultural expansion, and charcoal production. Common vegetation types include tall grasses such as *Andropogon gayanus* and *Hyparrhenia spp.*, interspersed with fire-tolerant tree species like *Vitellaria paradoxa (shea)*, *Terminalia spp.*, and *Daniellia oliveri*. The mix of combustible grasses and scattered trees show the ecological fragility of the transition zone and the heightened risk of recurrent wildfires (Asori and Appiah, 2021).

Research Design

A research design serves as the blueprint for conducting a study, providing a structured plan that guides data collection, analysis, and interpretation in alignment with the stated objectives (Bloomfield & Fisher, 2019). It ensures that the research problem is addressed systematically, enhancing the validity, reliability, and relevance of the findings. This study adopted a mixed-method design, integrating both quantitative and qualitative approaches. The use of mixed methods is important in exploring complex research issues, as it allows the combination of numerical data with contextual insights derived from respondents' experiences and perspectives (Creswell & Creswell, 2017). Through the incorporation of multiple forms of evidence, the approach facilitated data triangulation, thereby strengthening the accuracy and robustness of the results.

Data Collection Approach

Primary data were collected through face-to-face interviews using structured questionnaires and interview guides. The questionnaires administered to community members were structured to capture the socio-demographic characteristics, temporal trends of forest fire occurrence, key anthropogenic and environmental drivers and community preparedness and coping strategies for managing and mitigating wildfire risks. Purposive sampling was employed to select community members who had resided in the area for more than 10 years, ensuring the inclusion of individuals with relevant knowledge and direct experience of wildfire incidents. These individuals were identified with the assistance of community leaders and elders, who helped to select long-term residents with known experience of wildfire events within each community. Three key informants were interviewed from the Forestry Commission, NADMO, and GNFS. Specifically, we selected senior officers and district-level field officers who are directly involved in wildfire management, along with two traditional leaders from each study community. These informants were selected based on their roles, experience, and direct involvement in fire prevention, response, and local governance. Secondary data from institutional reports, records, and literature supplemented the primary dataset, offering historical and policy context.

The sample size was determined using the Cochran formula for sample size calculation in large populations (Cochran, 1977) to ensure reliable and valid results. The formula used is presented below as:

$$n_z = \frac{Z^2 \times p \times (1-p)}{e^2} \\ = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.08^2} = 151$$

where:

n_z is the sample size,

Z is the Z-value (1.96 for 95% confidence level),

p is the estimated proportion of an attribute that is present in the population (0.5)

e is the desired level of precision (margin of error) which is set at 0.08 (8%).

The estimated sample size was 151 participants. However, a total of 165 respondents were surveyed to account for potential non-responses and incomplete questionnaires, and to improve the robustness and representativeness of the dataset.

Data Analysis

The quantitative data collected through questionnaires was organized and processed using Microsoft Excel and analyzed using the Statistical Package for Social Sciences (SPSS) version 27. Descriptive statistics such as frequencies, percentages, and means were employed to summarize and present community responses on wildfire causes, preparedness, and coping strategies. Chi-square tests were conducted to examine associations between demographic variables (e.g., gender, age, education, and residential status) and coping strategies. In addition, logistic regression analysis was applied to identify the socio-demographic factors that predict the likelihood of being affected by wildfire. For the qualitative data, thematic analysis was used to analyze the responses from interviews and open-ended questionnaire items. Data were transcribed, coded, and grouped into themes and were then interpreted to provide further insights into the quantitative findings and to capture the community and institutional dynamics in wildfire management

Results

Demographic information of the respondents

The study involved 165 respondents across the selected communities, with males constituting a slightly higher proportion (52.7%) than females (47.3%). Most respondents were aged 36–45 years (32.7%), followed by those aged 26–35 years (27.9%). In terms of education, 30.9% had completed Junior High School and 27.3% reporting no formal education. Farming was the dominant occupation (43.0%), while 24.2% engaged in other livelihoods. The majority of respondents were natives (60.0%), with migrants accounting for 40.0%.

Table.1: Socio- demographic characteristics of respondents (N=165)

Variable	Category	Number of respondents	Percentage (%)
Community	Twumkrom	22	13.3
	Abonsrankrom	19	11.5
	Taforo	31	18.8
	Dobidi Nkwanta	36	21.8
	Sanwakyi	34	20.6
	Patuda	23	13.9
Gender	Male	87	52.7
	Female	78	47.3
Age	18–25 years	25	15.2
	26–35 years	46	27.9
	36–45 years	54	32.7
	46–60 years	28	17.0
	61 years and above	12	7.3
Educational Level	Primary	25	15.2
	JHS	51	30.9
	SHS	26	15.8
	Tertiary	18	10.9
	None	45	27.3

Variable	Category	Number of respondents	Percentage (%)
Occupation	Farmer	71	43.0
	Student	26	15.8
	Unemployed	28	17.0
	Other careers	40	24.2
Residential Status	Native	99	60.0
	Migrant	66	40.0

Community-Level Experiences of Wildfire Incidences

The results showed that wildfire exposure was a common phenomenon across all the six communities under study with most of the affected respondents reporting incidents within the past ten years. Wildfires were predominantly experienced on farmlands, often resulting from fires spreading from surrounding vegetation into cultivated areas. About 67.3% of respondents reported being affected by wildfires, while 32.7% indicated no direct experience. Sanwakyi (73.5%) and Abonsrankrom (78.9%) recorded the highest proportions of affected respondents, followed by Taforo and Dobidi Nkwanta (both 64.5%). Patuda showed the lowest reported impact, with just over half of respondents (52.2%) indicating wildfire experience, and 47.8% reporting none (Figure 2).

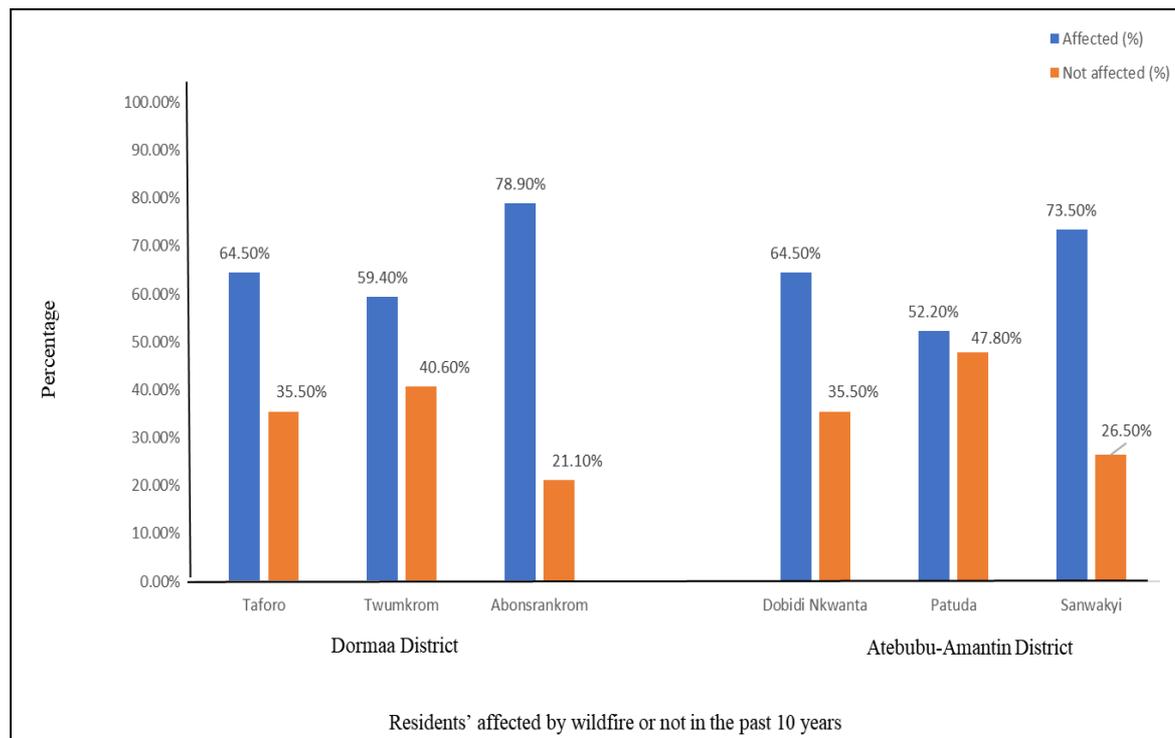


Figure 2: Residents' affected by wildfire or not in the past decade

Binary Logistic Regression Analysis of Socio-demographic Predictors of Wildfire Experience

A binary logistic regression analysis was conducted to identify the socio-demographic factors that significantly predict the likelihood of being affected by wildfire. The variables included in the model were gender, age, and residential status. The model results (Table 2) indicate that gender (B = 0.510, p = 0.048, Exp(B) = 1.67) and age (B = 0.830, p = 0.045, Exp(B) = 2.11) were significant predictors of wildfire experience. This suggests that the odds of reporting being affected were 1.67 times higher for males than for females, while older respondents (>35 years) had more than twice the odds of being affected compared to younger age groups (≤35 years). Conversely, residential status (B = 0.220, p = 0.247, Exp(B) = 1.15) did not significantly predict wildfire impact.

Reported Months of Wildfire Occurrence

The results indicate that wildfire incidents are concentrated in the dry season months, with the highest proportions occurring in December (23.0%), January

(19.4%), February (17.0%), and November (15.8%). The month of March recorded a moderate level of fires (5.5%), while the period from April to October showed relatively low frequencies (2.4%–3.0%) (figure 3).

Communities’ perspectives on observed changes in the number of wildfire incidences over the past ten years

Results from community perspectives show that wildfire incidences are generally seen to have declined over the past ten years across both Dormaa and Atebubu-Amantin Districts. In Dormaa, the proportion of respondents who believed wildfire cases had decreased significantly ranged from 61.5% in Abonsrankrom to 68.0% in Taforo, with smaller proportions indicating that incidences had either remained the same (12.0–17.2%) or decreased slightly (20.0–23.1%). Similarly, in Atebubu-Amantin, between 58.6% (Patuda) and 63.0% (Dobidi Nkwanta) of the respondents reported a significant decrease in wildfire occurrence, while 13.8–16.1% perceived no change and about 22–28% reported a slight decrease in number (figure 4).

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	Gender	.510	.210	5.900	1	.048	1.670
	Age	.830	.230	13.080	1	.045	2.110
	Residential Status	.220	.190	1.340	1	.247	1.150
	Constant	-1.080	.310	12.110	1	.000	.340

a. Variable(s) entered on step 1: Gender, Age, Residential Status

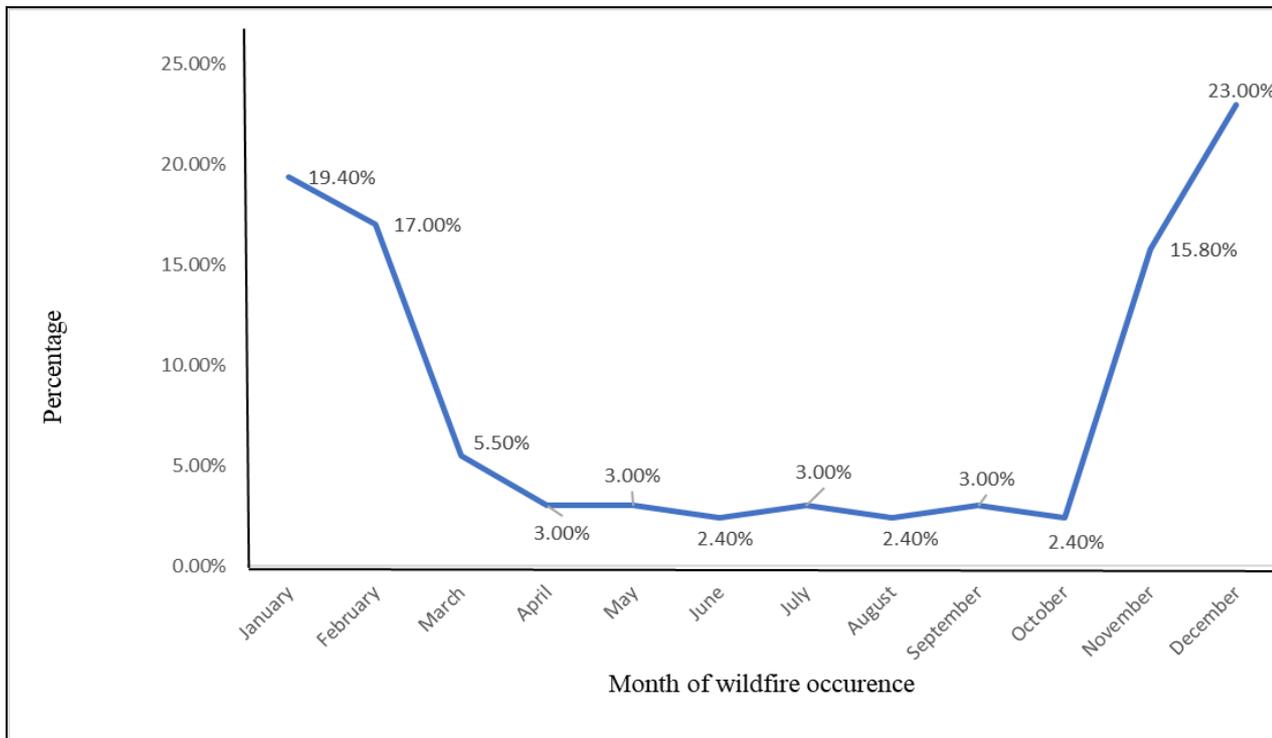


Figure 3: Months of Wildfire Occurrence

Changes in the number of wildfire incidence over the past ten years (Institutional Report)

Institutional records from the Fire Service, Forestry Commission, and NADMO indicate a general decline in wildfire incidences over the past decade in Dormaa and Atebubu-Amantin. Fire Service data show a drop from 19 to 6 cases in Dormaa and 22 to 6 in Atebubu-Amantin between 2015 and 2024, while Forestry Commission and NADMO records generally reported 0–4

cases annually, aligning with the observations of the community. The Fire Service recorded relatively higher numbers. According to experts from the Ghana National Fire Service, this is because even minor fires are frequently reported to their office and systematically documented, but all data confirm a consistent downward trend in wildfire occurrence (figure 5 and 6).

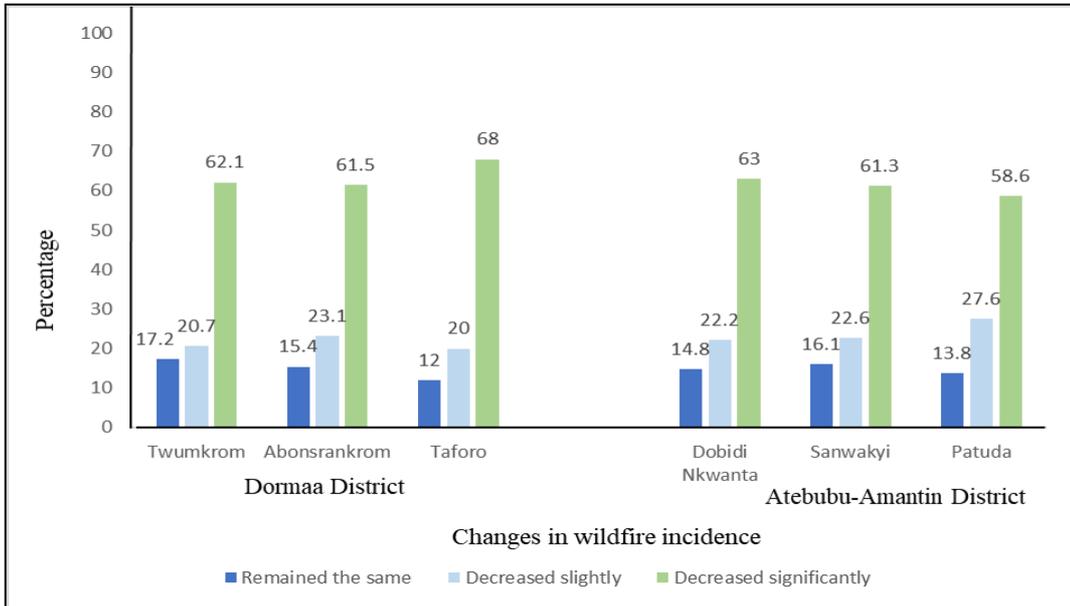


Figure 4: Observed changes in number of wildfire incidence over the past ten years

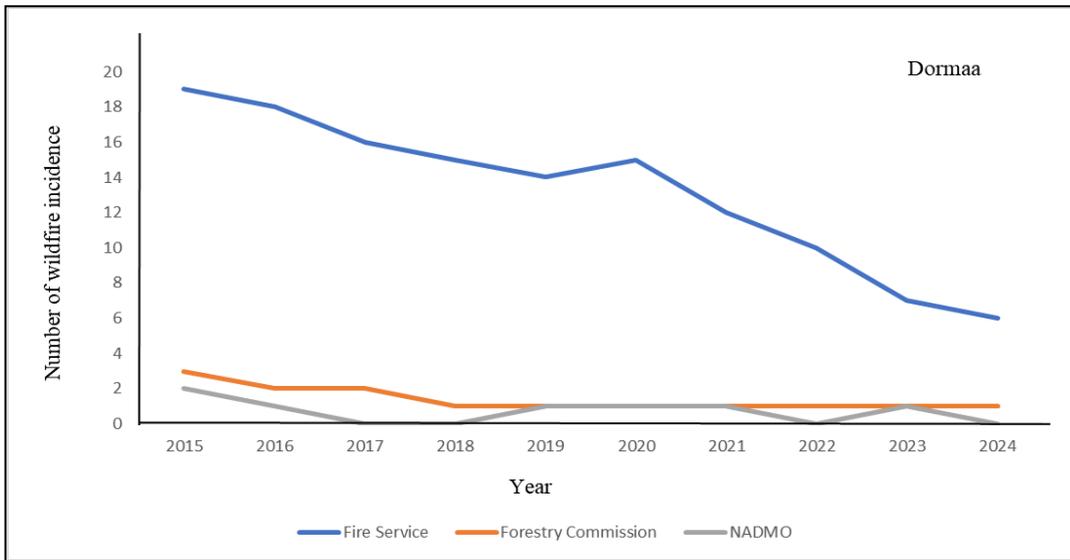


Figure 5: Changes in wildfire incidence from institutional data in Dormaa District

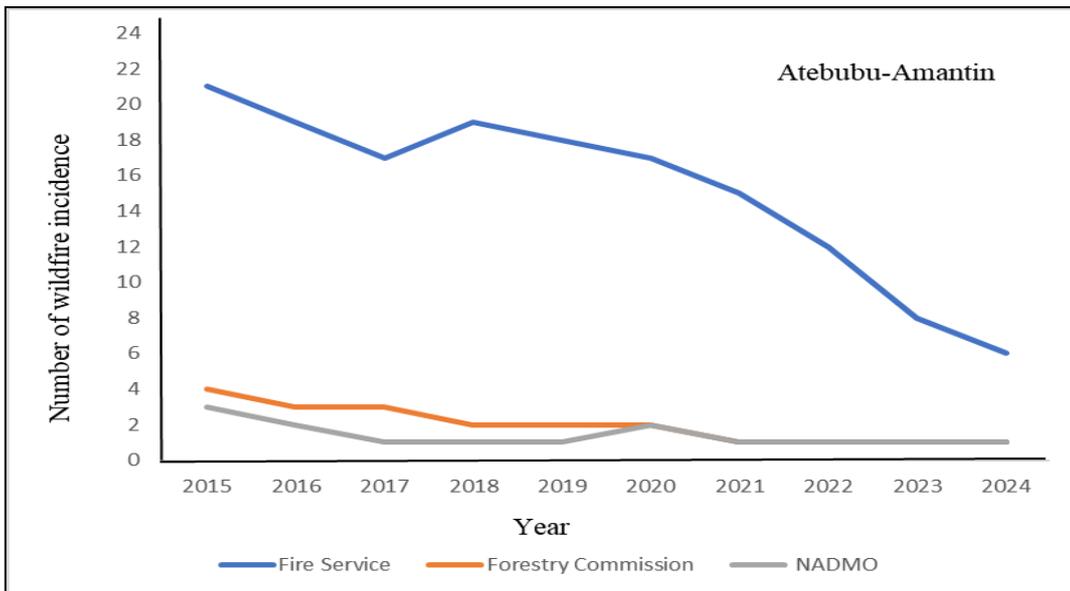


Figure 6: Changes in wildfire incidence from institutional data in Atebubu-Amantin District

Factors responsible for the changes observed

The results in figure 7 shows community perceptions of the factors contributing to the observed decline in wildfire incidences in the Dormaa and Atebubu-Amantin districts.

In Dormaa, the most frequently mentioned factors were sensitization and education campaigns (76.4%), cashew and cocoa expansion (69.4%), and the work of fire volunteer units (62.5%). In contrast, the responses from Atebubu-Amantin emphasized sensitization and education campaigns (75.3%), adoption of improved farming practices (62.4%), and a shift towards mixed farming systems (39.1%). The role of fire volunteer units was considered significant in Dormaa (62.5), but very minimal in Atebubu-Amantin (5.8%).

Key Anthropogenic and Environmental Drivers of Forest Fires in the Transition Zone

The key drivers of wildfires were classified into anthropogenic and environmental factors.

Perceptions of Human-Related Causes of Wildfires

The results in figure 8 shows the community perceptions of the main causes of wildfires in Dormaa and Atebubu-Amantin districts.

In Dormaa, the leading causes reported were land clearing (69.4%), smoking (62.5%), and hunting (58.3%), suggesting that agricultural expansion and individual practices remain critical fire triggers. In Atebubu-Amantin, the dominant causes were hunting (59.1%), grazing (51.6%), and land clearing (43%), reflecting the strong influence of livelihood activities linked to farming and livestock. Charcoal burning was also reported more frequently in Atebubu-Amantin (30.9%) compared to Dormaa (20.8%). The findings indicate that while land clearing and smoking drive most fires in Dormaa, hunting and grazing are the primary contributors in Atebubu-Amantin.

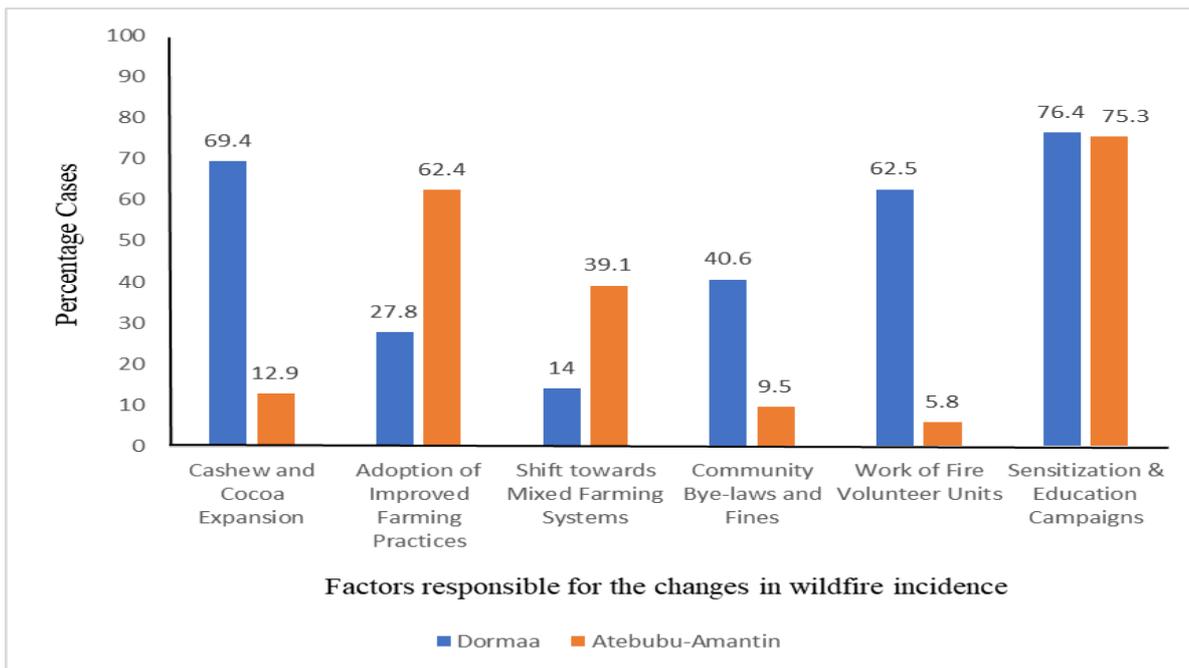


Figure 7: Factors responsible for the observed changes in wildfire incidence

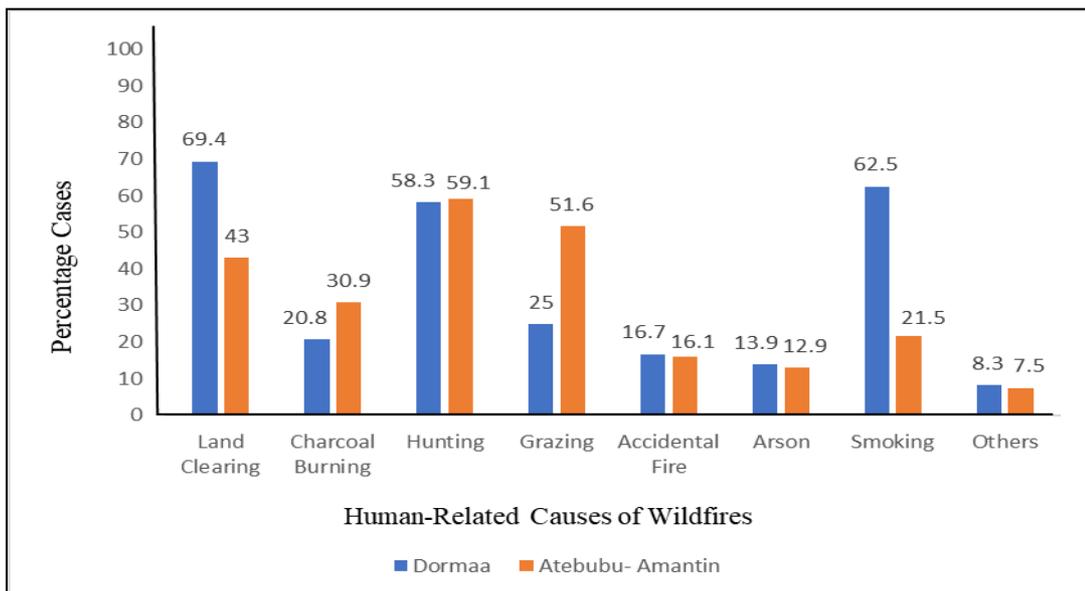


Figure 8: Perceptions of anthropogenic causes of wildfires

Interviews with key institutions provided insights that contextualize these community perspectives. Officials from the Ghana National Fire Service (GNFS) in Dormaa stressed that “most fires originate from indiscriminate slash-and-burn land clearing for crop farming, which often spreads uncontrollably during the dry season. Farmers often burn fields without proper supervision, and this practice escalates into wildfires when the winds are strong” (GNFS Staff 1, Dormaa).

Similarly, a representative from the Forestry Commission in Atebubu-Amantin explained that “in this district, grazing and hunting are central issues. Hunters use fire to flush out animals, and herders sometimes burn pasture to regenerate fresh grass for their cattle. These fires frequently escape control and spread into the forest” (FC Staff 2, Atebubu-Amantin).

Furthermore, officials from NADMO emphasized that smoking, though often overlooked, remains a consistent driver, especially in Dormaa: “We receive repeated reports of smokers discarding cigarette butts carelessly, which spark fires in the dry season when the vegetation is highly combustible” (NADMO Staff 1, Dormaa). This highlights how small, individual actions can escalate into large-scale environmental hazards. This shows that while farming and land-use practices dominate as causes of fire across both districts, the specific livelihood drivers vary.

A chief in Atebubu-Amantin linked the problem to large-scale hunting. He stated that “Group hunting with fire has become a menace. It is no longer just locals, but strangers who arrive in vans, sometimes in dozens, burning vast areas to drive out animals. These fires are far too big to control, and they leave behind destruction.” Another pressing issue identified by both institutions and local leaders is the role of nomadic herders. As one GNFS official opined, “Some herders and other nomadic groups deliberately set fire

to grasslands so that fresh pastures can sprout for their cattle. But these fires easily escape into farms and forest areas, causing tension with local communities” (GNFS Staff 2, Atebubu-Amantin).

Perceptions of Environmental Factors Contributing to Wildfires

The community responses showed that the prolonged dry season was the most widely acknowledged driver of wildfires in both Dormaa (88.9%) and Atebubu-Amantin (83.9%). High temperatures were also emphasized, particularly in Dormaa (80.6%). In contrast, degraded vegetation (61.3%) and fuel accumulation (63.4%) were more strongly reported in Atebubu-Amantin compared to Dormaa (43.1% and 48.6%, respectively) (figure 9).

Key informant interviews corroborated the community perceptions, highlighting similar environmental drivers of wildfires. One official from the GNFS stated that “the prolonged dry season and high temperatures create highly combustible conditions, making even small fires spread rapidly across communities” (GNFS Staff 2, Atebubu-Amantin).

Community Preparedness and Coping Strategies in Managing and Mitigating Wildfires

Community Preparedness in Managing and Mitigating Wildfires

Table 3 shows that communities generally agree they are aware of wildfire prevention measures (Mean = 4.12), know whom to report to (Mean = 3.85), participate in prevention (Mean = 3.68), and collaborate with authorities (Mean = 3.92). However, they reported inadequate tools and resources for fire management (Mean = 2.45), highlighting a key capacity gap.

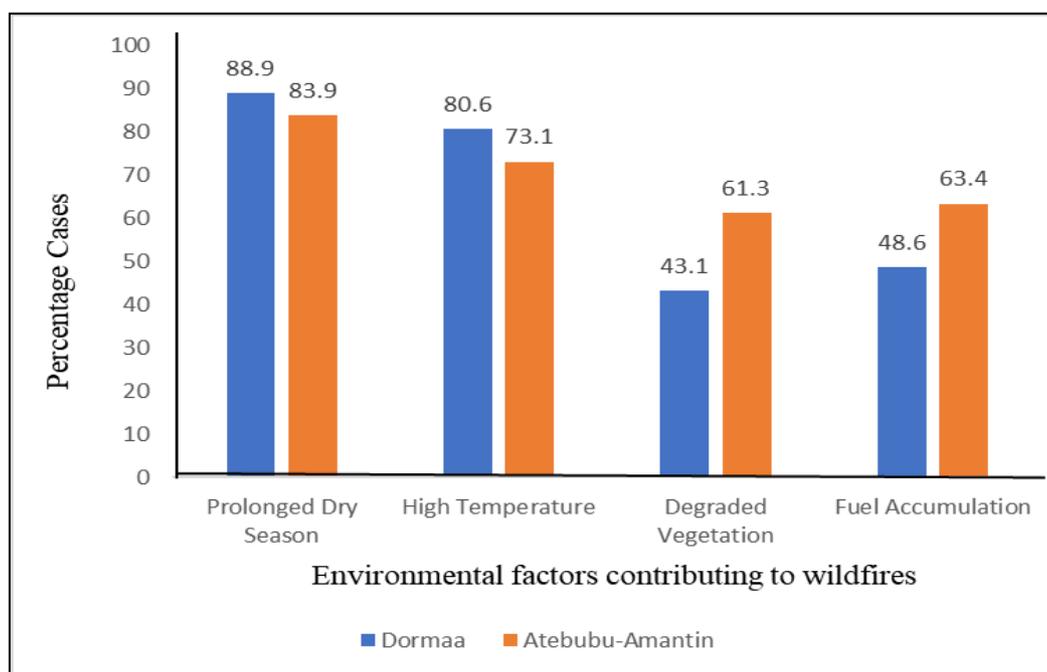


Figure 9: Perceptions of Environmental Factors Contributing to Wildfires

Table 3: Level of Agreement/Disagreement with Community Preparedness in Managing and Mitigating Wildfires

Statement	Mean	Standard Deviation (SD)
I know preventive measures to reduce wildfire occurrence.	4.12	0.78
I know whom to report to in case of a wildfire.	3.85	0.92
Community members actively participate in wildfire prevention.	3.68	1.05
The community has adequate tools and resources to manage fires.	2.45	1.12
The community collaborates with authorities and traditional leaders on fire management.	3.92	0.88

Coping Strategies in Managing and Mitigating Wildfires

The results in figure 10 shows that in Dormaa, communal patrols (72%) and switching from annual crops to cash crops (67%) were the most commonly practiced strategies. Firebreaks (65%), restricting slash-and-burn to safe periods (61%), and early/controlled burning (54%) were also moderately practiced. In contrast, Atebubu-Amantin communities showed higher adoption of more general preventive measures such as firebreaks (58%), restricting slash-and-burn (55%), and early/controlled burning (49%), while communal patrols (18%) and switching to cash crops (15%) were much less common.

associated with gender ($\chi^2 = 2.13, p = 0.044$) and education ($\chi^2 = 10.56, p = 0.032$), with males and respondents with higher education levels using it more actively, while age and residential status were not significant. Communal patrols were linked to gender ($\chi^2 = 4.98, p = 0.046$), but other demographics showed no effect. Early/controlled burning and restricting slash-and-burn showed no significant associations. Switching from annual to cash crops was significantly associated with gender, with males being more likely to switch ($\chi^2 = 5.87, p = 0.015$), and with residential status, where native residents were more likely to switch than non-natives ($\chi^2 = 8.11, p = 0.041$). No significant associations were found with age or education level (Table 4).

Chi-square Analysis of Coping Strategies by Demographic Variables

Chi-square analysis examined associations between demographic factors and the adoption of wildfire coping strategies. Firebreak use was significantly

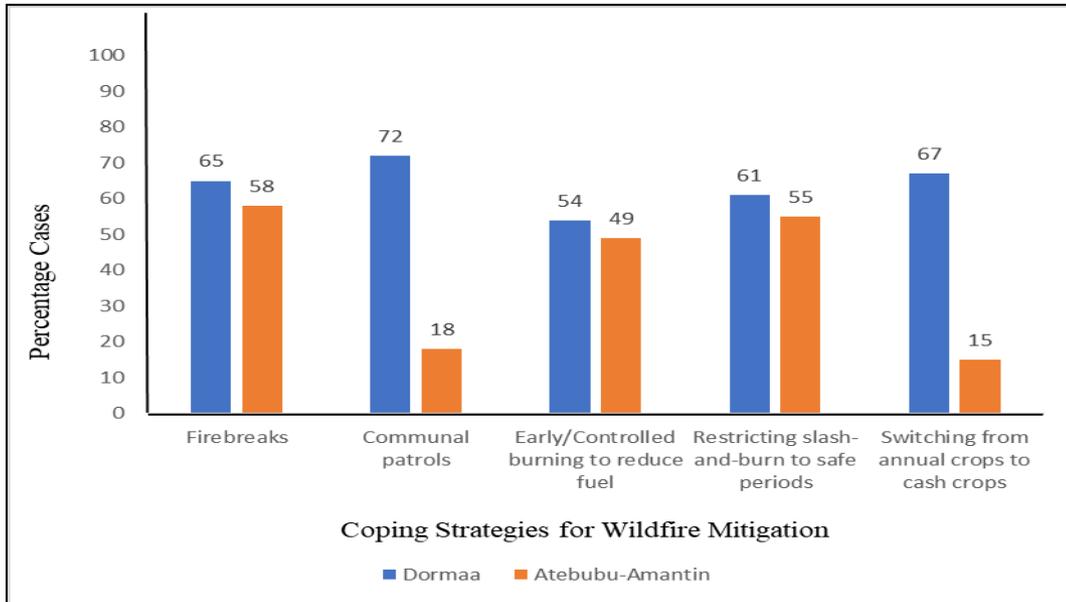


Figure 10: Coping strategies in managing and mitigating wildfires

Table 4: Association Between Demographic Characteristics and Adoption of Coping Strategies

Coping Strategy	Variable	χ^2	df	p-value
Firebreaks	Gender	4.16	1	0.044*
	Age	6.87	4	0.142
	Educational Level	10.56	4	0.032*
	Residential Status	1.05	1	0.306
Communal Patrols	Gender	4.98	1	0.046*
	Age	8.21	4	0.084
	Educational Level	5.12	4	0.274
	Residential Status	3.67	1	0.076
Early/Controlled Burning	Gender	0.95	1	0.330
	Age	7.42	4	0.115
	Educational Level	6.78	4	0.147
	Residential Status	0.82	1	0.366
Restricting Slash-and-Burn	Gender	1.88	1	0.171
	Age	9.02	4	0.071
	Educational Level	12.33	4	0.151
	Residential Status	2.41	1	0.121
Switching to Cash Crops	Gender	5.87	1	0.015*
	Age	10.45	4	0.133
	Educational Level	14.22	4	0.127
	Residential Status	8.11	1	0.041*

Discussion

Community-Level Experiences and Socio-Demographic Predictors of Wildfire Incidences

The widespread experience of wildfires across the study communities shows the pervasive fire risks in Ghana's transition zone, aligning with Amisssah et al. (2011)'s observations of agricultural lands' vulnerability. The socio-demographic patterns indicate that males and older individuals are more likely to experience wildfire impacts, reflecting gendered roles in land clearing and hunting in as indicated in Sahka (Burnasheva, 2022) and greater exposure among older residents. This highlights the transition-zone context where fire-dependent land preparation, hunting practices, and prolonged dry seasons expose most households especially men and older residents who engage more directly in these activities to wildfire risks. Residential status was not a significant factor, suggesting similar exposure for natives and migrants, although other contexts, such as Arizona, show differing vulnerabilities (Collins & Bolin, 2009). The contrast with contexts like Arizona arises from the differences in social structure and land tenure, as both natives and migrants in the study area have similar access to and dependence on farmed land, leading to comparable wildfire exposure. From a disaster vulnerability perspective, frameworks like the Pressure-and-Release (PAR) model and the social vulnerability theory help explain these patterns, showing how underlying socio-economic pressures, exposure to hazards, and limited adaptive capacity combine to make specific groups such as men and older residents more susceptible to wildfire impacts. These models highlight that vulnerability is not uniform, but shaped by both environmental hazards and social conditions.

The seasonal concentration of wildfire incidents during the dry months of November to February confirms broader regional patterns across West Africa's savanna and forest-savanna transition zones (Asori and Appiah, 2019). Comparable fire seasonality has also been documented in southern Africa (Archibald et al., 2018) and parts of Brazil's cerrado (Brando et al., 2020), where extended dry seasons, coupled with human activities, create conditions conducive to large-scale fire outbreaks. This shows that while local drivers shape community-level fire experiences, broader climatic and ecological conditions synchronize fire regimes across tropical landscapes.

These findings show that wildfires in Ghana's transition zone are not only an ecological concern, but also, are deeply-rooted social phenomena, affecting communities in differentiated ways. They highlight the need for community-based fire management strategies that recognize the heightened vulnerability of specific demographic groups, especially male farmers and older residents, while also aligning interventions with seasonal fire patterns. This aligns with the broader call for integrated fire governance approaches that combine ecological science with local socio-demographic realities (Reyes-García et al., 2016).

Observed Changes in Wildfire Incidences Over the Past Decade

The observed decline in wildfire incidences across the study areas suggest a gradual shift in wildfire dynamics within the Transition Zone. This can be interpreted through the hazards-of-place framework, which explain why certain communities remain more exposed despite the overall declines. The observation aligns with the broader shifts reported in other global contexts where community sensitization and institutional fire management interventions have been intensified (Bacciu et al., 2022). For instance, Giglio et al. (2013) reported that in Europe and Australia/New Zealand, the area burned has declined by about 5% per year. While wildfire frequency has also decreased in some regions, but these reductions are often offset by increases in fire intensity and severity (Bacciu et al., 2022).

In Mediterranean Europe and the U.S., fire suppression policies have historically decreased fire occurrences, yet they inadvertently contributed to fuel accumulation and larger, more catastrophic fires when they do occur (Turco et al., 2016; Stephens et al., 2014). In Ghana, despite the reduced frequency of wildfires, risks still persist due to accumulated dry biomass, prolonged dry seasons, and increasing temperatures, which can lead to occasional high-intensity fires that threaten farmlands, infrastructure, and community livelihoods. While the decline in wildfire incidences in Ghana's transition zone observed in this study signals progress, sustaining this trajectory will require continuous investment in community-based fire

management, integration of scientific monitoring, and climate-adaptive strategies.

Factors Influencing Changes in Wildfire Incidences

The decline in wildfire incidences in Dormaa and Atebubu-Amantin is linked to multiple factors, including education and sensitization campaigns, shifts in farming systems with increased cash crop cultivation, and the support of fire volunteer units and local bye-laws. These interventions have strengthened community-level prevention and control, aligning with patterns observed elsewhere in Africa (Archibald, 2016). Across the continent, awareness and training programs have been pivotal in reshaping farmer behavior and reducing uncontrolled burning. For example, in Tanzania, community education significantly limited late-season fires by promoting earlier and controlled burning (Katani et al., 2014; Köpke, 2025). Similarly, in northern Ghana, combining fire education with traditional knowledge has lowered both the frequency and severity of fires (Macnight Ngwese et al., 2018). These findings emphasize that behavioral shifts through sustained education remain among the most effective strategies for mitigating wildfire risks.

Beyond education, changing agricultural practices and livelihood dynamics also play an equally important role. The expansion of cash crops such as cocoa and cashew in Ghana reflects a broader regional trend where perennial crop adoption reduces reliance on slash-and-burn farming. Studies by Ruf (2011) observed that cocoa intensification discouraged farmers from using fire, given the risks of damaging tree crops with long-term economic value. Comparable outcomes have been documented in Uganda, where agroforestry adoption minimized uncontrolled burning due to increased incentives for land protection (Banana et al., 2014). These transitions illustrate how market-driven shifts in farming systems can inadvertently contribute to wildfire reduction by aligning farmer interests with fire prevention.

Institutional fire management, especially through volunteer units, plays a key role in wildfire control in Ghana, though its effectiveness varies across districts. In Dormaa, volunteer squads help ensure farm fires remain contained, reflecting findings by Amisssah et al. (2011), while Wrona (2020) highlights their cultural and community significance. Pieces of evidence from Poland (Feltynowski and Feltynowski, 2025) and Mediterranean countries (Tedim et al., 2016) show that well-supported volunteer brigades and community patrols can significantly reduce wildfire occurrences. The Dormaa case reinforces the value of such grassroots fire management systems, while the more limited role in Atebubu-Amantin highlights the need for stronger institutional coordination to maximize impact.

Anthropogenic and Environmental Drivers of Wildfire in the Transition Zone

The pattern of human-related and environmental drivers identified by communities in Dormaa and Atebubu-Amantin is consistent with a large body of empirical work showing that wildfire in tropical transition zones is a human-environment triggered problem. Social practices such as land-clearing with fire (slash-and-burn), cooking or smoking on farms, hunting fires, and grazing-related burning create frequent ignition sources and account for a substantial share of ignitions in many West African landscapes (Amisssah et al., 2011). Charcoal production and occasional deliberate arson, although reported less frequently, are also important because they target fuel-rich areas and often produce rapidly spreading fires (AFSM, 2023). The prominence of smoking and careless cigarette disposal as an ignition mechanism echoes findings from other settings where small, everyday behaviours produce outsized fire risk (Shi & Zhang, 2023).

Even though sensitization campaigns and local bye-laws have strengthened community-level wildfire prevention, the persistence of unsafe practices such as smoking and hunting continues to pose significant risks. This suggests that although awareness and regulations have created a foundation for better fire management, they are not sufficient to fully change entrenched behaviors. Cultural practices, livelihood needs, and limited enforcement capacity mean that people may still resort to fire-related activities despite knowing the dangers. Therefore, stronger enforcement mechanisms and culturally grounded interventions are needed to complement the existing education and sensitization efforts, ensuring that awareness is effectively translated into safer and more sustainable practices.

The study indicates that environmental factors amplify human-caused ignitions, influencing whether fires remain small or escalate into large-scale events. Climate variability and extended dry seasons lower fuel moisture and lengthen the fire season, while accumulated dead leaves, dry grasses, and unmanaged shrubs increase fire intensity and spread (Pausas & Keeley, 2021; Awuah, 2017; Kokosza et al., 2024). The Transition Zone's fire regime reflects the interaction between everyday land-use practices and climatic/biophysical conditions, a pattern observed across African savannas and tropical woodlands (Chidumayo, 2013). Effective management therefore, requires an integrated approach combining behavior-change interventions, fuel and landscape management, strengthened local firefighting capacity, stricter enforcement against deliberate burning, and climate-informed monitoring and early-warning systems.

Community Preparedness and Coping Strategies in Managing and Mitigating Wildfires

The findings show the importance of community awareness and social capital in wildfire preparedness, and this aligns with broader evidence that rural communities often develop strong informal systems of risk knowledge and reporting, even when formal firefighting infrastructure is weak (McCaffrey et al., 2012). The relatively high levels of awareness of preventive measures and collaboration with authorities reflect growing success of sensitization campaigns and local governance structures, a pattern also observed in parts of East Africa where farmer field schools and extension programs have been leveraged for fire prevention (Osumba et al., 2021). However, the reported lack of tools and resources echoes similar challenges documented in other low-resource contexts, where capacity gaps hinder the translation of knowledge into effective on-the-ground responses (Dube, 2013). This suggests that while awareness and coordination are improving, the effectiveness of wildfire management in the study communities remains constrained by limited material and institutional support, highlighting the need for context-specific interventions that combine knowledge, resources, and local governance mechanisms.

The coping strategies identified reveal the differences in the adaptation pathways between Dormaa and Atebubu-Amantin, reflecting the influence of agricultural systems on fire management behaviour. Dormaa's reliance on communal patrols and permanent cash crops aligns with evidence from West African cocoa and cashew landscapes, where perennial crops encourage investment in fire prevention to safeguard long-term yields (Oduro et al., 2024). This contrasts with Atebubu-Amantin, where annual cropping systems dominate, and fire management relies more on preventive practices such as firebreaks and controlled burning. Such variation illustrates how livelihood strategies shape local fire regimes, echoing global studies that emphasize the socio-ecological dimensions of wildfire adaptation (Pausas & Keeley, 2021).

The observed associations between the demographic characteristics and coping strategies for wildfire management can be explained by considering the interplay of gender roles, education, and livelihood practices within the study communities. The significance of gender, with males more actively participating in firebreak construction and communal patrols, likely reflects the gendered division of labor, where men are more involved in physically demanding tasks such as land clearing and patrol activities (Eriksen and Waitt, 2016), while women's roles may be shaped by domestic responsibilities and limited mobility. Higher educational levels influencing firebreak adoption suggests that awareness and knowledge gained through schooling enhance individuals' capacity to understand the importance of preventive measures. The lack of association between age and most strategies may indicate that wildfire coping practices are seen as community obligations rather than age-specific responsibilities. Interestingly, switching to cash crops was associated with both gender and residential status with males and native residents being more likely to switch, reflecting how economic roles and land tenure systems shape livelihood decisions (Lambrecht and Asare, 2016). Men and natives often have greater access to land and resources, enabling them to invest in long-term cash crops, whereas women and migrants may rely more heavily on annual crops for immediate subsistence (Britwum et al., 2014). These patterns can be situated within the Social-Ecological Systems (SES) framework, which highlights how interactions between social structures, resource access, and ecological conditions determine community adaptive capacities and coping behaviors.

Importantly, the findings highlight that community resilience to wildfire risk depends not only on local knowledge and practices but also on the ability to institutionalize these measures through support from formal agencies. Evidence from Ethiopia shows that integrated fire management strategies (ie., combining local patrols, early burning, and technical support) are most effective when state institutions provide equipment, training, and enforcement mechanisms (Zewdie et al., 2023). In this regard, strengthening fire volunteer units, expanding resource allocation, and embedding wildfire preparedness into broader rural development planning would significantly enhance adaptive capacity in Ghana's Transition Zone.

Conclusion

This study examined the trends, drivers, community preparedness, and coping strategies related to forest fires in the Dormaa and Atebubu-Amantin Districts of Ghana's Transition Zone. The findings revealed a general decline in wildfire incidences over the past decade, attributed to a combination of sensitization campaigns, shifts in farming practices, crop diversification, and, in some areas, the work of fire volunteer units. Nonetheless, wildfires remain a recurrent challenge driven largely by anthropogenic activities such as land clearing, hunting, smoking, and grazing, compounded by environmental stressors like prolonged dry seasons, rising temperatures, degraded vegetation, and fuel accumulation. Community preparedness was found to be moderate, with awareness and reporting mechanisms in place, but with limited access to tools and resources to effectively suppress fires. The coping strategies varied across communities, highlighting both proactive approaches such as communal patrols and firebreaks, and adaptive livelihood choices like shifting from annual to perennial cash crops.

The study emphasizes the need for an integrated wildfire management approach that combines community behavior-change interventions with strengthened institutional capacity. At the local level, campaigns should target unsafe practices like indiscriminate burning, hunting with fire, and careless smoking, while fire volunteer units require adequate equipment, training, and coordination with agencies such as the Ghana National Fire Service, Forestry Commission, NADMO, and traditional authorities. From a policy perspective, wildfire management should be embedded within forest landscape restoration and climate adaptation strategies, including regulated fire use in agriculture, mechanized land preparation, improved grazing management, early-warning systems, climate-sensitive monitoring, promotion of tree-crop systems, and integration into district development plans. Through the combination of local knowledge, institutional support, and climate-informed policies, Ghana can enhance ecological resilience, protect rural livelihoods, and advance SDG 13 (Climate Action) and SDG 15 (Life on Land).

Declaration of interests

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

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Ethics Approval Statement

This study received approval from the ethics committee of the Department of Silviculture and Forest Management - KNUST. Informed consent was obtained from all participants before data collection.

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