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Climate change adaptation responses and human mobility in the Mekong Delta: local perspectives from rural households in An Giang Province, Vietnam

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Climate change influences the adaptation responses and mobility patterns of smallholder farmers across multiple scales. This study employed an inductive approach to observe smallholder farmers in An Giang Province in the Vietnamese Mekong Delta to compare the effects of various environmental and climate-related stressors on households with and without contributing migrant household members and on households of different income levels in two rural communes. We looked into the roles that adaptation responses and human mobility patterns play in the daily livelihoods of (translocal) households. We adopted a mixed-methods approach, which involved the administration of a livelihood survey among households in two rural communes ($N = 106$) and, subsequently, two focus group discussions, unstructured in-depth interviews, and secondary data analysis. We discovered that human mobility, adaptation responses, and climate change are interwoven in a web of complex relationships. No clear differences in effects and climate adaptation responses were discovered between emigrant and nonemigrant households. Hence, paradigms that either portray migration as a failure to adapt or as a form of adaptation in the context of climate change do not adequately explain the findings of this study. Differences between income groups were, however, observed. Relative to other income groups, middle-income farmers were disproportionally affected by climate-related disasters. Additionally, out-migration, aging, upstream hydropower development, and COVID-19 lockdowns posed significant challenges to the livelihoods of smallholder farmers. The compound effects of these multiple stressors indicate that human mobility, climate change and adaptation patterns should be best approached as 'wicked' problems.

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Introduction

According to the Sixth Assessment Report of the Inter-governmental Panel on Climate Change (IPCC), climate change and extreme weather events can severely affect the livelihoods, food security, socioeconomic status, health, and security of individuals worldwide, and can lead to increased migration and displacement (Pörtner et al., 2022). Migration, especially environmental migration, is linked in the academic literature to climate-change adaptation in several ways: some studies perceive it as a failure of household adaptation, whereas others celebrate it as an adaptation opportunity (Maretti et al., 2019; Pörtner et al., 2022). Environmental migrants are often defined as "persons who are displaced primarily for environmental reasons" (Koubi et al., 2016b, p. 440). Studies have linked the phenomenon of environment migration to climate change and climate-related disasters (Dun and Gemenne, 2008; Piguet, 2010; Maretti et al., 2019; Cattaneo et al., 2019; Milán-García et al., 2021). Such studies that predict that climate change will imminently affect human mobility patterns are often publicized in media reports (Henley, 2020), international reports (Rigaud et al., 2018; UNHCR, 2020), and governmental national reports (The White, House, 2021). Estimates of the number of individuals that will be forced to become climate or environmental migrants (both domestically and internationally) in the near future vary, ranging from tens of millions to more than a billion (Rigaud et al., 2018; Henley, 2020; Burzyński et al., 2021).

Though the various push and pull factors in environmental migration are recognized to be environmental, socioeconomic, political, or psychological, the findings of studies that assess the influence of environmental factors on household decisions to migrate are inconsistent (Cattaneo et al., 2019). Additionally, research on environmental migration is often not in line with the doom scenarios outlined in publicized reports, such as the aforementioned. Some studies are overly environmentally deterministic (Myers, 2002; Xu et al., 2020), whereas others tend to focus on the socioeconomic and micro-level factors and determinants in addition to the environmental factors that lead individuals and households to migrate (Koubi et al., 2016a). Though many studies solely focus on investigating the environmental factors that influence household mobility patterns within the context of climate change (i.e., Koubi et al., 2016b), we argue against such scientific attempts. Instead, human mobility (which includes environmental migration), adaptation and climate change are interwoven in a web of complex relationships (Paprocki, 2020; Bayrak et al., 2022).

The present study employs a mixed-methods and inductive approach to compare the effects of various environmental and climate-related stressors on emigrant and nonemigrant households and households of different income levels in two rural communes (subdistrict administration units) in An Giang Province, which is a noncoastal province of the Vietnamese Mekong Delta (VMD). We specifically focus on the roles that adaptation responses and human mobility patterns play in the daily livelihoods of translocal households. The VMD was chosen because it is often labeled as a climate change "hotspot" and because millions of farmers in the region have been predicted to have migrated to urban areas due to their inability to adapt to climate change (Koubi et al., 2016b; Szabo et al., 2016). The VMD was also featured prominently in the Sixth Assessment Report of the IPCC as a region in Asia that requires priority in research (Shaw et al., 2022). By investigating beyond these alarmist scenarios, the present study provides a more nuanced understanding of how human mobility and adaptation responses have actually occurred on the ground and how these processes contribute to household efforts to deal with the effects of climate change at the delta scale.

This article is structured as follows. Section "Climate change, adaptation, and human mobility in the VMD and beyond" establishes a theoretical framework by outlining three main paradigms concerning human mobility and household adaptation responses in the context of climate change. Section "Research context and methods" discusses the methodology and research context. In the results and discussion section, we argue that there are no notable differences between emigrant and nonemigrant households concerning climate-change impacts and adaptation responses. We identify several threats related to the livelihoods and mobility patterns of emigrant and nonemigrant households and households of different income levels (low, middle, and high). We also discuss broader (transboundary) adaptation challenges, such as COVID19 lockdowns and upstream hydropower development. The final section is the conclusion and presents our reflections on the limitations of this study and our recommendations for future research.

Climate change, adaptation, and human mobility in the VMD and beyond

The VMD, which is known as the rice basket of Vietnam, has been a subject of interest in several studies on environmental migration, adaptation, and challenges. A study published in *Science* warned of the possible sinking of the delta due to land subsidence driven by upstream hydropower development, sand mining, excessive pumping of groundwater, and government development policies (Kondolf et al., 2022). Other environmental problems faced by the VMD are also linked to climate change (Brown et al., 2018), sea-level rise and salinization (Chapman and Darby, 2016; Chapman et al., 2017; Khong et al., 2020), flooding (Hoang et al., 2018), erosion (Marchesiello et al., 2019), upstream hydropower development (Eyler et al., 2020), and disruptions of suspended sediment flux (Bussi et al., 2021). Many of these studies assume that these adverse impacts will trigger increased out-migration flows in the delta (Bayrak et al., 2022), especially among smallholder rice-farmers migrating to "urban centers that are already foci of subsidence" (Kondolf et al., 2022, p. 583). While some studies have specifically focused on the factors influencing human mobility patterns in the VMD (Dun, 2011; Koubi et al., 2016a; Tran, 2019), there is no clear consensus on how the relationships between environmental change, human mobility, and adaptation are formed (Bayrak et al., 2022). This study attempts to explore the different paradigms on human mobility and adaptation, and how they inform the theoretical framework of this study.

We proposed that the three main paradigms of human mobility and adaptation are: (1) migration as a failure to adapt, (2) migration as a form of adaptation, and (3) migration as a 'wicked' phenomenon (cf. Black et al., 2011; Cattaneo et al., 2019). The first paradigm indicates that people move when environmental stressors or thresholds have made current livelihood strategies untenable (Bardsley and Hugo, 2010). People who fail to adapt, that is, who are unable to change their livelihood strategies, might opt to migrate. This paradigm has become less relevant in contemporary environmental migration literature (Cattaneo et al., 2019); however, it is often an implicit assumption in environmental change studies that do not employ migration or human mobility as their primary focus (Bayrak et al., 2022). For instance, studies that focus on one of the aforementioned environmental challenges in the VMD often assume that the challenges will inadvertently turn millions of people into environmental migrants or climate refugees (cf. Chapman & Tri, 2018). Therefore, migration is often implied to be a household's failure to adapt to challenges in origin areas (see Bayrak et al. (2022) for a more in-depth discussion).

The second paradigm has gained a stronger foothold in the environmental migration literature (Piguet, 2010; Black et al., 2011). Scheffran et al. (2012) investigated environmental migration by employing three approaches. The first approach involves avoiding forced migration as a response to distress (adaptation preventing forced migration). Farmers and communities have developed various adaptation mechanisms to deal with environmental challenges. These mechanisms include seasonal or temporal migration. The second approach, migration-as-adaptation, involves an adaptive response to environmental stressors and shocks when local adaptation and protection efforts are ineffective or insufficient. Families might send out individual household members to diversify the household's income, gain knowledge, spread risk, and improve their capability to sustain the livelihood and resilience of the community. The third approach, migration-for-adaptation, involves enabling new migrants to seek opportunities, acquire new resources, and establish new networks in host regions. These migrants transfer their new capabilities and resources to their origin communities. The third approach involves knowledge and technology transfer, social capital strengthening, remittances, and return migration. This allows left-behind communities to diversify their livelihoods, support climate adaptation, and strengthen livelihood resilience (Scheffran et al., 2012; Szabo et al., 2018).

The third paradigm rejects a causal relationship among environmental change, migration, and adaptation, and indicates that migration decisions and patterns are 'wicked' problems (Boas et al., 2018). A 'wicked' problem is complex and unstructured, difficult to define and delineate from other often bigger problems, and poses a constant challenge because its resolution may be difficult to determine (Jentoft and Chuenpagdee, 2009; Boas et al., 2018). To understand how and why people migrate within the context of environmental stressors and shocks, one should focus on structural determinants, such as political economy and ecology; power relations, which may be unequal; underlying socioeconomic and historical drivers; government policies; and transboundary governance challenges and micro-level factors, such as psychological factors, cultural aspirations, and personal desires and motivations that coshape or codetermine human mobility patterns (Wrathall et al., 2014; Baldwin and Bettini, 2017; Radel et al., 2018; Bayrak et al., 2022). Though most mainstream studies have understood environmental migration as being caused by multiple factors (Gemenne, 2011; Boas et al., 2019; Burzyński et al., 2021), studies that are more critical argue against isolating environmental factors from other structural determinants and power relations that lead households and individuals to migrate (Bettini and Andersson, 2014; Paprocki, 2020). Hunter and Simon (2022) argued that migration theory needs to be considered in climate scenarios to prevent the development of environmentally deterministic explanations for human mobility and climate change.

In the present study, the aforementioned paradigms informed the development of a theoretical lens. In the scope of this study, we focus specifically on climate-change impacts and adaptation responses between different household groups based on their emigration and income status rather than their motivations and reasons to migrate, the latter being beyond the scope of current study. First, we investigated the extent to which farmers in An Giang Province are exposed to environmental shocks and stresses and climate-related disasters. Second, we identified the adaptation strategies, including temporary and permanent migration, of local households to these stresses and shocks. Last, we analyzed the differences between emigrant and nonemigrant households, and between households of low, middle, and high incomes to understand which factors coshape household climate-change adaptation responses within the context of transboundary challenges and structural determinants that reshape the development landscape of the VMD and associated livelihoods.

Research context and methods

Research context. An Giang is one of the 13 provinces and cities, and most populated province in the VMD. It has a population of approximately 1.9 million people with a population density of 540 people/km^2 in 2019 (People's Committee of An Giang Province—PCAGP, 2019). The province consists of 2 cities, 1 town, 8 rural districts, and 156 communes. With 68.42% of the population living in rural areas, An Giang's economy is based primarily on the agricultural industry. In 2018, 84.39% of An Giang's total land area (353,668.02 ha) was devoted to rice agriculture (PCAGP, 2019). Furthermore, An Giang is a multi-ethnic province with the Kinh taking the largest proportion of the provincial population (95.15%), followed, respectively, by the Khmer (3.98%), Cham (0.59%), and Chinese (0.27%) (General Statistics Office of Vietnam—GSO, 2019).

An Giang is located in the upper part of the VMD. Households in An Giang are significantly negatively affected by climate-related disasters, and excessive flooding in particular (Chapman and Darby, 2016; Tran and Weger, 2018). In 2011–2016, economic losses in the area due to climate-related disasters amounted to approximately US$64 million (VND1,463 billion) (General Statistics Office of Vietnam—GSO, 2019). An Giang has one of the highest out-migration rates in the VMD. For instance, in 2019, 72.1 per 1000 people migrated out of the province (GSO, 2019). Since 2000, An Giang has—like other provinces in the VMD—undertaken massive flood-control programs, with dyke heights varying from 0–2 to 3.5 m or higher. These efforts drastically reshaped the flood infrastructure in the province. The dyke systems in An Giang are meant to prevent flooding and facilitate triple rice cropping; however, they also limit the supply of fluvial sediment reaching the floodplain (Manh et al., 2015; Chapman et al., 2016). Traditionally, farmers in An Giang have practiced annual single or double rice cropping because of seasonal flooding. Currently, double and triple rice cropping are the two primary farming systems within An Giang's dyke rings (e.g. Bac Vam Nao scheme), and are contingent on the regulatory operations of low and high dykes (Chapman and Darby, 2016; Binh et al., 2022). All of these factors contributed to the justification of our selection of An Giang Province as a case study. While coastal provinces in the VMD might face climatic challenges such as higher sea-level rise and saline intrusion (Manh et al., 2015; Marchesiello et al., 2019), relatively little is known about how out-migration patterns have occurred in the upper part of the VMD within the context of coupled climatic and hydopower development challenges. Findings of this study could thus contribute to the extant literature on climate change and rural adaptive livelihoods in the VMD and the broader context of the Mekong region.

Two rural communes in An Giang of contrasting geographical characteristics were selected: Le Tri in Tri Ton District, and Binh Phu in Chau Phu District (Fig. 1). In particular, Le Tri commune is mostly located in an upland area with an elevation of 1–700 m above sea level, and was reported to be home to 5859 people in 2019 (Son, 2007; People's Committee of Le Tri commune—PCLTC, 2019). In 2020, Le Tri had the highest poverty rate in the district [approximately 21.3% of residents earned ≤VND755,000 (approximately $US32) a month]. Economic activities in the commune were primarily based on agriculture and forestry, with the agricultural land accounting for 69.4% of the commune's total land. According to the local government statistics, Le Tri often experiences severe droughts in the dry season and flash floods caused by monsoon rains (PCLTC, 2019). Located in the
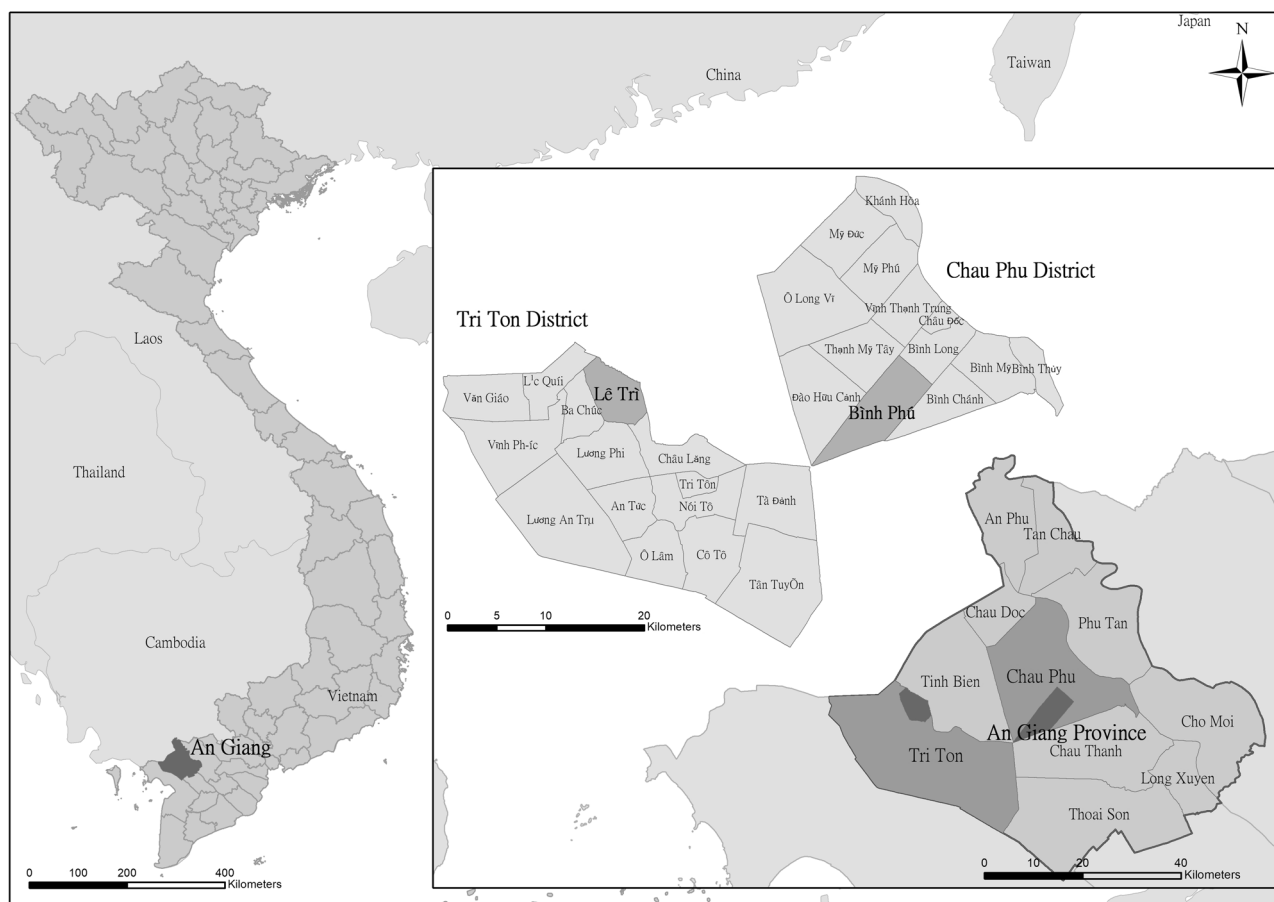
Fig. 1 Study sites in An Giang Province, Vietnam (data retrieved from: GADM, 2020).

lowlands, Binh Phu commune is traditionally prone to flooding. Home to 7394 people, the commune had a poverty rate of approximately 14.8% in 2020. Binh Phu has a total agricultural area of 4481 ha out of a total land area of 4779 ha (PCBPC, 2020). Since 2010, full dyke systems have been built in both communes. This has had a considerable effect on farmers in Binh Phu because the decrease in flooding events has drastically reduced soil fertility in the commune.

Methods and data analysis. This study adopted the mixed-methods sequential explanatory design guided by Creswell and Clark (2018). Following this inquiry strategy, we first administered a survey among 106 households (Le Tri, $n = 55$; Binh Phu, $n = 51$), which was followed by the undertaking of two focus group discussions (FGDs) in each commune, unstructured in-depth interviews with farmers and government officials ($n = 6$), and desk research. Additionally, one of the co-authors of this paper is a native of Tri Ton District and was able to link the study's findings to the lived experiences of people in the district. The main research activities were conducted from October to December 2020, followed by in-depth interviews in August 2022. Doing fieldwork during the height of the COVID-19 pandemic was challenging but gave us an opportunity to empirically investigate how COVID-19 lockdowns affected mobility patterns and household livelihoods.

We employed a stratified sampling strategy to randomly select households for the survey (De Vaus, 2013). Using the commune statistical handbooks on income categories, we divided households into three categories on the basis of income level, namely low, middle, and high. In Le Tri

commune, the total number of households was 1568; 21%, 58%, and 21% of them were high-income, middle-income, and low-income households, respectively. In Binh Phu commune, high-income, middle-income, and low-income households comprised 26.2%, 60%, and 14.8%, respectively, of the 2018 total households. For each income level, we selected approximately 15–20 households and approached every fifth household in each stratum until our criteria were met. The sample size was selected with consideration of the time and resources allocated for the research. A total sample size of 100 or more was eligible for conducting our inferential statistical analyses (Onwuegbuzie and Collins, 2007).

The administered questionnaire consisted of four parts. In the first part of the questionnaire, we asked about the various livelihood strategies of the respondents and their household members. The second part assessed how climate-related issues, especially the 2015–2016 and 2019–2020 droughts, affected livelihoods, property, and agriculture-related assets (cf. Binh et al., 2022). The catastrophic droughts in 2015–2016 and 2019–2020 in the VMD were selected because previous studies have highlighted these as focusing events (Loc et al., 2021). In the present study, a focusing event was defined as "a sudden, exceptional experience that, because of how it leads to harm or exposes the prospect for great devastation, is perceived as the impetus for policy change" (Michaels et al., 2006, p. 983). The third part of the questionnaire consisted of a 5-point Likert-scale with statements investigating respondents' perceptions of climate-related disasters, adaptation strategies, migration, risk appraisal, and the effects of COVID-19 on their livelihoods. The last part of the questionnaire investigated the socioeconomic backgrounds of respondents.

We employed descriptive statistics, correlation analyses, Student's *t* tests, and post hoc analyses for quantitative analysis. Depending on whether the assumptions of equivalence of variance were violated or not, Games-Howell or Scheffe's post hoc tests were performed, respectively, to investigate differences between the three income groups (cf. Lee and Lee, 2018). The Likert-scale items were analyzed both in terms of the frequency of responses in the various categories and a calculation and comparison of the mean scores for each item. The endpoints ranged from 1 (*completely disagree*) to 5 (*fully agree*; cf. Sullivan & Artino, 2013). We compared differences between the two communes, between emigrant ($n = 55$) and nonemigrant households ($n = 51$), and between households of different income levels. Emigrant households were defined as those in which household members reside permanently outside of the commune (>50%), are migrants themselves, or are recently returned (within the previous 5 years) former migrants. We considered a *p*-value of <0.05 or <0.1 to indicate statistical significance. The data were analyzed in SPSS, PowerBI, and Microsoft Excel.

FGDs were conducted in each commune. Representatives of approximately 10 households participated in each FGD. Representatives were selected on the basis of gender, income, livelihood, and migration status to ensure a variety of perspectives was obtained. Each FGD lasted for approximately 3 h, involving intensive discussions on: (1) a timeline of the preceding 10 years of major climate-related disasters in the commune; (2) participatory mapping exercises; and (3) major changes in the commune over the past 10 years, particularly in relation to out-migration, adaptation strategies, and the COVID-19 pandemic. The results from the FGDs and in-depth interviews were analyzed using a thematic framework and were primarily used to contextualize and understand the survey findings.

Last, we conducted desk research that involved the collection and analysis of secondary data. These included statistical handbooks, relevant journal articles, and government reports on local socioeconomic development. The secondary data were analyzed to provide a broader understanding of the study context and to complement the study findings. These documents can be found in the reference list of this article.

Results and discussion

Descriptive statistics. Table 1 shows the descriptive statistics of the surveyed respondents. No significant differences were observed between the two communes. The average age of the respondents was 50.22 years, suggesting that the populations of both communes were aging. The dependency on remittances for both communes was at 15.43% out of an average yearly income of VND94,682,214 (US$4028). Khmer individuals in Le Tri commune were underrepresented in this study. Although 51.2% of the total population in the commune was Khmer, only 14.5% of respondents were Khmer. The average household size in both communes was 4.9 individuals, which was larger than the national average (3.6 individuals; GSO, 2019). Approximately 33.0%, 36.8%, and 30.2% of the sample were classified as high-income, middle-income, and low-income households, respectively. Out-migration was both temporary (less than 6 months per year) and permanent. In total, 76.7%, 14.0%, and 4.65% of the migrant household members moved to Binh Duong province, Ho Chi Minh City, and Long Xuyen City, respectively.

Climate-related stressors and effects. Figures 2 and 3 show the adverse effects of excessive flooding, drought, heatwaves and higher temperatures, and unpredictable rainfall on the respondents' agricultural output and productivity, property, livestock, opportunity to work, and water supply over the past 10 years. Overall, the findings show that these perceived challenges are more nuanced among the selective dimensions, with the "no impact" category as the most frequently opted. Though, the most problematic issues over the past 10 years in Binh Phu were unpredictable rainfall, excessive flooding and drought, of which 42%, 32%, and 21% of the respondents experienced very severe or

| Table 1 Descriptive statistics of survey respondents.						
	Le Tri ($n = 55$)		Binh Phu ($n = 51$)		Total ($n = 106$)	
	%	abs	%	abs	%	abs
Ethnicity						
Kinh	83.6	46	98.0	50	90.6	96
Khmer	14.5	8	2.0	1	8.5	9
Hoa (Chinese)	1.8	1	0.0	0	0.9	1
Gender						
Female	49.1	27	70.6	36	59.4	63
Male	50.9	28	29.4	15	40.6	43
Emigration status						
Emigrant HH	45.5	25	58.8	30	51.9	55
Nonemigrant HH	54.5	30	41.2	21	48.1	51
Income categories						
Low	27.3	15	33.3	17	30.2	32
Middle	34.5	19	39.9	20	36.8	39
High	38.2	21	27.5	14	33.0	35
	Mean	SD	Mean	SD	Mean	SD
Household size	4.78	2.21	5.02	2.56	4.90	2.38
Children in household	1.45	1.18	1.51	1.50	1.48	1.34
Age (years)	49.45	12.13	51.04	10.78	50.22	11.47
HH yearly income (VND)	92,223,846 [3924 USD]	64,757,994	97,188,784 [4135 USD]	96,785,391	94,682,214 [4028]	81,822,307
Remittance as a proportion of total household income (%)	14.26	26.49	16.68	30.36	15.43	28.30
Temporarily migrated family members	0.11	0.37	0.67	2.41	0.38	1.71
Permanently migrated family members	0.64	0.99	0.55	0.95	0.59	0.96
Land-size (m², owned)	8632.22	14,519.02	7701.37	21,964.77	8184.36	18,394.82
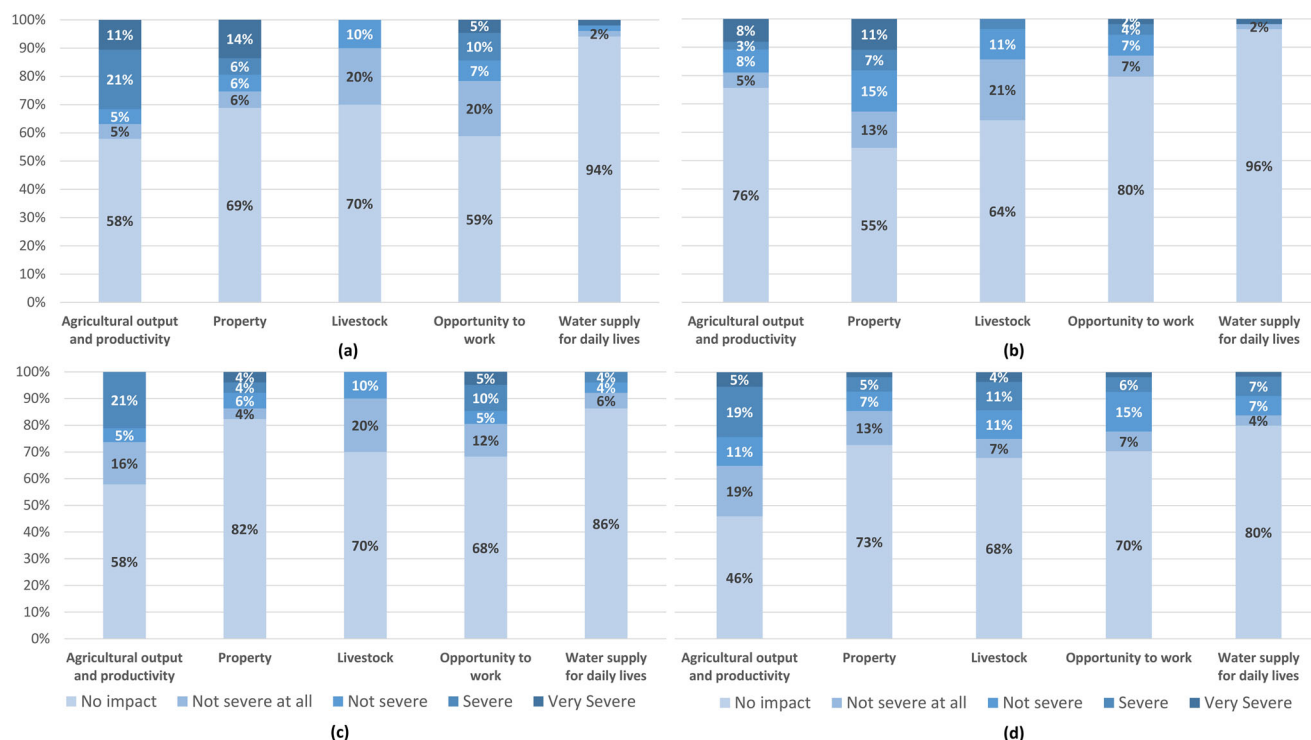
Fig. 2 Adverse climate change impacts on households in both communes. Excessive flooding on Binh Phu (**a**); excessive flooding on Le Tri (**b**); drought on Binh Phu (**c**); and drought on Le Tri (**d**).
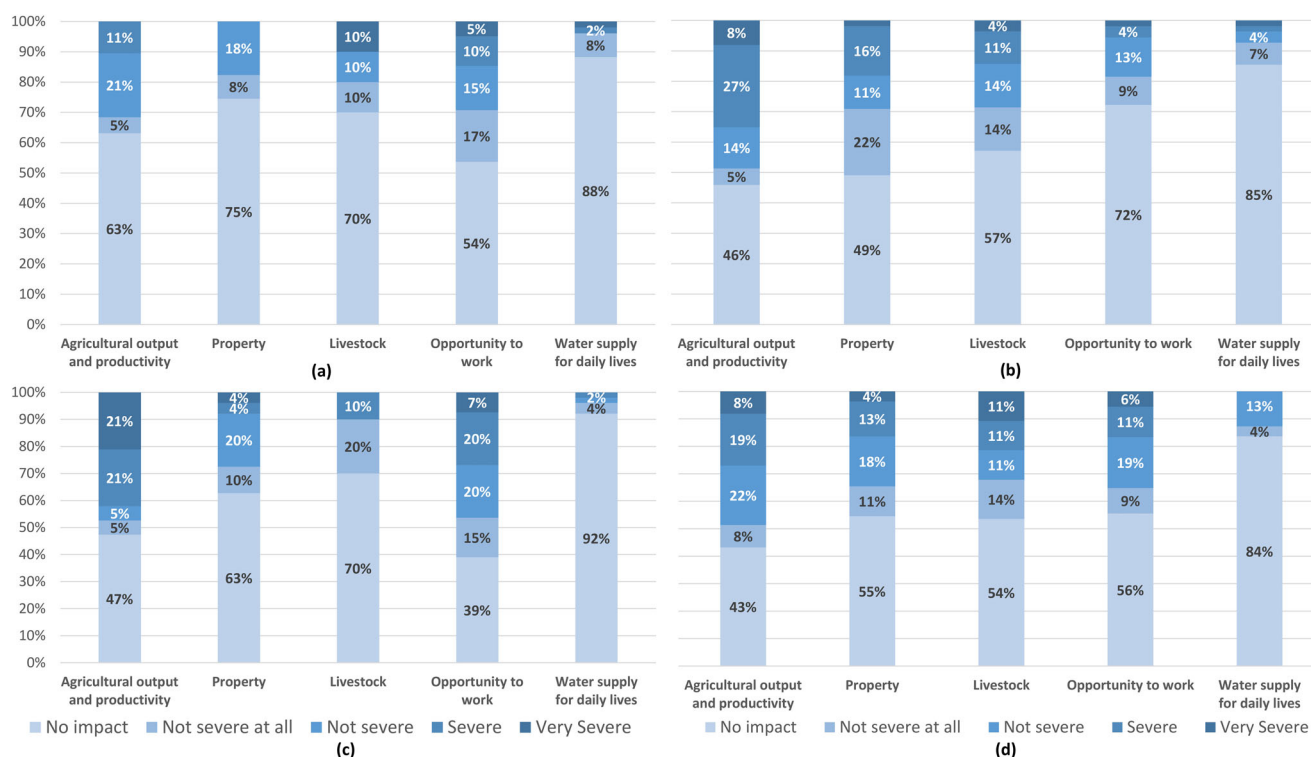

Fig. 3 Adverse climate change impacts on households in both communes (cont'd). Heatwaves on Binh Phu (**a**); heatwaves on Le Tri (**b**); unpredictable rainfall on Binh Phu (**c**); and unpredictable rainfall on Le Tri (**d**).

severe adverse effects on their agricultural output and pro-ductivity, respectively. For Le Tri, the most problematic issues were heatwaves (35%), unpredictable rainfall (27%) and drought (24%). This finding is more or less consistent with local

governmental reports, as discussed in section "Research context and methods", and corroborate the findings of the FGDs. In Le Tri, for instance, the FGD participants stated that unusual weather patterns and rainfall have substantial effects on local

Table 2 Estimated damage from the 2015–2016 and 2019–2020 drought events by survey respondents.

Monetary damage (VND):	Le Tri		Binh Phu		Total	
	Mean	SD	Mean	SD	Mean	SD
2015–2016	6,238,636 [266 USD]	10,196,0367	3,863,636 [164 USD]	10,278,881	5,051,136 [215 USD]	10,248,364
2019–2020	7,351,170 [312 USD]	12,792,726	3,465,957 [147 USD]	8,749,839	5,408,564 [230 USD]	11,073,825
Affected land (m²):						
2015–2016	2133.33	6870.89	1407.35	6390.251	1778.59	6612.312
2019–2020	1729.64	5995.39	1578.16	5077.038	1656.34	5540.456
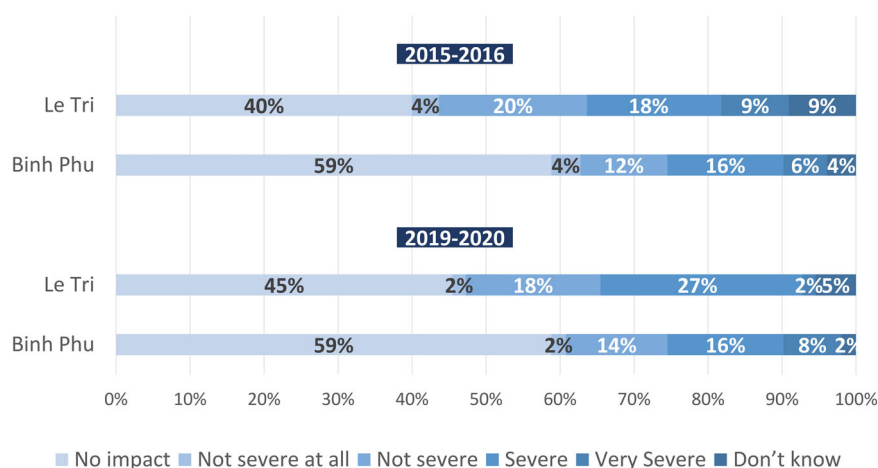
Fig. 4 Subjective assessment by survey respondents of the severity of the 2015–2016 and 2019–2020 drought events.

agricultural production and seasonal husbandry. One respondent reported that her ducks had stopped laying eggs due to 'unusual sunlight' and changing weather patterns (FGD Le Tri 2020). In Binh Phu, FGD participants complained that their fruit crops, such as Thai jackfruit, tomato, mango and lemon, were severely affected by unpredictable weather events (FGD Binh Phu 2020). Climate-related stressors, such as unpredictable rainfall in both communes and heatwaves in Le Tri, affected respondents more than flooding and drought events did. This finding is important because the former is a direct consequence of changing climatic conditions, whereas the latter is affected by other factors, such as flood infrastructure, transboundary water governance, government policies, and other anthropogenic drivers (Park et al., 2021). Concomitantly, the lack of flooding also negatively affected the livelihoods of respondents in Binh Phu: FGD participants stated that the fish stock has severely declined due to a lack of flooding in 2020 (FGD, Binh Phu 2020). This seemingly contradictory finding reiterates the initial statement that the adverse impacts of climate change are often more nuanced and complex.

The occurrence of the drought events in 2015–2016 and 2019–2029 suggests that the VMD has been confronted with the aggravating effects of climate change. The 2015–2016 drought was considered to be the worst event in the VMD in 90 years (Lee and Dang, 2019) until the 2019–2020 drought, which was even worse. Park et al. (2021) labeled the 2019–2020 event the worst saline water intrusion disaster of the past century, which corroborates Loc et al.'s (2021) study. In the present study, both drought events are closely linked to climate change and other structural and geophysical driving factors, such as upstream hydropower development, riverbed sand mining, sea-level rise, and land subsidence (Eyler et al., 2020; Loc et al., 2021; Park et al., 2021). These two drought events had significant but uneven effects on the respondents (Table 2; Fig. 4).

Drought events come at a considerable cost at the household level. The estimated monetary damage of the drought events was

on average VND6–7 million for each household in Le Tri and VND3–4 million for each household in Binh Phu. No statistically significant differences were identified between the two communes. Within the communes, respondents were divided based on how much effect the drought events had on their livelihoods (Fig. 4). In Binh Phu, 70.6% and 66.7% of respondents stated that they did not experience any notable financial burden from the 2015–2016 and 2019–2020 drought events, respectively. For Le Tri, these numbers were 45.5% and 50.9%, respectively. This indicates that the effects within communes were highly uneven. In Binh Phu, 6%–8% of households experienced an estimated damage of VND20 million (US$860) or more; in Le Tri, 10%–16% of households experienced a similar damage. Similar trends were identified for the estimated damages on agricultural land (Table 2).

Livelihood and adaptation strategies. The respondents in both communes employed multiple livelihood strategies. In Le Tri, 40.0% of the respondents reported engaging in business and offering services, which mainly involved renting out machinery and labor to other farms, at the time of being surveyed. Other frequently employed livelihood strategies were engaging in factory jobs (30.0%), livestock rearing (38.2), and land labor (18.2%). Triple and double rice cropping accounted for 14.5% and 16.4% of the employed livelihood strategies of the respondents, respectively. In Binh Phu, respondents engaged in business and services (45.1%), factory work (27.5%), land labor (25.5%), and double-crop (13.7%) and triple-crop (11.8%) rice farming (see Appendix A). The primary reasons for respondents in both communes, especially poor respondents, of not being able to engage in rice farming were attributed to not owning land, personal choice, not having enough time, bad health, old age, and a lack of money and skills. Environmental factors played a limited role. Flooding

C1: Drought has become worse over the past 10 years.
15% | 47% | 19% | 12% | 7%

C2: Flooding has become worse over the past 10 years.
4% | 23% | 18% | 36% | 19% | 1%

C3: Unpredictable rain events have become worse over the past 10 years.
7% | 58% | 16% | 8% | 10% | 1%

C4: My household can cope with climate-related issues independently.
26% | 30% | 16% | 10% | 11% | 6%

C5: The district government supports us to cope with climate-related issues.
5% | 18% | 5% | 34% | 34% | 5%

C6: My household changed our agricultural practices because of climate-related issues.
4% | 17% | 6% | 35% | 31% | 8%

C7: My household is using more salt-tolerant varieties over the past 10 years.
2% | 1% | 27% | 45% | 25%

C8: I am developing more individual dikes because of climate-related issues over the past 10 years.
4% | 13% | 8% | 38% | 31% | 7%

C9: My household shifted to aquaculture because of climate-related issues.
5% | 4% | 41% | 43% | 8%

C10: My household shifted to non-farm activities because of climate-related issues.
1% | 9% | 9% | 34% | 41% | 8%

C11: Over the past 10 years, my household is facing more financial difficulties.
21% | 43% | 17% | 8% | 8% | 3%

C12: Over the past 10 years, I have borrowed more money from the bank.
8% | 25% | 13% | 30% | 22% | 2%

C13: Over the past 10 years, I have borrowed more money from friends/shops.
4% | 28% | 8% | 36% | 24% | 1%

C14: My household is more dependent on remittances from family members outside the commune over the past 10 years.
6% | 10% | 5% | 33% | 43% | 3%

C15: Over the past 10 years, I have more difficulties growing rice and other crops.
4% | 24% | 4% | 22% | 42% | 6%

C16: Over the past 10 years, I have received government subsidies to help me with farming.
2% | 6% | 3% | 38% | 43% | 8%

C17: I am afraid that in the next few years drought will worsen in our commune.
5% | 32% | 30% | 9% | 13% | 10%

C18: Me and my household would like to migrate because of climate-change related issues in the next few years.
1% | 3% | 7% | 34% | 56%

C19: Covid19 has a significant impact on our livelihood.
13% | 29% | 11% | 18% | 28%

■ Fully agree   ■ Agree   ■ Neutral   ■ Disagree   ■ Completely disagree   ■ Don't know

Fig. 5 Household statements on adaptation responses, human mobility and broader challenges.

(3.48%), a lack of water retention (0.85%), and land being unsuitable for cultivation (1.74%) were some of the reasons that restricted respondents from engaging in rice farming. Nonetheless, FGD participants in both communes proclaimed that especially monoculture rice-farmers were negatively affected by unpredictable rainfall and storms (FGDs in Binh Phu and Le Tri, 2020).

Most respondents agreed that drought and unpredictable rain events have worsened over the past 10 years (Fig. 5 and Appendix B; Statements C1 and C3); however, mixed responses were provided in relation to worsening flooding events over the past 10 years (C2). A statistically significant difference was observed between the communes concerning Statement C3, with mean scores of 3.69 and 3.17 for Binh Phu and Le Tri, respectively. A majority of the households claimed to be able to cope with climate-related issues independently (C4); however, how they dealt with the situations was unclear. To cope with climate stressors, most respondents generally did not adapt their agricultural practices (C6), did not plant saline-tolerant varieties (C7), did not heighten individual dykes (C8), and did not shift to aquaculture (C9) and nonfarming livelihood activities (C10). Additionally, only 23% of respondents claimed to receive support from the district government for coping with climate stressors (C5). This finding contrasts with those of other case studies in the

VMD that showed that farmers diversified or adapted their livelihood strategies to cope with or adapt to environmental change by, for example, shifting to shrimp farming (Poelma et al., 2021), triple-crop rice farming (Chapman and Darby, 2016), and nonfarming livelihood activities (Tri et al., 2019); adapting their agricultural activity calendars (Tri et al., 2019); or planting saline-tolerant varieties (Paik et al., 2020).

A majority of the respondents claimed to have faced more financial difficulties over the past 10 years (C11); however, mixed responses were provided on how they mitigated these difficulties [e.g., borrowing more money from the bank (C12) or from friends or shops (C13)]. The role of remittances did not increase in its importance over the past 10 years (C14) and neither did that of subsidies from the government (C16). The majority of the respondents claimed not to have encountered more difficulties with growing rice and other crops over the past 10 years (C15), although the majority of respondents in both communes engaged in non-farm livelihood activities, such as business and providing services. In total, 37% of respondents expected drought events to worsen in the next 10 years (C17); however, only 4% of respondents, mostly poor households, considered out-migration as a means of coping with climate stressors (C18). The latter finding will be further explored in the next two sections.

More strikingly, 42% of the respondents' perceived COVID-19 lockdowns as placing a significant burden on their livelihoods (C19). During the in-depth interviews and FGDs, the emigrant households in particular stated that COVID-19 lockdowns were a livelihood burden. The findings showed that some migrants who engaged in factory work had to return to their villages due to company shutdowns and an inability to afford daily expenses in cities. Some cases of rural-to-urban remittances were also observed; household members in the city had more difficulties obtaining bank loans to compensate for their loss of income than their families in rural areas did. Emigrant households borrowed money from the agricultural banks to send to their household members outside of the commune. Those who stayed at the commune also faced several livelihood burdens: for instance, some households had problems selling their livestock and eggs to outside distributors. These together have substantial effects on household livelihood resilience and the wider food security in the region (cf. Lebel et al., 2021).

Differences between emigrant and nonemigrant households. With the exception of statements C13 and C14, no statistically significant differences were observed between the statements provided by the emigrant and nonemigrant households (Fig. 5 and Table 3). For the emigrant households, approximately 29.73% of the yearly income was obtained from remittances, while for the nonemigrant households, 0.00% was reported. Emigrant households also had a significantly higher household size than nonemigrant households, with an average of 5.38 for the former and 4.37 for the latter. With the exception of the aforementioned, no significant differences were noted between how these households were affected by the 2015–2016 and 2019–2020 drought events. In addition, no statistical differences in terms of average income, land size, or any other socioeconomic indicators were observed between the groups (Table 3). However, when remittances are excluded, the emigrant households had a lower yearly income and borrowed money more often from friends and shops than their counterparts did.

These findings suggest that emigration status had no significant effect on how households were affected by climate-related disasters and how they subsequently shaped their adaptation strategies. This was also reflected in how respondents linked out-migration with climate-related issues. For instance, 90.2% and 86.3% of the nonemigrant households, respectively, stated in the survey that they were not likely at all to migrate to cities or other rural districts because of climate-related issues. Households currently having migrant members ($n = 47$) were divided on whether their family members migrated permanently or would eventually return to the commune. The lack of jobs in the city due to COVID19 (27.5% of the respondents ascribed this to be a completely or very likely reason for their migrant household members to return); to help their family out with farming (23.4%); or having new livelihood opportunities in the commune (21.2%) were some of the underlying conditions why migrant household members would return to the commune according to the respondents. Thus, migration was not always perceived by the respondents as a permanent phenomenon, but rather as opportunity-driven and dynamic, with migration patterns being often perceived as temporary and circular.

Conclusively, our findings better fit the third paradigm (migration as a 'wicked' phenomenon) than the other two paradigms on environmental migration (migration as a failure to adapt and migration as a form of adaptation). In the FGDs in both communes, environmental change caused by both climate and anthropogenic drivers was often linked to out-migration and was always mentioned in combination with other structural determinants, such as the mechanization of agriculture, poverty, upstream hydropower development and government policies (cf. Tran, 2019). Recurring crop failures, whether they were caused by environmental, climate or anthropogenic factors, were not perceived by the FGD participants and interviewees to be the main driving force for people to migrate (both temporarily or permanently), but it was rather lack of alternative work, such as seasonal land labor, being often no longer available due to the mechanization of agriculture and restructuring of the rural economy in the VMD.

Differences between income groups. In addition to emigration status, we compared the three income category groups (low, middle, and high) across several dimensions. The statistically significant results are presented in Tables 4 and 5. As expected, significant differences were observed between the three groups in terms of household yearly income and land ownership (Table 4). A significant difference was observed between the average percentage of remittances in relation to total income between the low-income and high-income households, which was 28.16% for the former and 6.81% for the latter, but not for the low-income and middle-income households or for the middle-income and high-income households. This indicated that low-income households were relatively more dependent on remittances than high-income households were (cf. Barney, 2012). Furthermore, although significant differences were observed between the low-income and high/middle-income households regarding the financial burden of the 2015–2016 and 2019–2020 droughts, no significant differences were observed between the middle-income and high-income households. This indicated that middle-income households were disproportionately affected by the droughts. Additionally, a correlation analysis was conducted focused on the financial burden of the 2015–2016 drought and 2019–2020 drought, and a moderate correlation was found (0.522; $p < 0.001$). The VMD is bracing for more years of severe droughts (Hunt, 2022), and this presents a real risk to these same households who may be negatively affected once again.

In terms of the household statements (Table 5), low-income households felt less prepared to cope with climate-related issues independently than high-income households did (C4; $p = 0.070$). In addition, high-income households changed their agricultural practices more often than low-income households did (C6). Although low-income and middle-income households faced more financial difficulties than high-income households did, no significant difference was observed between the two income levels. Low-income households stated more frequently that they borrowed more money from friends or shops over the past 10 years (C13) than the households of the high income level did, which made them more vulnerable to falling into debt. Furthermore, significant differences were observed between the low-income and high-income households and low-income and middle-income households regarding facing more difficulties with growing rice and crops over the past 10 years (C15), with the middle-income and high-income households facing relatively more difficulties. No significant differences were observed between middle-income and high-income households' responses for this statement, reiterating the finding that middle-income households were disproportionally negatively affected by climate-related disasters. Smaller-scale farmers in An Giang often become more vulnerable to external stressors when they transition to a triple-cropping system (Chapman and Darby, 2016). However, why the present study's findings indicate that middle-income farmers are disproportionally affected by climate-related disasters remains unclear. Anecdotal evidence indicates that many low farmers lack the ability to transition to triple-cropping systems,

Table 3 Differences between emigrant and nonemigrant households.

Dimensions: Statement C1-19	Emigrant HH		Nonemigrant HH		Independent-samples T test		
	Mean	SD	Mean	SD	Levene	T	p-value
C1: Drought has become worse over the past 10 years	3.57	1.059	3.46	1.147	0.601	0.520	0.604
C2: Flooding has become worse over the past 10 years	2.50	1.160	2.63	1.149	0.077	−0.587	0.558
C3: Unpredictable rain events have become worse over the past 10 years	3.53	1.052	3.30	1.129	0.469	1.068	0.288
C4: My household can cope with climate-related issues independently.	3.35	1.412	3.71	1.225	3.846	−1.365	0.175
C5: The district government supports us (e.g., training or subsidies) to cope with climate-related issues	2.12	1.211	2.32	1.301	0.876	−0.810	0.420
C6: My household changed our agricultural practices because of climate-related issues.	2.19	1.197	2.24	1.238	0.280	−0.213	0.832
C7: My household is using more salt-tolerant varieties over the past 10 years.	1.44	0.641	1.49	0.675	0.202	−0.352	0.726
C8: I am developing (building/heightening) more individual dikes because of climate-related issues over the past 10 years.	2.22	1.263	2.08	1.047	3.026	0.620	0.536
C9: My household shifted to aquaculture because of climate-related issues.	1.80	0.866	1.55	0.679	0.481	1.558	0.122
C10: My household shifted to non-farm activities because of climate-related issues.	2.00	1.041	1.75	0.934	1.015	1.244	0.216
C11: Over the past 10 years, my household is facing more financial difficulties.	3.70	1.137	3.54	1.199	0.121	0.687	0.494
C12: Over the past 10 years, I have borrowed more money from the bank.	2.61	1.352	2.72	1.230	1.041	−0.429	0.669
C13: Over the past 10 years, I have borrowed more money from friends/shops.	2.75	1.280	2.28	1.161	3.273	1.945*	0.055
C14: My household is more dependent on remittances from family members outside the commune over the past 10 years.	2.51	1.353	1.44	0.705	29.132	5.070***	0.000
C15: Over the past 10 years, I have more difficulties growing rice and other crops.	2.10	1.345	2.35	1.347	0.346	−0.924	0.358
C16: Over the past 10 years, I have received government subsidies (money, fertilizer, larvae, etc.) to help me with farming.	1.72	0.994	1.76	0.894	0.309	−0.191	0.849
C17: I am afraid that in the next few years drought will worsen in our commune.	2.90	1.212	3.24	1.015	1.094	−1.483	0.142
C18: Me and my household would like to migrate because of climate-change related issues in the next few years.	1.55	0.872	1.64	0.749	0.121	−0.544	0.588
C19: Covid19 has a significant impact on our livelihood.	2.82	1.478	2.80	1.443	0.104	0.075	0.940
Estimated financial damage from the drought events							
2015-2016	6,266,667	12,106,347	3,779,070	7,795,987	6.873	1.151	0.253
2019-2020	4,8008,333	10,127,671	6,034,891	12,063,202	0.624	−0.535	0.594
Socioeconomic characteristics							
Household Size	5.38	2.792	4.37	1.697	3.187	2.228**	0.028
Children in household	1.67	1.552	1.27	1.041	1.090	1.539	0.127
Age (years)	51.95	11.806	48.35	10.910	0.010	1.623	0.108
HH yearly income (VND)	104,796,074	101,378,835	83,536,327	51,346,736	9.041	1.361	0.177
Remittance as a proportion of total household income (%)	29.73	33.53	0.00	0.00	119.805	6.575***	0.000
Land-size (m², owned)	7,318.84	20,309.354	9,117.76	16,229.465	0.005	−0.501	0.617

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$. Household statements were answered using a score between 1 (completely disagree) to 5 (fully agree).

Table 4 Differences among income groups and socioeconomic dimensions.

Socioeconomic dimensions	Income category	N	Mean	SD	Post hoc tests *p*-values (Games-Howell)
Household yearly income (VND)	Low	31	40,073,161.29	30855167.03	Low & Middle (0.00***)
	Middle	39	86,114,871.79	58587806.30	Middle & High (0.02**)
	High	33	156,106,666.67	97478264.07	Low & High (0.00***)
	Total	103	94,682,213.59	81822307.29	
How much land for farming/aquaculture ponds do you and your household? own (m^2)	Low	32	175.81	629.05	Low & Middle (0.02**)
	Middle	39	3,689.23	5905.57	Middle & High (0.03**)
	High	35	20,515.31	27668.73	Low & High (0.00***)
	Total	106	8,184.36	18394.82	
How much percentage of household income comes from remittances in one year?	Low	32	28.16	37.29	Low & Middle (0.117)
	Middle	39	12.71	24.03	Middle & High (0.456)
	High	35	6.81	17.99	Low & High (0.014**)
	Total	106	15.43	28.30	
What is the combined estimated financial damage on your farm, property or sources of income of the 2015–2016 drought	Low	24	41,666.67	204124.15	Low & Middle (0.005***)
	Middle	36	6,166,666.67	10778947.74	Middle & High (0.827)
	High	28	7,910,714.29	12463319.20	Low & High (0.007***)
	Total	88	5,051,136.36	10248363.98	
What is the combined estimated financial damage on your farm, property or sources of income of the 2019–2020 drought	Low	26	280,961.54	759752.62	Low & Middle (0.004***)
	Middle	37	7,664,864.86	13121022.49	Middle & High (0.975)
	High	31	7,016,129.03	11888708.84	Low & High (0.010***)
	Total	94	5,408,563.83	11073824.67	

***p* < 0.05; ****p* < 0.01.

Table 5 Difference among income groups and mean scores of the Likert-scale statements.

Household statements	Income category	N	Mean	SD	Post hoc tests *p*-values (Scheffe or Games-Howell)
C4: My household can cope with climate-related issues independently	Low	27	3.04	1.427	**Levene *p* > 0.05**
	Middle	39	3.62	1.184	Low & Middle (0.214)
	High	34	3.82	1.336	Middle & High (0.794)
	Total	100	3.53	1.329	Low & High (0.070*)
C6: My household changed our agricultural practices because of climate-related issues.	Low	27	1.85	1.027	**Levene *p* < 0.05**
	Middle	39	2.08	1.061	Low & Middle (0.665)
	High	32	2.69	1.401	Middle & High (0.114)
	Total	98	2.21	1.212	Low & High (0.029**)
C11: Over the past 10 years, my household is facing more financial difficulties	Low	30	4.00	1.203	**Levene *p* < 0.05**
	Middle	39	3.90	0.821	Low & Middle (0.915)
	High	34	2.97	1.218	Middle & High (0.001***)
	Total	103	3.62	1.164	Low & High (0.003***)
C13: Over the past 10 years, I have borrowed more money from friends/shops.	Low	31	2.84	1.293	**Levene *p* > 0.05**
	Middle	39	2.64	1.112	Low & Middle (0.796)
	High	35	2.11	1.255	Middle & High (0.182)
	Total	105	2.52	1.241	Low & High (0.058*)
C15: Over the past 10 years, I have more difficulties growing rice and other crops.	Low	28	1.46	0.962	**Levene *p* < 0.05**
	Middle	38	2.34	1.258	Low & Middle (0.006***)
	High	34	2.71	1.467	Middle & High (0.504)
	Total	100	2.22	1.345	Low & High (0.001***)

**p* < 0.1; ***p* < 0.05; ****p* < 0.01. Household statements were answered using a score between 1 (completely disagree) to 5 (fully agree).

unlike middle-income farmers, who are able to gather enough resources to do so while facing heightened and new vulnerabilities and debts.

The findings presented in Tables 4 and 5 largely correspond to the outcomes of the FGDs and in-depth interviews in both communes. Poverty status was often linked to out-migration, but was also linked to unstable market prices, unprofitable rice yields, unpredictable weather patterns, drought, fish shortages due to a lack of flooding events and the implementation of the full dyke system, and younger households increasingly migrating to urban areas. We analyzed whether current and former double-crop rice-farmers experienced a significantly higher negative estimated damage due to

the 2015–2016 drought than the control group did and found an average amount of VND8,030,303 (US$341) for the former and VND3,263,636 (US$138) for the latter ($p = 0.049$). This could partly explain why households would rather focus on nonfarming livelihood activities than on rice farming, and corroborate the FGD findings. However, the scope of the present study did not enable us to elaborate on the reasons for this difference.

Conclusions
Concluding remarks. The present study argues that emigration status has no mitigating influence on climate-change effects and

adaptation strategies among the smallholder farmers in An Giang Province. The effects of income status exhibited some statistical differences in terms of climate-change effects on households, dependency on remittances, and subsequent adaptation responses. Although environmental factors, whether induced by climate change or anthropogenic factors, affected the livelihoods of the respondents in our study, the study findings did not show that out-migration mitigated these impacts and adaptation responses. While the analysis from the FGDs indicated that climate stressors were often linked to out-migration, thereby supporting the first environmental migration paradigm, there was no clear empirical evidence of causal relationships among out-migration, climate-change effects, and households' failures to adapt.

Our data are partly aligned with the second environmental migration paradigm because the remittance percentages were high, and many households' livelihoods operated at a translocal level. However, there was no clear relationship between respondents being affected by climate stressors and changing their livelihood or adaptation strategies. Adaptation, like environmental migration, is a 'wicked' phenomenon and not a linear process. In this regard, the migration-as-adaptation paradigm faces two challenges. First, a direct link needs to be established between environmental stressors and households reacting to this through adaptation strategies. Second, a link needs to be established to determine whether migration can be considered a strategy for household's adaption to environmental change. These possible links need to be further investigated in future studies, but we strongly question whether causal direct links can be found.

Although this study supports the third paradigm, we do not argue that climate stressors do not play any role in households' migration patterns and adaptation responses. Though, these patterns and responses can be better understood through a critical lens shaped by local perspectives and broader structural determinants. Furthermore, several threats were identified in this study: double-crop rice-farmers seemed to be most affected by the 2015–2016 drought, middle-income farmers were disproportionally affected by climate stressors, aging and out-migration of young households continued to shape communities, and climate stressors had highly uneven effects on respondents. Adding more complexity to an already complex context, COVID-19 lockdowns proved to be a significant challenge to household livelihoods.

Limitations and future research directions. This study has several limitations. First, this study did not sufficiently analyze the perspectives of Khmer households. Future research needs to investigate how cultural and social dimensions contribute to shaping households' adaptation pathways in the VMD and beyond (Marks et al., 2022). Second, this study lacked a gendered perspective on adaptation and migration patterns. As gender plays an important role in climate-change adaptation (Carr and Thompson, 2014), this needs to be further addressed in migration studies, especially in the developing world. Third, the sample size of this study was relatively small, and we did not conduct a comparative study between, for instance, coastal versus noncoastal provinces of the VMD. Future studies, therefore, need to address this issue and expand the comparative approach on a larger scale. Last, more research needs to be conducted at a translocal level, focusing on dynamics of translocality between emigrants and nonemigrants. In this study, we solely focused on rural households and thereby failed to incorporate perspectives from urban migrants.

Data availability

The data are available from the corresponding author upon reasonable request as we are at the moment of submitting this article still analyzing the data for future publications and comparative studies, and also the data set contains personal information of the respondents, which we are not allowed to share publicly. However, the PowerBI analysis of the entire data set can be found here: https://tinyurl.com/vcrz6ed7 and the supplementary materials of this study contain additional data, which support the findings of this study.

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by MMB, TVH, DTTQ, YYH, and TN. The first draft of the manuscript was written by MMB, TAT, and TVH, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This study received ethical approval from the Research Ethics Committee, National Taiwan Normal University (No. 201906HS005).

Informed consent

All respondents provided written informed consent prior to participating in the research and in accordance with the ethics approval.

Additional information

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