VNU Journal of Science: Earth and Environmental Sciences

Journal homepage: https://js.vnu.edu.vn/EES

Original Article

# Impact of Climate Change and Natural Disasters on Livelihoods in Northern Mountainous Regions of Vietnam: A View from Dien Bien Province

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Received 03 May 2024
Revised 8 August 2024; Accepted 26 September 2024

**Abstract:** This study examines impacts of climate change and natural disasters on livelihoods in Dien Bien province, located in Northern Mountainous Region of Vietnam. Based on meteorological data, household surveys, interviews, and focused group discussions conducted across four communes, the research finds that Dien Bien is experiencing more frequent and intense extreme weather events, including heavy rainfall, landslides, and droughts. These changes are severely impacting agriculture-dependent ethnic minority communities, with over 60% of households reporting arable land and crop productivity losses of 40-65% in 2022 alone. Income losses are the most pronounced in remote areas, where 62% of households lost over half of their annual income. While social welfare and climate-smart agriculture programs exist, the coverage and adoption rates vary widely across communes. The findings highlight the disproportionate impacts on marginalized populations and the need for tailored, culturally-sensitive adaptation strategies. The study recommends promoting multipurpose tree planting, establishing community-based nurseries, diversifying livelihoods through small-scale family activities, and expanding inclusive financial

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https://doi.org/10.25073/2588-1094/vnuees.5110

mechanisms to enhance resilience. Findings from this study provide new insights into the complex vulnerabilities of ethnic minority communities in mountainous regions and offers targeted interventions to safeguard their livelihoods under accelerating climate change.

*Keywords:* Climate resilience, Ethnic minority communities, Northern Mountainous Vietnam, Sustainable livelihood, Adaptation strategies.

## 1. Introduction

Dien Bien province, located in the Northern Mountainous Region (NMR) of Vietnam, is one of the most climate change-vulnerable areas [1-3]. This vulnerability is due to its rugged terrain, steep slopes, and frequent severe weather, making it prone to climate hazards. Dien Bien is home to many ethnic minority communities who depend on agriculture and forestry for their livelihoods and income. Additionally, Dien Bien had the highest poverty rate in Vietnam in 2020 at 27.33% [4], which worsens its susceptibility to climate-related challenges.

Recent studies have documented the profound impacts of climate change on Dien Bien province. The NMR, including Dien Bien, has experienced a faster rate of warming trend compared to other regions in Vietnam. Between 1958 and 2018, temperature in the area rose by 0.8-1.3 °C, surpassing the national average [2]. Concurrently, rainfall patterns have undergone significant transformations, with a gradual decline in annual average precipitation [2, 5]. This reduction in rainfall has exacerbated the occurrence and severity of droughts, intensifying water shortages for both agricultural and domestic purposes. Moreover, Dien Bien has been grappling with the increasing frequency and intensity of extreme weather events. These include unusual, prolonged, and severe cold spells, particularly in mountainous areas [6, 7], as well as unpredictable and intense tropical storms, leading to heavy rainfall, flash floods, and landslides. Storm seasons have also tended to extend and exhibit complex movement patterns, further complicating climate – related challenges in the region [8-11].

These climatic changes have had far-reaching and severe impacts on the predominantly agriculture-dependent communities in Dien Bien. Declining crop yields, have directly affected food security and income stability [12-14]. Climate disasters have also disrupted access to education, as extreme weather events have made attending school difficult for children in Dien Bien, leading to extended periods of absenteeism and infringing upon children right to education [15,16]. Significantly, the poor and marginalized ethnic minority communities in Dien Bien are disproportionately affected due to their high exposure, limited resources, and low adaptive capacity [17].

Vietnam has committed to global climate action by ratifying international agreements, including the Montreal Protocol (1994), the Kyoto Protocol (2002), and the Paris Agreement (2016) [18]. Nationally, the country has implemented the National Strategy on Climate Change (2011) [19] and developed a National Adaptation Plan (NAP) for resilience-building [20]. The Strategic Program for Sustainable Agriculture and Rural Development (2021-2030) aims to enhance agricultural adaptation, crucial for livelihoods in Dien Bien [21].

Persistent challenges continue to hinder effective resilience-building in the remote and vulnerable NMR and Dien Bien province. A pressing issue is climate change's increasing impact on agriculture, the primary livelihood source for many residents [22, 23]. Abnormal rainfall patterns, frequent floods, droughts, and storms have caused crop losses, threatening food security and income stability in Dien Bien [24]. Rural and mountainous areas in the province often lack the necessary resources, knowledge, and capacity to redesign agricultural production systems for resilience [25]. The geographical remoteness and rugged terrain of Dien Bien create difficulties in accessing basic services, support, and recovery opportunities after

disasters, widening development gaps. Insufficient infrastructure, early warning systems, and disaster response plans leave communities ill-equipped to manage climate risks effectively. Socio-economic inequalities, including poverty, gender disparities, and marginalization of ethnic minorities, further exacerbate vulnerabilities in Dien Bien, limiting access to resources, decision-making processes, and adaptation opportunities for the most vulnerable groups.

However, several gaps remain in the existing literature. While broad national policies have been studied, there's a lack of research on how these translate to effective local-level actions in Dien Bien. Additionally, previous studies have not adequately examined the role of local knowledge and practices in building resilience. Most research focuses on specific impacts or sectors, failing to provide a comprehensive analysis of the interconnected challenges faced by Dien Bien's communities. Furthermore, the unique vulnerabilities and adaptive capacities of ethnic minorities and other marginalized groups in Dien Bien require further investigation.

This study aims to provide a comprehensive analysis of the impacts of climate change and natural disasters on livelihoods in Dien Bien province, the efforts undertaken by stakeholders, and strategies to address the multi-faceted challenges these communities face. By identifying the unique vulnerabilities, adaptive capacities, and resilience approaches of communities in Dien Bien, this research aims to guide policymakers, practitioners, and community leaders in designing and implementing effective interventions that enhance resilience and well-being amidst a rapidly changing climate.

## 2. Study Area, Data Sources, and Research Methods

### *2.1 Study Area and Background*

The North Mountainous Region (NMR) of Vietnam, particularly Dien Bien province, serves as the focal study area for this research. Dien Bien exemplifies the NMR's distinct geographical, demographic, and socio-economic characteristics, making it ideal for assessing climate change vulnerability. Its elevated terrain contributes to unique microclimates and susceptibility to weather phenomena like heavy rainfall, landslides, and flash floods. The region's rich biodiversity, adapted to the mountainous environment, is vulnerable to climate change impacts. Socioeconomically, Dien Bien is home to ethnic minority communities heavily reliant on agriculture and natural resources, with high poverty rates exacerbating their vulnerability to climate-induced shocks [24]. Dien Bien province has a sparse population density of about 65 people per square kilometer, predominantly inhabited by ethnic minority groups. Livelihoods revolve around small-scale agricultural production and forest-based activities, often characterized by cultivation on steep slopes and traditional shifting practices [25]. As of 2020, Dien Bien had the highest poverty rate in Vietnam at 27.33%, consistently ranking among the poorest provinces with ethnic minorities constituting the majority of the poor population [26].

In this study, four communes in Dien Bien province were chosen for the survey - Huoi Leng in Muong Cha District, Muong Dun in Tua Chua District, Ta Ma in Tuan Giao District, and Xuan Lao in Muong Ang District (Figure 1, Table 1). These communes represent the dominant ethnic minority populations in their districts, primarily the Thai and Mong, along with other minorities like the Dao, Kho Mu, Ha Nhi, La Hu, Giay, Lao, Lu, Muong, and Phu La (Table 1). Population density ranges from 30 people per $km^2$ in Huoi Leng to 113 people per $km^2$ in Muong Dun. The distance to the nearest town varies from 19 km (Xuan Lao) to 38 km (Ta Ma), affecting remoteness and service access. Access to basic services remains a significant challenge across these communes. In Huoi Leng, up to 99% of ethnic minorities like Muong Muon lack access to schools, especially in border areas. In Ta Ma, public schools have a shortage of teaching staff,

particularly at the elementary and middle levels. In Tuan Giao district, where Ta Ma is located, 12 out of 18 communes have satisfied the "New Rural Criteria" as of 2023, indicating progress in rural development. Social protection measures like social insurance coverage and housing programs for poor and pro-poor families are also in place, although coverage remains limited. For instance, in Ta Ma, only 62% of the population had social insurance coverage as of 2023.

Tran et al., (2021) highlighted the importance of understanding ethnic and cultural vulnerabilities for effective resilience-building and disaster risk reduction, ensuring inclusivity in multi-ethnic nations like Vietnam [27, 28]. The selected hamlets, with scattered and remote ethnic populations, were difficult to access but maintained traditional social structures led by village elders. Little research exists on these highly vulnerable communities. Therefore, findings from these indigenous groups will offer unique insights into climate change and sociology. Although most respondents spoke Vietnamese, a local assistant facilitated trust between researchers and interviewees.

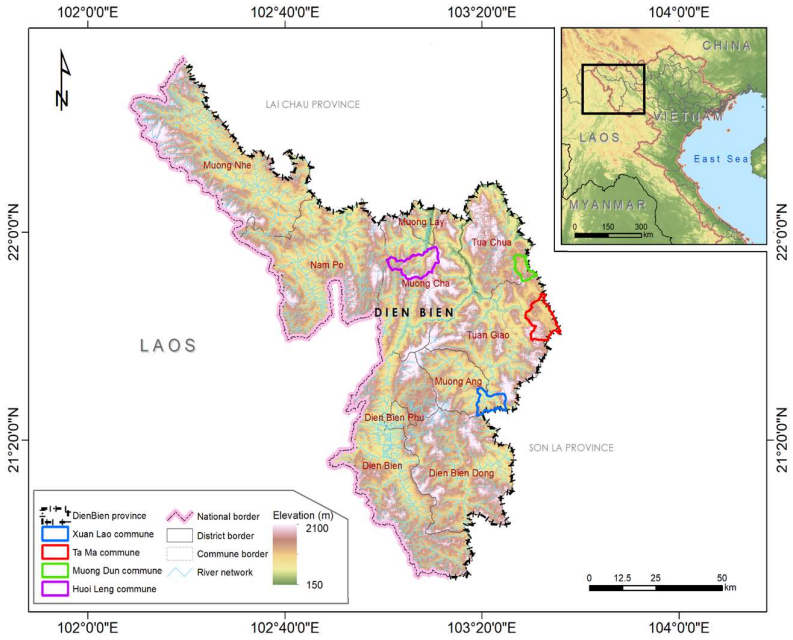


Figure 1. Map of Dien Bien Province overlaid on a topographic map. The blue line delineates the study communes.

Table 1. Selected survey communes' information (site survey in September -October 2023)

| Commune | Huoi Leng | Muong Dun | Ta Ma | Xuan Lao |
|---|---|---|---|---|
| District | Muong Cha | Tua Chua | Tuan Giao | Muong Ang |
| Population | 3327 | 4279 | 4001 | 5533 |
| Number of HHs | 25 | 25 | 25 | 25 |
| Area ($km^{2)}$ | 108.1 | 37.56 | 107.02 | 59.08 |
| Density (people/$km^2$) | 30 | 113 | 37 | 92 |

| Ethnic Group(s) (majority) | Thai<br>Mong | Thai<br>Muong<br>Phu La | Mong<br>Thai<br>Muong | Thai<br>Mong |
|---|---|---|---|---|
| Distance to Nearest Town/Urban Center (km) | 22 | 20 | 38 | 19 |
| Access to Basic Services (e.g., health facilities, schools, markets) | Lack of access to schools, especially communes located at the border (2024)<br><br>All communes have access to public roads | 11/19 communes satisfy "new rural criteria" (2023)<br><br>Lack of access to public health services<br><br>Lack of access to schools | 12/18 communes satisfy "new rural criteria" (2023)<br>Lack of teaching staff in public schools especially elementary schools and middle schools (2024)<br>Social insurance coverage is 62%, but limited voluntary insurance.<br>Housing program for the poor and pro-poor families (2023). | World Vision program is working in six communes (for children) (2023)<br>30/36 schools satisfy "National standard schools) (2023)<br>Access to public roads (2021-2025) |

*2.2. Data Collection and Research Methods*

A multi-method approach was employed to gather comprehensive data for this study. In addition to recorded meteorological and weather data from the National Centre for Hydro-Meteorological Forecasting (NCHMF) covering the period from 1960 to 2019, social and demographic data were collected through a combination of household surveys, in-depth interviews with key informants, and focus group discussions (FGDs) across four hamlets in Dien Bien province. The collection of social and demographic data was conducted in October 2023. The household survey sampled of 100 households using snowball and purposive sampling techniques. The snowball sampling method is particularly appropriate for rural communities in Vietnam, where social networks and kinship ties play a significant role [29,30]. Additionally, purposive sampling ensured an equal representation of males and females, adhering to a gender-sensitive approach to capture diverse perspectives and experiences. The pre-tested, structured questionnaire used during the interviews gathered information on livelihoods, health, education, and overall well-being, with a particular focus on the impacts of climate change on households, especially vulnerable groups. Complementing the quantitative data, qualitative insights were gathered from 18 in-depth interviews, including four in Huoi Leng (Muong Cha district) with key informants such as a commune leader and representatives from health, children's, and women's groups. These interviews highlighted community-specific vulnerabilities and adaptation measures, such as establishing community gardens and health awareness programs. Furthermore, four FGDs were organized, each comprising 6 to 10 participants from diverse community groups, totaling 37 people. These included 8 children aged 11 to 14, ethnic minorities (Dao, Kho Mu, Ha Nhi, Muong, and Phu La), 20 women, and 23 youth under 50. This approach ensured a comprehensive understanding of livelihoods, climate change vulnerabilities, and coping strategies from various perspectives.

The data was analyzed using the DPSIR framework [31], assessing drivers and pressures of climate change, environmental and livelihood states, impacts on communities, and responses in Dien Bien province. The analysis considered

factors like deforestation, greenhouse gas emissions, soil erosion, poverty rates, and reliance on small-scale agriculture. Provincial and community responses, such as reforestation efforts and climate-resilient agricultural techniques, were also examined. The DPSIR analysis framework further aids in identifying suitable intervention measures to enhance adaptive capacity and sustainable development in the region.

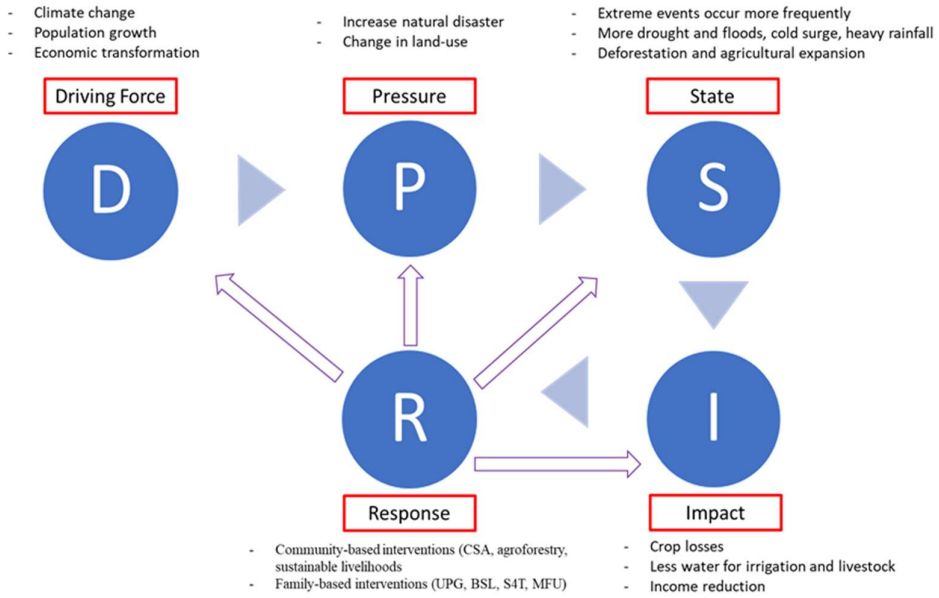


Figure 2. DPSIR framework designed for this research.

## 3. Results and Discussion

### *3.1 Climate Change Characteristics*

Dien Bien province is facing severe impacts of climate change. Historical meteorological data shows a clear increasing trend in the number of heavy rainfall days, indicating a rise in extreme precipitation events (Figure 3). From the 1960s to the 2010s, the number of heavy rainfall days nearly doubled, increasing from 3.4 days per year in the 1960s to 6.7 days per year in the 2010s. This surge in heavy rainfall can increase the risk of flash floods, landslides, and other water-related disasters in the region. Additionally, statistics reveal a fluctuating pattern in the number of hot days, with a peak observed in the 1960s (10.3 days per year) and a gradual decline in subsequent decades. However, the data only reflects the frequency of hot days and not the overall temperature trend, which may still show an increasing pattern over the years. Regarding drought periods, there is a relatively stable trend, with the number of drought days ranging between 1.8 and 3.1 days per year across the six decades. However, it is crucial to consider that the intensity and duration of these drought events, rather than just their frequency, can significantly impact the region's agricultural activities and water resources.

On the other hand, Figure 3 shows a notable decrease in the number of cold days, dropping from 36.3 days per year in the 1960s to 13.4 days per year in the 2010s. This trend aligns with the expected impacts of climate change, which generally lead to warmer temperatures and a reduction in the frequency of extremely cold days. These trends are specific to the region under study and may not be representative of the entire Northern mountainous region of Vietnam.

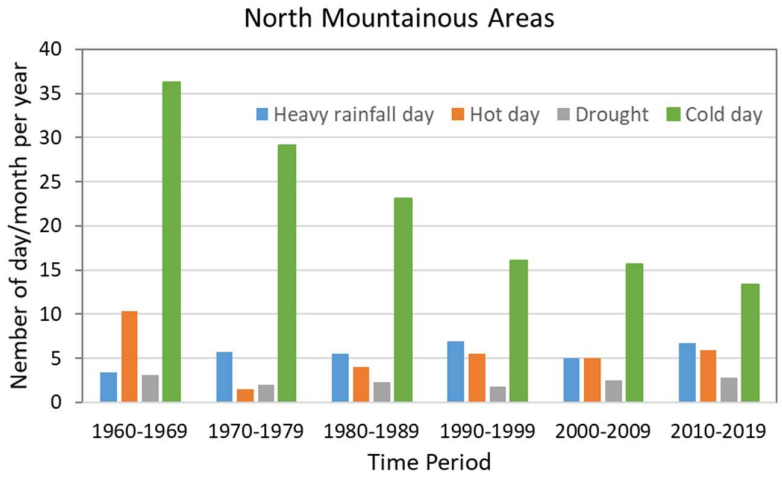


Figure 3. Number of of extreme weather events (day or month) per decade in the North mountainous region: statistical analysis based on meteorological data from the Viet Nam Meteorological and Hydrological Administration (VNMHA).

Natural disasters, including landslides, rockslides, flash floods, and tropical storms, present significant challenges in Dien Bien. These events are influenced by various factors, such as geological faults like the Dien Bien Phu fault system [32-34]. Studies focusing on Dien Bien Province have highlighted the region's disadvantaged nature, which exacerbates the impact of these disasters [35]. Factors like topography and weather conditions contribute to the occurrence of flash floods, which are common in mountainous areas like Dien Bien [36, 37]. Dien Bien has the highest risk of rockslides in the Northern Mountainous Region, with nearly 60% of the province classified as high-risk areas [38]. The household survey results corroborate this, with respondents reporting an increased occurrence of these extreme events, which have caused significant damage to infrastructure, agricultural lands, and livelihoods. Climate change has also contributed to soil degradation, biodiversity loss, and impacts on water sources in Dien Bien [25, 39].

According to Minh et al., (2022), climate change has led to a 15% increase in soil erosion rates in upland areas of Dien Bien over the past two decades, resulting in decreased agricultural productivity and increased vulnerability to landslides [39]. Additionally, Tran Dang et al., (2018) reported a decline in plant and animal species diversity in the region, with the loss of important animal and plant species due to habitat changes and species migration [38]. These environmental changes have far-reaching consequences for the province's ecosystems and the ecological services they provide, upon which many rural communities depend for their livelihoods [40]. The loss of important animal and plant species due to habitat changes and species migration seriously affects the region's ecological balance [38].

### *3.2. Assessment of Livelihood Impacts*

According to local perceptions (Figure 4), common natural disasters in Dien Bien province include heavy rain, heat waves, landslides, and droughts. In 2016, the province experienced five severe and damaging cold spells, with temperatures plummeting as low as 4.3 $^{o}$C. Persistent heavy rainfall resulted in four fatalities, 11 injuries, damage to 142 schools and 267 classrooms, and substantial losses in agricultural areas, forestry, and livestock.

Numerous infrastructure projects also suffered damage, costing an estimated 380 billion Vietnamese dong. In 2022, the region endured severe cold spells in January and February, hailstorms and strong winds in March and April, flash floods and landslides from May to October, and an extended period of heavy rains in July 2023.

These natural disasters have significantly impacted livelihoods and socio-economic well-being in the province. As shown in Figure 5, the subjects most severely damaged are houses (77% of respondents), agricultural fields (70%), and transportation systems (63%), affecting production output and reducing incomes (53%). There were two deaths and one injury recorded in 2022 due to natural disasters. Property damage affected 138 households in 2022, including houses damaged by hail, storms, flooding, and landslides, and 12 households in Huoi Leng commune. In 2023, natural disasters impacted 99 households district-wide, with two households in Huoi Leng commune affected by hail and strong winds. Agricultural losses in 2022 amounted to 23.614 billion Vietnamese dong, and in the first half of 2023, losses reached 17.7 billion Vietnamese dong, significantly impacting rice fields and flower crops. The district also reported substantial damage to infrastructure like schools, irrigation systems, and transportation, resulting in nearly 900 million Vietnamese dong in losses. Natural disasters also increased environmental pollution risk (50%) and negatively impacted children's education.

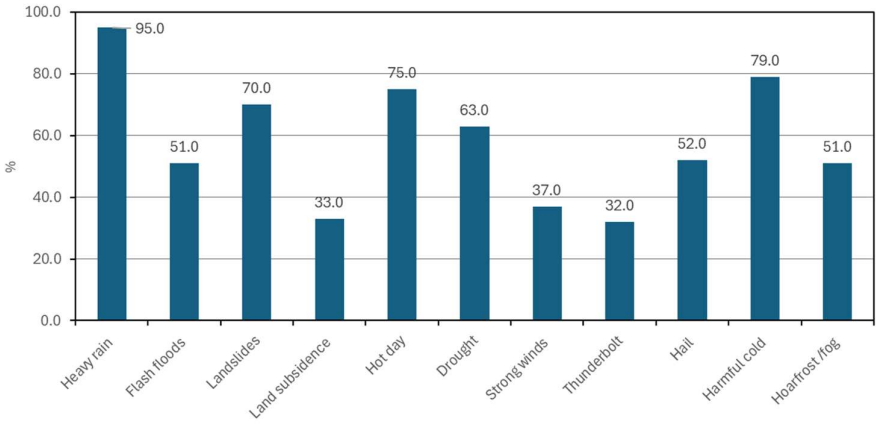


Figure 4. Percentage of individuals affected by negative impacts from natural disasters in the North mountainous areas (Source: Household survey, September - October 2023).

Across the surveyed communes of Huoi Leng, Muong Dun, Ta Ma, and Xuan Lao, local communities reported an increasing frequency and intensity of extreme weather events like droughts, heavy rains, cold spells, thunderstorms, and hail storms as drivers of climate change, i.e. 65% of respondents in Muong Dun and 72% in Xuan Lao experienced at least two hail storms per year recently, compared to just 15-20% a decade ago. Consequently, soil erosion has intensified, and landslide risks have heightened across these communes.

The environmental state of natural resources critical for livelihoods has degraded due to these climatic pressures. Over 60% of households across the four communes reported a decrease in arable land area due to soil erosion and degradation. Water scarcity during dry seasons has become a major issue, with only 35% of farming households in Ta Ma and 28% in Huoi Leng having adequate irrigation access.

Agriculture-based livelihoods, which predominate in these communities, have been severely impacted. In Xuan Lao, 83% of ethnic

minority households stated that climate change has reduced crop productivity, while 77% in Muong Dun reported declines in livestock rearing. Crop losses from extreme events ranged from 40% in Ta Ma to 65% in Huoi Leng in 2022 alone. Consequently, income losses were most pronounced in Huoi Leng, where 62% of households lost over half their annual income.

Certain ethnic minority groups exhibited heightened vulnerability due to their heavy reliance on climate-sensitive natural resources. For instance, 95% of the Mong in Xuan Lao and 88% of the Thai in Muong Dun depended on agriculture, forests, and water sources, making them susceptible to climate impacts on these sectors. In contrast, the Dao in Ta Ma demonstrated greater adaptive capacity, with 47% engaged in off-farm livelihoods like handicrafts and tourism, allowing for income diversification.

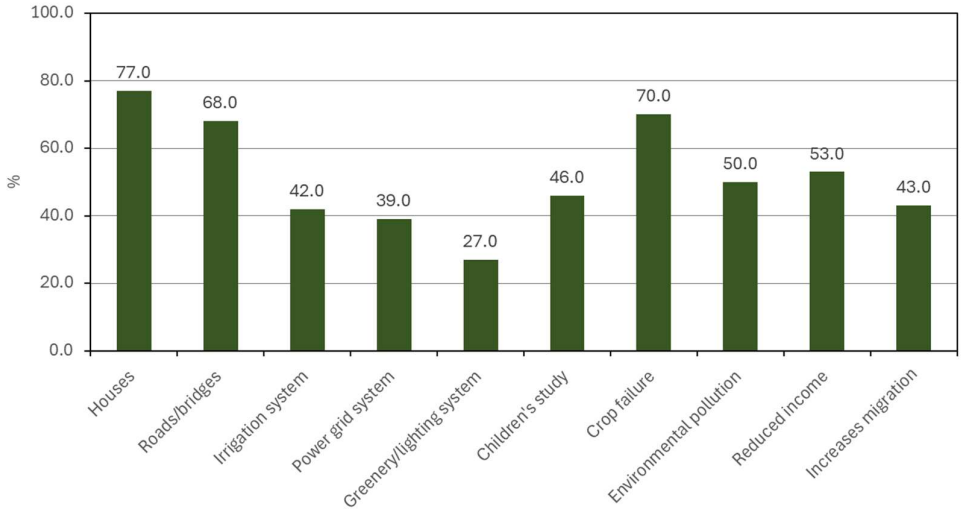


Figure 5. Percentage of individuals affected by negative impacts of climate change in the North mountainous areas (Source: Household survey, September - October 2023).

Across the communes, the study revealed extensive damage to key livelihood assets, property, and infrastructure caused by natural disasters. A 92% of households reported that recent disasters had damaged their homes and local infrastructure. Vital assets like agricultural fields (70% of respondents), houses (77%), and transportation systems (63%) were severely impacted. Landslides during storms frequently caused direct damage to crops and livestock.

However, the economic toll varied, with losses to agricultural production estimated at 23.6 billion VND in 2022 and 17.7 billion VND in just the first half of 2023 across the province. Notably, 53% of respondents indicated that natural disasters had reduced their incomes, with low-income households below 10 million VND/year being among the most severely affected due to their heavy reliance on agriculture.

While social protection programs and NGOs interventions promoting climate-smart agriculture exist, their coverage and adoption rates varying across communes. In the remote Huoi Leng commune, only 32% of households accessed housing support for the poor. Meanwhile, climate-smart agricultural practice adoption was 35% in Ta Ma compared to just 12% in Muong Dun.

These findings highlight the disproportionate impacts of climate change on ethnic minority livelihoods across the four

communes and the need for tailored culturally sensitive adaptation strategies. Enhancing access to basic services, diversifying income sources, strengthening social safety nets, and building on local knowledge systems are crucial for bolstering resilience in these vulnerable communities. Concerted efforts addressing the multi-faceted challenges of climate change are essential to safeguard livelihoods and well-being across Dien Bien's marginalized populations.

### *3.3 Recommendations for Climate Resilience Livelihoods in the Context of Climate Change*

The Northern Mountainous region of Vietnam faces significant challenges due to climate change, necessitating adaptive strategies to build resilient livelihoods. A multifaceted approach combining agricultural innovation, environmental conservation, and community empowerment can address these challenges effectively. Promoting multipurpose tree planting through agroforestry offers numerous benefits, including food security, carbon sequestration, and ecosystem preservation. Community-based nurseries for indigenous tree species serve as hubs for biodiversity conservation and knowledge exchange, fostering local ownership and expertise in sustainable land management.

Climate-smart agriculture (CSA) [41] is crucial for adapting to erratic weather patterns and extreme events. By utilizing drought and flood-resistant crop varieties alongside sustainable farming practices such as conservation tillage and crop rotation, farmers can maintain productivity while protecting soil health. Efficient water management and organic farming methods further enhance resilience by optimizing resource use and fostering biodiversity.

Diversifying income sources through small-scale, family-based activities is essential for promoting sustainable livelihoods [42]. Initiatives such as backyard poultry farming, small-scale aquaculture, and beekeeping can enhance food security and economic resilience. These activities not only provide alternative income sources but also contribute to nutrition security during periods of climate-induced agricultural stress.

Community-led financial mechanisms play a vital role in building economic resilience. Savings and credit groups, like "Saving for Transformation" (S4T), empower members to pool resources, access affordable credit, and invest in income-generating activities [43]. Micro Financial Units (MFUs) provide comprehensive services beyond microcredit, offering business development support and market access assistance. These initiatives foster financial literacy, entrepreneurship, and risk management, enabling communities to invest in climate-resilient activities and build assets over time.

To ensure the success of these interventions, it is crucial to engage local communities in their design and implementation. Building capacity through training, knowledge sharing, and participatory decision-making will be essential. Additionally, fostering partnerships with local organizations, government agencies, and NGOs can provide further support and resources for effective implementation in the Northern Mountainous regions of Vietnam. By integrating these strategies into community-based interventions and engaging local stakeholders, it is possible to enhance the adaptive capacity of local communities, reduce their vulnerability to climate-related risks, and promote sustainable development in the face of ongoing environmental challenges.

## 4. Conclusions

This study aims to assess the vulnerability of ethnic minority communities to climate change impacts in the Northern Mountainous Region of Vietnam, with a specific focus on Dien Bien province. Through a multi-method approach combining meteorological data analysis, household surveys, in-depth interviews, and focus group discussions, the research provided a comprehensive view of climate change characteristics and their impacts on local livelihoods.

Findings of this study revealed significant climate change trends in Dien Bien, including an increase in heavy rainfall days and a decrease in cold days over the past six decades. The region experiences a high frequency of natural disasters such as landslides, flash floods, and tropical storms, exacerbated by its unique geological and topographical features. These climatic changes have severely impacted livelihoods, with substantial damage reported to houses, agricultural fields, and transportation systems by the majority of respondents.

The study also highlighted the disproportionate vulnerability among ethnic minority groups, particularly those heavily reliant on climate-sensitive natural resources, while noting varied adaptive capacities across communes, with some groups demonstrating greater resilience through income diversification. These findings underscore the urgent need for tailored, culturally sensitive adaptation strategies to enhance the resilience of these vulnerable communities. Recommendations include promoting climate-smart agriculture, diversifying income sources, strengthening social safety nets, and building on local knowledge systems.

This research contributes valuable insights for policymakers and development practitioners working to address climate change impacts in mountainous and ethnically diverse regions, emphasizing the importance of targeted interventions that consider the unique challenges and capacities of different ethnic minority communities in the face of climate change.

## Acknowledgments

This article was made possible through funding provided by World Vision Vietnam (WVV) under the research project: "Study on the inclusion of viable climate change resilience interventions in WVV's existing technical programs and area programs". The author would like to thank the editor and two reviewers for their valuable comments and suggestions, which significantly enhanced the quality of this manuscript.

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