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Do Socioeconomic Factors Influence Who Is Most Likely to Relocate after Environmental Disasters? A Case Study in Indonesia

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Abstract: Environmental mobility (residential moves influenced by environmental factors) is increasingly recognized as an important issue, both today and under future conditions of climate change. Those who experience climate- and weather-related disasters rarely respond as a homogenous group of migrants, yet relatively limited studies have specifically examined individual-level heterogeneities across those exposed. In this paper, we used self-reported data to investigate differences in sociodemographics (age, marital status, sex, and education) between those who relocated after environmental disruptions in Indonesia and those who did not relocate. Individuals with 12 years of education at the time of an environmental exposure were 3.93 (95% confidence interval [CI]: 1.38, 11.20) times more likely to move for environmental reasons than those with <12 years of education. Assuming education as a proxy for socioeconomic status, these findings suggest that those in the mid-range socioeconomic brackets may be most likely to migrate after environmental disruptions, while the poorest are less likely to move. This may reflect that the costs of relocation are prohibitively high for those with lower socioeconomic status. Collectively, these results add to an inconsistent body of literature on environmental mobility and indicate that further site- and context-specific research on climate- and weather-related relocation is needed.

Keywords: migration; displacement; climate change; natural disasters; environmental refugees

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1. Introduction

Human mobility is often observed following natural disasters and extreme weather events such as hurricanes or drought. This movement can result in adverse health outcomes for the displaced and for populations in both the sending and receiving communities [1,2]. Further, mobility may put significant strain on infrastructure, natural resources, and international politics [1]. An increasing number of empirical studies have examined this relationship. Much of this work focuses either on single extreme events such as Hurricane Katrina or Hurricane Sandy in the United States [3,4] or on the association between changes in weather (e.g., temperature and precipitation) and changes in migration patterns [5–8]. However, little research has specifically examined individual-level differences between those who move after environmental exposures and those who do not move.

These individual-level differences may inform our understanding of who is most likely to relocate because of environmental disruptions, and which populations are most in need of public services. This has important policy implications for disasters in the present day and also the future, as climate change has the potential to cause major environmental degradation and the movement of millions of people over the next century. There is no clear consensus regarding how many people are at risk, with estimates ranging between 10 and 300 million by 2050 [9]. However, the uncertainty of these estimates restricts their utility, as does the limitation that single estimates are unable to encompass heterogeneity among movers. In order to develop successful policies to alleviate the potential impact of this

mobility, scientific evidence is needed on the different types of people who move following environmental disruptions, where they move to and from, and how the environment interacts with other drivers of mobility [9].

Indonesia is an important case study for environmental mobility. It is the fourth most populous country in the world and has a long history of internal mobility. Pre-colonial mobility was centered on migration to cities in the inland kingdoms of central Java and the smaller, coastal kingdoms in Java and Sumatra [10]. By 1930, while Indonesia was under Dutch rule, at least 11.5% of the population reported living outside of their district of birth, representing around 3.3 million internal migrants (this number roughly doubled by 2000) [11]. Mobility during the colonial era was largely associated with exploitation of laborers as Javanese workers were recruited to farm Dutch plantations on the less populated Outer Islands [10]. In the early 20th century, this outward mobility was compounded by Dutch policy to incentivize movement away from the heavily populated island of Java to the Outer Islands [11]. However, internal migration to Java continued as colonial activities centered on the island led to increased economic activity, largely in and around the capital city of Jakarta (formally Batavia) [10]. Urbanization grew in the post-war era (after Indonesia gained independence), due in part to the high number of internally-displaced persons after the war [10]. The population remains highly mobile today and urbanization continues rapidly [12].

Relevant to this study, Indonesia also has a history of mobility specific to the environment. Sudden-onset disasters, including volcanic eruptions, have repeatedly resulted in the displacement of large swaths of the population (e.g., 85,000 people displaced by the 1963 eruption of Mt. Agung; 30,000 displaced by the 1982 eruption of Mt. Galunggung) [10]. There is also evidence of circular migration strategies being employed to adapt to gradual environmental degradation: the Makianese people in eastern Indonesia, for example, have experienced soil degradation resulting from frequent volcanic eruptions and have utilized mobility as an adaptive strategy for centuries [13]. This environmental mobility continues today as landslides, tsunamis, and earthquakes regularly displace populations across the archipelago [14]. Major displacements in recent history occurred in 2004 following the Indian Ocean earthquake and tsunami (resulting in more than 500,000 displaced persons in Indonesia), and in 2018 following the earthquake in Lombok (resulting in 445,000 displaced persons in Indonesia) [14].

This study builds on previous studies of environmental mobility in Indonesia [7,15]. Existing work has focused on understanding the association between migration and changes in environmental factors (including rainfall and temperature) [7,15]. Bohra-Mishra et al. [15] investigated the impact of climactic factors on household-level permeant mobility in Indonesia, while Thiede and Gray [7] assessed individual-level mobility and also considered how associations varied across sociodemographic characteristics. In contrast to these high-level approaches, this paper contributes to the understanding of environmental migration by using self-reported data (i.e., data in which the movers themselves specify the reason for the move) and employing methodologies to explore individual-level heterogeneities comparing environmental movers to non-movers.

In this study, we first describe the theoretical background for the project by presenting a conceptual framing for understanding both heterogeneities across different types of relocations (migrations vs. displacements) and across different groups of environmental movers. We then use household-level survey data from the Indonesian Family Life Survey (IFLS) to investigate differences in demographics and socioeconomic status (SES) between those who did and those who did not relocate after an environmental exposure. Throughout this paper we use the phrases "environmental exposure" or "environmental disruption" to refer to any changes to an ecosystem (including biological, physical, or chemical) that render it unsuitable to support human life (either temporarily or permanently) [16]. This definition encompasses both sudden- and slow-onset environmental disasters (e.g., tropical cyclones and sea-level rise, respectively).

We hypothesized that those who move due to environmental disruptions have different sociodemographic characteristics from those who stay in place. Innovative aspects of this study include the use of self-reported reasons for migration, which allows us to directly evaluate moves made for environmental reasons based on the movers' own perceptions of the reason for their move, and the application of a novel case-control approach that matches environmental movers to non-movers based on location and date. This epidemiological method allowed us to compare those who moved because of an environmental disruption to those who likely experienced the same event but did not move. Matching also has the advantage of helping to control for unmeasured confounders and to improve statistical efficiency [17,18].

2. Theoretical Background

2.1. Heterogeneity of Moves: Migration vs. Displacement

Residential relocation is a common response to adverse economic, environmental, political, and personal conditions. The decision to move is usually influenced by a combination of these factors at the macro-, meso-, and micro-levels (see Black et al. [9], Figure ES.1 for a conceptual diagram). Despite the complexity of migration decisions, scholars and policymakers often resort to binary descriptors as shorthand to characterize different types of moves. For example, moves can be temporary (as such moves made seasonally for work) or permanent, or they can be voluntary or involuntary (involuntary moves are often referred to as forced migrations or displacements).

Ultimately, while these terms may serve as practical ways to distinguish between different types of moves, these distinctions are not truly binary. In the context of environmental disasters, a drought, for example, may make living in a certain area economically challenging, which could result in a farmer and their family relocating. Whether or not this move is voluntary can be unclear to researchers and policy makers, and potentially to individuals themselves. In contrast, one might argue that a wildfire that destroys a person's home more clearly forces that person to move. Therefore, some have argued that sudden-onset disasters (wildfires, hurricanes) lead to displacement (which is often forced and temporary), while slow-onset disasters (drought, sea-level rise) may result in migration (which is often more voluntary and more permanent) [19]. Implicit in this distinction is the question of causality. A sudden-onset disaster may be more clearly viewed as a direct or proximate cause of mobility, but slow-onset disasters usually act more distally and in conjunction with other drivers of mobility (e.g., income), making them more difficult to link causally. However, this division can become muddled when we consider that not all sudden-onset disasters cause complete and obvious destruction, and individuals may choose to relocate, for example, after repeated exposure to small sudden-onset events. Thus, most moves in fact fall on a spectrum between "involuntary" and "voluntary."

These interrelations and the spectra between temporary–permanent and voluntary–involuntary relocations are demonstrated by Figure 1. The left side of the figure (involuntary) depicts moves that are typically referred to as "displacement." The right side of the figure (voluntary) depicts moves that are sometimes referred to as "migration"; however, this is a less universal definition [20]. The data used in this study are also represented in Figure 1. We focused on moves made within Indonesia (internal moves) during which individuals relocated for at least 6 months. While moves made in this time frame are likely to be permanent [15], the data source used for the study, the IFLS, did not allow us to explicitly categorize moves as temporary or permanent, nor as voluntary or involuntary. Because it can be difficult to discern whether a move is voluntary or involuntary, and because the data source used in this study does not distinguish between permanent and temporary moves, we primarily use the terms "moves" and "mobility" in lieu of migration or displacement throughout this paper.

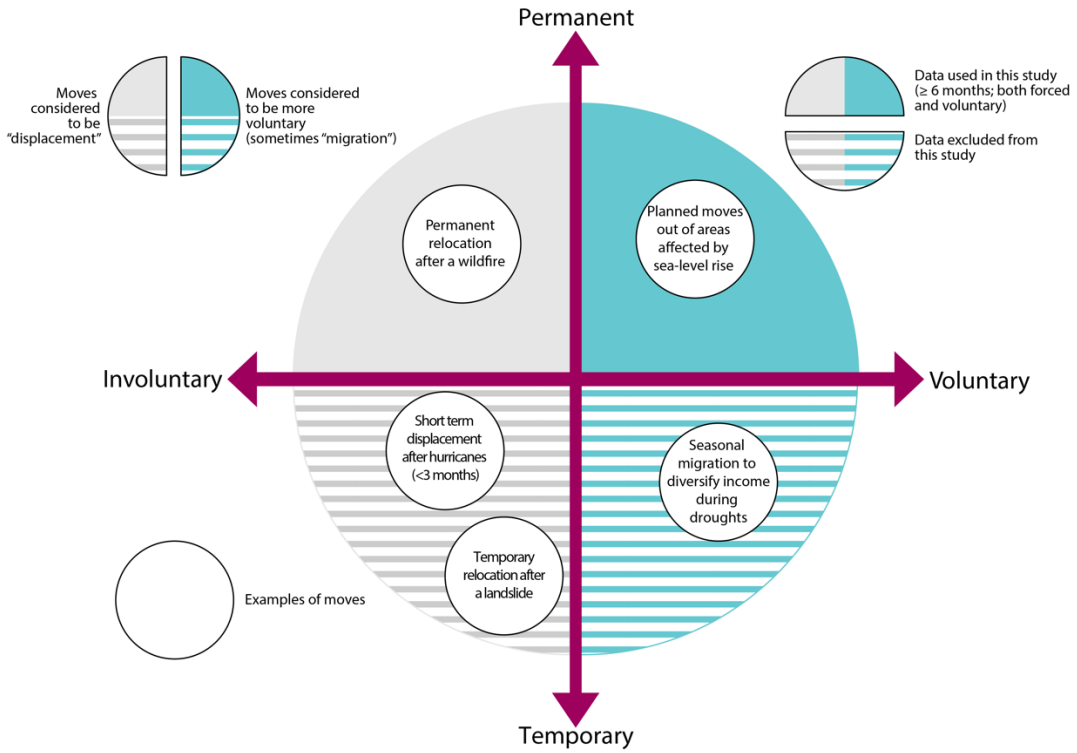

Figure 1. Conceptual matrix of mobility showing continua from involuntary to voluntary and from temporary to permanent, including examples in each quadrant.

A significant body of literature has explored environmental mobility at the macro-level [21] (for a thorough review, see [22]). However, the question of causality described above can be particularly challenging to assess at the macro-level as it can be difficult to differentiate moves made during times of environmental exposure from moves caused by environmental exposures. This is an important distinction as moves made during times of environmental exposure (e.g., drought) may be unrelated to that environmental exposure occurring at the same time (e.g., a high school student moving away for college at the same time as a drought). In order to address this limitation, in this study we used self-reported reasons for migration to compare characteristics between those who relocated because of environmental reasons and those who were likely exposed to the same event but did not move. One of the primary strengths of utilizing self-report is that we can be confident that moves were in fact driven by environmental factors. As mobility is rarely attributable to a single cause we may miss some people who reported their moves as non-environmental but were in part influenced by environmental factors [23]. However, it is less likely that moves self-reported as environmental would be misclassified. While heterogeneities across different environmental moves (forced vs. voluntary; migration vs. displacement) are not the primary focus of this study, these ideas provide a theoretical foundation for this paper and underscore the value of using self-reported data.

2.2. Heterogeneity of Movers: Who Relocates after Environmental Events?

The primary focus of this project is to better understand who is most likely to relocate after exposure to weather- and climate-related disasters and who is most likely to stay behind. Attempts to estimate the number of persons who will be displaced by climate change often focus on identifying populations that are at-risk of environmental disruptions, not necessarily the number of people who are expected to relocate [24]. However, it is increasingly clear that individuals exposed to climate- and weather-related disasters do not respond as a homogenous group to these risks. For example, research in the United States

following survivors of Hurricane Katrina found that young adults (age 25–39 years) were more likely to move further away from New Orleans than their older counterparts [25].

In addition to differences across age groups, some researchers have also identified differential patterns in mobility by sex. Massey et al. [26] found that changes in natural resource availability in Nepal affected men and women differently: increases in the time required to gather fodder were associated with increases in local migration among women but not men, while increases in the time required to gather firewood were associated with increases in local migration among men but not women. These differences reflect that the gathering of firewood and fodder are highly gendered activities in the study area, underscoring the degree to which migratory response to environmental disruptions may be highly localized. Gray and Mueller [27] found that in Bangladesh the effects of crop failure and flooding on mobility were stronger for women than men, which may reflect that women in this context have less secure access to land. In contrast, Mallick and Vogt [16] found that, following Tropical Cyclone Aila in Bangladesh, male members of the family relocated to nearby cities to find income (following the end of emergency aid). Taken together, these findings highlight that sex (and differences in gender-based social roles and norms), can have varied impacts on mobility, depending on the context and the exposure.

The impact of income on environmental mobility has been discussed widely in conceptual literature, most frequently as a mechanism through which lower-earning households and individuals may become "trapped" in a place, referring to an inability to move due to the prohibitively high cost of relocation [19,28,29]. Empirical examples have supported this theory, showing differing mobility patterns across income levels, often with middle- or higher-income households having increased opportunities for relocation and greater income diversification than their lower-income counterparts [30,31]. However, in other contexts (such as following flooding and crop failure in Bangladesh), no clear difference in environmental mobility is observed between high- and low-income households [27] again underscoring the complexity and place-specific nature of environmental mobility.

While there is a growing body of literature investigating the heterogeneities in who relocates after disasters, one limitation is that much of this work focuses on major disasters (such as Hurricane Katrina or Tropical Cyclone Aila) which may not be representative of the majority of environmental disruptions. The present study addresses this limitation by using IFLS data, which was not designed to investigate a specific disaster. This means that the environmental moves included in our analysis are not restricted to moves made for severe environmental disruptions, but also include smaller events and the cumulative impact of multiple environmental events that could lead to a move. An improved understanding of who is most likely to relocate following environmental disruptions will help improve disaster response and protect the health and wellbeing of environmental movers, those who remain behind, and the populations of receiving communities—both today and under future climate change conditions.

3. Materials and Methods

3.1. The Indonesian Family Life Survey

In this project, we used data from the IFLS, an on-going longitudinal survey that was conducted five times (referred to as five "waves") between 1993 and 2018 by the RAND Corporation. The IFLS was designed to be a multipurpose survey and since the first round of data collection has included household- and community-level information about demographics, health, and economics [32]. Accordingly, a wide range of researchers have used IFLS data since the mid-1990s to assess nutrition and food security [33–35], economic status and development [36–38], health and healthcare [39–41], and education [42], among others. The survey is divided into "books" that are subdivided into modules. For this study we focused on Book 3A, which contains individual-level data for adult respondents, including demographic factors and SES, as well as health status of respondents. Importantly for our purposes, the IFLS also asked detailed questions about mobility. This project focused on IFLS4 (conducted in 2007/2008) and IFLS5 (conducted in 2014/2015) [43,44]. In IFLS4,

Book 3A was completed (in part or in full) by 29,059 interviewees and in IFLS5, Book 3A was completed (in part or in full) by 34,458 interviewees. Between both IFLS4 and IFLS5, this resulted in 40,636 adults who responded to Book 3A. IFLS4 and IFLS5 were selected because they asked the question: "What was the main purpose/reason for your move to (DESTINATION)?" ("Apa maksud/alasan utama Ibu/Bapak/sdr pindah ke (TEMPAT TUJUAN)?") and allowed the same set of responses for both waves [43]. Throughout this paper, we use the translation "reason for move" to be consistent with previous literature [45]. Earlier IFLS waves also asked about the reason for a respondent's move, but differences in the allowed responses reduce comparability of this specific question across waves. Because of this, we restricted our analysis to pooled cross-sectional data from IFLS4 and IFLS5.

We used variables for: the date of move, location (province and regency of origin and destination; or province and regency of residence for non-movers), demographics (sex and age based on date of birth), marital status, and level of education. Age, marital status, and education level are time-varying covariates and were calculated at the time of the move for movers and at the time of the matched-pair move for non-movers (the matching procedure is detailed in Section 3.3).

The use of IFLS data is an important strength of this study because sample selection is a common challenge for research focused on mobile populations. A number of studies have sampled displaced persons following climate- and weather-related disasters; however, these may be extreme cases that are not necessarily representative of the scope of environmental moves [46]. In contrast, the IFLS is representative of ~83% of Indonesia and thus our study included some environmental moves that were not associated with major natural disasters. Another approach used by other studies is to sample sending communities; however, this may miss entire households that have relocated [47]. By using IFLS data, our study was not restricted to sending communities and we were able to capture whole households that had relocated. Finally, we were able to include non-movers and non-environmental moves as a comparison groups in our analyses.

3.2. Inclusion Criteria

Our primary hypothesis was that demographic characteristics are associated with whether an individual moved for environmental purposes or did not move at all. The unit of analysis was individuals (within households). We began by identifying individuals interviewed in IFLS4 and IFLS5 who had complete data for demographic variables (age, sex, marital status, and level of education), and for province, regency, or district of residency. We next excluded those in marriages with multiple wives (<1% of study participants), as well as those who had been married more than once (<1%) because we did not have complete information about when each marriage started and ended. We also removed records that did not have full end dates for marriages, which may have skewed our sample towards those who are still married or who were never married. However, prior to this exclusion, <5% of respondents were separated or divorced. Education status was coded based on years of education (<12, 12, or >12). This cutoff was selected because 12 years of education marks the end of senior secondary school for both secular and religious schools in Indonesia (after which some students would continue on to higher education) and reflects the current level of compulsory education [48]. We also removed those who reported in IFLS5 that they had not moved since IFLS4 but who had different places of residency between the two waves, as these were considered errors.

We identified "non-movers" as participants who reported not moving, either since their last interview (if they participated in earlier IFLS waves) or since age 12 if they were a new interviewee. The result was 19,519 non-movers with complete data meeting the inclusion criteria. These are treated as "controls." We identified "environmental movers" as the subset of movers who reported ever moving for environmental reasons in their migration histories. Moves made for environmental reasons ("environmental moves") included those with a main purpose identified as either "dry season/drought" or "natural and other disasters" (excluding social conflict). Finally, for environmental movers, we

applied an additional exclusion criterion to remove records with missing values for date of move (month and year). The result was 42 environmental movers ("cases") that met the inclusion criteria. These 42 movers were unique adults from different households. Of these respondents, 38.1% moved because of floods, 33.3% because of tsunamis, 11.9% because of dry season/droughts, 11.9% because of unspecified environmental reasons, and 4.8% because of landslides.

3.3. Analyses

We matched environmental movers (cases) to non-movers (controls) who lived in the same district, regency, and province in the same month and year. This approach allowed us to match on the environmental exposure, assuming that if a case and control live in the same location at the same time, and a case experienced an environmental disruption, the control was also exposed (i.e., experienced the environmental disruption). For example, a case who moved from the Banuhampu district in the Agam regency in West Sumatra due to a drought in May 2008 would be matched to all non-movers who were residing in Banuhampu in 2008. This matching procedure helps control for potential unmeasured confounders related to place of residence, such as severity of exposure. One limitation of this approach is that matching and the assumption of exposure to the event might be more effective for larger-scale events such as droughts or floods than for more localized events such as landslides. The majority of environmental movers in our dataset moved because of flooding, tsunamis, or drought/dry season (83.3%), which are often non-localized and may cover the district-level scale.

We then randomly selected two controls per case from the possible matched controls, and identified demographic characteristics at the time of the environmental move (e.g., level of education for both the case and controls in the month and year of the environmental disruption). This resulted in 84 controls, each matched 2:1 to a case. Finally, we used a conditional logistic regression on the matched pairs to model whether demographic characteristics were associated with whether an individual moved for environmental purposes, while controlling for other demographic characteristics as covariates.

4. Results

We calculated the demographic characteristics of environmental movers and their matched controls (Table 1). The level of education differed significantly between environmental movers and non-movers, but age, marital status, and sex did not. Overall, environmental movers were more educated than their matched non-moving counterparts.

Table 1. Description of demographic characteristics of environmental movers and non-movers (matched pairs). (Table values are mean ± SD for age and *n* (column %) for categorical variables.)

Characteristic	Non-Movers (*n* = 84)	Environmental Movers (*n* = 42)	*p*-Value (*t*-Test or χ^2 Test)
Age (years)	28.6 ± 11.1	26.3 ± 11.2	0.288
Level of Education			0.033
<12 years	48 (57.1)	17 (40.5)	
12 years	19 (22.6)	19 (45.2)	
>12 years	17 (20.2)	6 (14.3)	
Marital Status			
Never married	31 (36.9)	15 (35.7)	0.896
Married	53 (63.1)	27 (64.3)	
Sex			0.206
Male	42 (50.0)	16 (38.1)	
Female	42 (50.0)	26 (61.9)	

We then used a conditional logistic regression to model whether demographic characteristics were associated with whether an individual, when exposed to an environmental

disruption, would relocate for these environmental reasons or would not relocate, controlling for other demographic characteristics as covariates and for place and time through matching. These results are presented in Table 2.

Table 2. Matched logistic regression model predicting environmental move. Comparing environmental movers to non-movers, matched for exposure to environmental disruption.

Variable	Adjusted Odds Ratio (95% CI)
Age (for increment of 1 year)	0.94 (0.88, 1.01)
Level of Education	
<12 years	1.00
12 years	3.93 (1.38, 11.20)
>12 years	1.15 (0.31, 4.32)
Marital Status	
Never married	1.00
Married	1.62 (0.46, 5.7)
Sex	
Male	1.00
Female	1.60 (0.73, 3.47)

These findings show that individuals with 12 years of education at the time of an environmental disruption were 3.93 (95% confidence interval (CI): 1.38, 11.20) times more likely to move for environmental reasons than those with <12 years of education. In contrast, we found that sex, age and marital status were not associated with whether or not an individual moved when exposed to an environmental disruption. Those in the highest education category (>12 years) were not statistically different from the other education groups (<12 or 12 years) in terms of their likelihood of moving, but the central estimate was most similar to those with low education (<12).

Next, we performed a sensitivity analysis in which we selected one instead of two random controls for each case. Results were consistent with the findings from our main analysis of Table 2. Only level of education, 12 years versus <12 years, was identified as having a statistically significant association with whether a participant moved for environmental reasons or did not move. Using the 1:1 case to control ratio, individuals with 12 years of education were 5.77 (1.37, 24.32) times more likely to move for environmental reasons than those with <12 years of education (Table 3).

Table 3. Sensitivity analyses using a 1:1 case to control ratio rather than using a 1:2 ratio and separate analysis using a restricted dataset with cross-validated environmental disruptions. Based on matched logistic regression model predicting environmental move.

Variable	Adjusted Odds Ratio (95% CI)		
	Original Analysis	**1:1 Cases to Controls**	**Cross-Validated Dataset**
Age (for increment of 1 year)	0.94 (0.88, 1.01)	1.00 (0.92, 1.10)	0.95 (0.89, 1.01)
Level of Education			
<12 years	1.00	1.00	1.00
12 years	3.93 (1.38, 11.20)	5.77 (1.37, 24.32)	3.35 (1.06, 10.54)
>12 years	1.15 (0.31, 4.32)	1.90 (0.43, 8.39)	1.78 (0.38, 8.29)
Marital Status			
Never married	1.00	1.00	1.00
Married	1.62 (0.46, 5.7)	1.13 (0.23, 5.57)	1.07 (0.26, 4.38)
Sex			
Male	1.00	1.00	1.00
Female	1.60 (0.73, 3.47)	1.60 (0.51, 5.01)	0.93 (0.34, 2.50)

Due to data limitations, we are unable to evaluate directly whether individuals were *exposed* to specific environmental disruptions. Therefore, the primary assumption used in this analysis is that if one person reported moving for an environmental reason in a given location (case), then a different person also living in that location at the same time (control) was also exposed to the same event. For this assumption to be true, environmental disruptions had to be large enough (i.e., non-localized) to have impacted more than the individual person who reported moving. We tested this assumption using government records to cross-validate the environmental exposures. If an environmental disruption was reported by only one person, and the same type of event was not recorded in the Badan Nasional Penanggulangan Bencana (National Board for Disaster Management, BNPB) database during the same year and season, the disaster might have been hyper-local, suggesting a violation of our assumption that other people in the same location and time period were exposed [49]. As an additional sensitivity analyses, we created a new dataset that excluded all un-validated entries. We also excluded records that did not report the specific type of environmental exposure as we were unable to validate these events. The resulting dataset had 30 environmental movers, as compared to the 42 in the original dataset. We then followed the same procedure for matching and data analysis using this reduced dataset. Again, only level of education, 12 years versus <12 years, was statistically different between environmental movers and non-movers. Those who moved for environmental reasons were 3.35 (1.06, 10.54) times more likely to have 12 years of schooling than those who did not move (Table 3). Thus, results from this cross-validated dataset were broadly consistent with the main results.

5. Discussion

While we know that the environment affects mobility, far less is known regarding which groups within a population will be likely to move due to environmental disruptions [50]. Our study addressed this gap by exploring which demographic characteristics were associated with whether an individual moved for environmental reasons. We found that individuals with more education (12 years vs. <12 years) at the time of an environmental disruption were more likely to move, although those with the highest education (>12 years) did not move more often than the other two groups, and their likelihood of moving was most similar to those with <12 years education. Education is commonly used as an approximation for SES [51] and using this proxy, our findings support the hypothesis that environmental mobility may follow an inverted U-shape in relation to SES [51]. In this conceptual framework, those with the lowest SES are less likely to move because of the high cost associated with relocation and those with the highest SES are less likely to move because they have the capacity to adapt in-situ [52]. Therefore, those in the middle SES brackets are most likely to move because they may be able to afford to relocate, but may not have access to sufficient capital to adapt in ways that would allow them to stay [52].

This reflects the concept that lower SES communities may be "trapped" and unable to move, potentially due to a lack of resources [8]. These findings are consistent with those of other studies: following drought in Kenya, for example, the poorest herders were unable to relocate, while middle-income residents were able to move away temporarily, and the richest households did not need to relocate [31]. However, as noted in Section 2.2, other studies in different locations have found no differences in environmental mobility between high- and low-income households [27] Therefore, while this paper adds empirical evidence to the literature on trapped populations, it also indicates the need for continued research to better understand who leaves and who stays behind after environmental disruptions.

These findings are also important in the context of environmental justice. The most vulnerable groups, often lower SES communities or communities of color, may live in the areas that are most exposed to extreme environmental disruptions [53]. If these individuals are less likely to relocate after environmental exposures (as is indicated by our findings), the effects of environmental disruptions will not be felt uniformly across the population, with the highest burden placed on the already vulnerable (i.e., those unable to move and left in

the wake of the disaster). In this way, we can view environmentally-driven mobility as an issue of environmental justice, both in terms of which groups are exposed to disasters and thus are faced with a possible need to relocate, and which subgroups among the exposed lack the resources to move away from disaster-prone areas.

In contrast with other studies, we did not find differences in environmental-mobility by age or sex. These findings may again reflect the place-specific nature of environmental-mobility. In some cases, for example, women may be more likely to remain in place after environmental disruptions [8]. For example, Mueller et al. [6] found that men in rural Pakistan appeared to be more likely to respond to heat stress through migration than women. In other contexts, environmental disruptions appear to drive women's migration either via impacts on environmental resources that women are traditionally responsible for [26], or through increases in marriage-related moves in times of economic distress [5]. Contributing to this contradicting body of literature, we found that the odds of environmental moves were slightly higher for females compared to males (though not significantly different). Given the range of ways in which the environment affects sex-specific mobility, it is likely that we would need to disaggregate the dataset by environmental disruption in order to fully understand this relationship. This was not possible for this study due to data limitations and warrants further investigation.

A primary limitation of this study is its small sample size: out of 21,282 moves with complete data, 65 moves were attributed to environmental reasons (and 42 of those 65 had matched pairs of non-movers who experienced the environmental event). This may be surprising given the degree to which Indonesia experiences environmental disruptions, as well as historical instances of environmental mobility. One explanation for the small number of environmental moves is that temporary (short-term and circular) moves would not have been captured in this study [13]. A second explanation is that as moves are often the result of a combination of factors and these factors can be interrelated, it is possible that many environmental moves were not viewed by the respondent as having a primary environmental cause. This may be more likely in situations of slow-onset disasters, such as drought, in which the respondent may have felt that other drivers (e.g., economic) were more significant to their move (even if environmental causes played a role). In such cases a move would not be captured as environmental because survey respondents were permitted to select only one cause of the move. Thus, our findings may not be generalizable to temporary environmental moves, or moves in which the environment was a distal cause of mobility. The small sample size also increases the risk of a Type II error and the possibility that age, sex or marital status may have been associated with relocation after environmental exposures in a larger data set, but the null hypothesis was not rejected in this study. Future work should include larger sample sizes of self-reported movers.

An additional limitation of this project is that, because the IFLS was not intended to collect data on environmental disruptions, we were unable to assess housing damage or personal injury, which may be associated with relocation after disasters [46]. Future studies should continue to utilize self-report as a way to identify whether moves are environmentally driven and capture the perceptions of the movers themselves. When possible, surveys should be expanded to allow respondents to identify multiple reasons for their move (and perhaps rank order their choices), which would better reflect how migration decisions are made as a function of multiple factors. Surveys should also include more details on the environmental-drivers, including whether movers sustained housing damage or personal injury following environmental exposures.

Despite these limitations, this research provides important insight into who is most likely to relocate after environmental disruptions, contributing to our understanding of a highly important group and opening new directions for future research. The use of national-level IFLS data allowed us to capture a range of different environmental disruptions, which may be more representative of the majority of environmental movers in Indonesia, compared to those who were displaced after extreme climate- and weather-related disasters as are typically investigated in earlier studies that focused on a single severe event. To

the best of our knowledge, this is among the first studies to use self-reported reasons for moves to examine who is most likely to relocate after environmental exposures (allowing participants to select the environment from a list of possible reasons for relocation). This marks a methodological contribution that improves on earlier efforts and can inform future research approaches. While the results of this study may not be generalizable outside of environmental movers in Indonesia, our methodology could be applied in different contexts in future studies. Lastly, though our sample size was limited, the robustness of our findings was supported by two sensitivity analyses, which yielded consistent results. The findings presented here support the need for further research to better understand the complexities of environmental mobility and immobility. While the potential for trapped populations has been discussed at length in conceptual (and increasingly in empirical) literature, there remains a need to assess the pathways through which a group or subgroup might become immobile [28]. This work should focus on identifying at-risk populations who may need additional support after exposure to climate- and weather-related disasters, using intersectional and systems thinking approaches to understand the ways in which vulnerability (and resiliency) operate at both individual and structural levels. This could help us better understand whether persons have the ability (via economic, social, or other resources) to choose to stay in a place and adapt or if they are trapped in a place and would want to leave if they had the opportunity.

6. Conclusions

By understanding how people move following environmental disruptions today, we can potentially improve planning for current conditions and for future climate change scenarios. This study contributes to the growing empirical evidence surrounding environmentally-driven mobility. Our findings also support the hypothesis that environmental mobility may follow an inverted U-shape in relation to SES. However, we found that sex was not associated with environmental mobility. These findings add to an inconsistent body of literature on these relationships. This inconsistency may relate to the long-recognized understanding that environmental mobility is highly context-specific and responses will likely vary across regions. While our ability to directly extrapolate these findings to climate change conditions is somewhat limited, one author noted that "the most likely effect of environmental change over the next 50 years will be to amplify and modify pre-existing migration channels" [54]. Therefore, by better understanding current patterns of environmental mobility, we can improve our capacity to prepare for future impacts.

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References

1. Dun, O.V.; Gemenne, F. Defining 'environmental migration'. *Forced Migr. Rev.* **2008**, *31*, 10–11.
2. McMichael, C.; Barnett, J.; McMichael, A.J. An Ill Wind? Climate Change, Migration, and Health. *Environ. Health Perspect.* **2012**, *120*, 646–654. [CrossRef]

3. Schwartz, R.M.; Rasul, M.R.; Kerath, M.S.M.; Watson, B.A.R.; Lieberman-Cribbin, M.W.; Liu, B.; Taioli, E. Displacement during Hurricane Sandy: The impact on mental health. *J. Emerg. Manag.* **2018**, *16*, 17–27. [CrossRef]
4. Schwartz, R.M.; Tuminello, S.; Kerath, S.M.; Rios, J.; Lieberman-Cribbin, W.; Taioli, E. Preliminary Assessment of Hurricane Harvey Exposures and Mental Health Impact. *Int. J. Environ. Res. Public Health* **2018**, *15*, 974. [CrossRef]
5. Gray, C.; Wise, E. Country-specific effects of climate variability on human migration. *Clim. Chang.* **2016**, *135*, 555–568. [CrossRef]
6. Mueller, V.; Gray, C.; Kosec, K. Heat stress increases long-term human migration in rural Pakistan. *Nat. Clim. Chang.* **2014**, *4*, 182–185. [CrossRef]
7. Thiede, B.C.; Gray, C.L. Heterogeneous climate effects on human migration in Indonesia. *Popul. Environ.* **2016**, *39*, 1–26. [CrossRef]
8. Rigaud, K.K.; de Sherbinin, A.; Jones, B.; Bergmann, J.; Clement, V.; Ober, K.; Schewe, J.; Adamo, S.; McCusker, B.; Heuser, S.; et al. *Groundswell: Preparing for Internal Climate Migration*; World Bank: Washington, DC, USA, 2018.
9. Black, R.; Adger, N.; Arnell, N.; Dercon, S.; Geddes, A.; Thomas, D. *Foresight: Migration & Global Environmental Change*; The Government Office for Science: London, UK, 2011.
10. Hugo, G. Forced Migration in Indonesia: Historical Perspectives. *Asian Pac. Migr. J.* **2006**, *15*, 53–92. [CrossRef]
11. Van Lottum, J.; Marks, D. The determinants of internal migration in a developing country: Quantitative evidence for Indonesia, 1930–2000. *Appl. Econ.* **2011**, *44*, 4485–4494. [CrossRef]
12. Sodriak, A.; Garniwaa, I. The effect of urbanization on road energy consumption and CO_2 emissions in emerging megacity of JaNarta, Indonesia. *Procedia-Soc. Behav. Sci.* **2016**, *227*, 728–737. [CrossRef]
13. Piguet, E.; Pécoud, A.; de Guchteneire, P.; Guchteneire, P.F. *Migration and Climate Change*; Cambridge University Press: Cambridge, UK, 2011.
14. Internal Displacement Monitoring Centre. Country Information: Indonesia. Available online: https://www.internal-displacement.org/countries/indonesia (accessed on 17 January 2021).
15. Bohra-Mishra, P.; Oppenheimer, M.; Hsiang, S.M. Nonlinear permanent migration response to climatic variations but minimal response to disasters. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 9780–9785. [CrossRef]
16. Mallick, B.; Vogt, J. Population displacement after cyclone and its consequences: Empirical evidence from coastal Bangladesh. *Nat. Hazards* **2014**, *73*, 191–212. [CrossRef]
17. De Graaf, M.A.; Jager, K.J.; Zoccali, C.; Dekker, F.W. Matching, an Appealing Method to Avoid Confounding? *Nephron Clin. Pract.* **2011**, *118*, c315–c318. [CrossRef] [PubMed]
18. Pearce, N. Analysis of matched case-control studies. *BMJ* **2016**, *352*, i969. [CrossRef] [PubMed]
19. Black, R.; Arnell, N.W.; Adger, W.N.; Thomas, D.; Geddes, A. Migration, immobility and displacement outcomes following extreme events. *Environ. Sci. Policy* **2013**, *27*, S32–S43. [CrossRef]
20. Stapleton, S.O.; Nadin, R.; Watson, C.; Kellett, J. *Climate Change, Migration and Displacement: The Need for a Risk-Informed and Coherent Approach*; United Nations Development Programme: New York, NY, USA, 2017.
21. Koubi, V.; Spilker, G.; Schaffer, L.; Böhmelt, T. The role of environmental perceptions in migration decision-making: Evidence from both migrants and non-migrants in five developing countries. *Popul. Environ.* **2016**, *38*, 134–163. [CrossRef]
22. Adger, W.N.; Arnell, N.W.; Black, R.; Dercon, S.; Geddes, A.; Thomas, D.S.G. Focus on environmental risks and migration: Causes and consequences. *Environ. Res. Lett.* **2015**, 10. [CrossRef]
23. Obokata, R.; Veronis, L.; McLeman, R. Empirical research on international environmental migration: A systematic review. *Popul. Environ.* **2014**, *36*, 111–135. [CrossRef]
24. Gemenne, F. Why the numbers don't add up: A review of estimates and predictions of people displaced by environmental changes. *Glob. Environ. Chang.* **2011**, *21*, S41–S49. [CrossRef]
25. Sastry, N.; Gregory, J. The location of displaced New Orleans residents in the year after Hurricane Katrina. *Demography* **2014**, *51*, 753–775. [CrossRef]
26. Massey, D.S.; Axinn, W.G.; Ghimire, D.J. Environmental Change and Out-Migration: Evidence from Nepal. *Popul. Environ.* **2010**, *32*, 109–136. [CrossRef]
27. Gray, C.L.; Mueller, V. Natural disasters and population mobility in Bangladesh. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 6000–6005. [CrossRef] [PubMed]
28. Ayeb-Karlsson, S.; Smith, C.D.; Kniveton, D. A discursive review of the textual use of 'trapped' in environmental migration studies: The conceptual birth and troubled teenage years of trapped populations. *Ambio* **2018**, *47*, 557–573. [CrossRef]
29. Mallick, B.; Schanze, J. Trapped or Voluntary? Non-Migration Despite Climate Risks. *Sustainability* **2020**, *12*, 4718. [CrossRef]
30. Chan, N.W. Choice and constraints in floodplain occupation: The influence of structural factors on residential location in Peninsular Malaysia. *Disasters* **1995**, *19*, 287–307. [CrossRef] [PubMed]
31. Herren, U.J. "Droughts have Different Tails": Response to Crises in Mukogodo Division, North Central Kenya, 1950s–1980s. *Disasters* **1991**, *15*, 93–107. [CrossRef] [PubMed]
32. Frankenberg, E.; Karoly, L.A.; Gertler, P.; Achmad, S.; Agung, I.G.N.; Hatmadji, S.H.; Sudharto, P. The 1993 Indonesian Family Life Survey: Overview and Field Report. Available online: https://www.rand.org/pubs/drafts/DRU1195z1.html (accessed on 29 May 2021).
33. Isaura, E.R.; Chen, Y.-C.; Su, H.-Y.; Yang, S.-H. The Relationship between Food Security Status and Sleep Disturbance among Adults: A Cross-Sectional Study in an Indonesian Population. *Nutrients* **2020**, *12*, 3411. [CrossRef]

34. Frankenberg, E.; Suriastini, W.; Thomas, D. *Nutritional Status in Indonesia: Evidence from the 1993 Indonesian Family Life Survey*; RAND Corporation: Santa Monica, CA, USA, 1998.
35. Ahsan, M.N.; Kelly, I.R. Earnings gaps for conspicuous characteristics: Evidence from Indonesia. *South Econ. J.* **2018**, *85*, 121–141. [CrossRef]
36. Smith, J.P.; Thomas, D.; Frankenberg, E.; Beegle, K.; Teruel, G. Wages, employment and economic shocks: Evidence from Indonesia. *J. Popul. Econ.* **2002**, *15*, 161–193. [CrossRef]
37. Thomas, D.; Frankenberg, E.; Beegle, K.; Teruel, G. Household Budgets, Household Composition and the Crisis in Indonesia: Evidence from Longitudinal Household Survey Data. In Proceedings of the Annual Meeting of the Population Association of America, New York, NY, USA, 25–27 March 1998.
38. Gertler, P.; Levine, D.I.; Moretti, E. Do microfinance programs help families insure consumption against illness? *Health Econ.* **2009**, *18*, 257–273. [CrossRef]
39. Aizawa, T. The impact of health insurance on out-of-pocket expenditure on delivery in Indonesia. *Health Care Women Int.* **2019**, *40*, 1374–1395. [CrossRef]
40. Hidayat, B.; Thabrany, H.; Dong, H.; Sauerborn, R. The effects of mandatory health insurance on equity in access to outpatient care in Indonesia. *Health Policy Plan.* **2004**, *19*, 322–335. [CrossRef]
41. Frankenberg, E.; Thomas, D. *Women's Health and Pregnancy Outcomes: Does Access to Services Make a Difference?* RAND Corporation: Santa Monica, CA, USA, 2000.
42. Newhouse, D.; Beegle, K. The effect of school type on academic achievement evidence from indonesia. *J. Hum. Resour.* **2006**, *41*, 529–557. [CrossRef]
43. Strauss, J.; Witoelar, F.; Sikoki, B. *The Fifth Wave of the Indonesia Family Life Survey: Overview and Field Report*; Rand: Santa Monica, CA, USA, 2016.
44. Strauss, J.; Witoelar, F.; Sikoki, B.; Wattie, A.M. *The Fourth Wave of the Indonesian Family Life Survey (IFLS4): Overview and Field Report*; RAND Corporation: Santa Monica, CA, USA, 2009.
45. Coulter, R.; Scott, J. What motivates residential mobility? Re-examining self-reported reasons for desiring and making residential moves. *Popul. Space Place* **2015**, *21*, 354–371. [CrossRef]
46. Fussell, E.; Sastry, N.; Vanlandingham, M. Race, socioeconomic status, and return migration to New Orleans after Hurricane Katrina. *Popul. Environ.* **2010**, *31*, 20–42. [CrossRef]
47. Mallick, B.; Vogt, J. Cyclone, coastal society and migration: Empirical evidence from Bangladesh. *Int. Dev. Plan. Rev.* **2012**, *34*, 217–240. [CrossRef]
48. Mulyadi, A.W.E. Policy of inclusive education for education for all in Indonesia. *Policy Gov. Rev.* **2017**, *1*, 201–212. [CrossRef]
49. Badan Nasional Penanggulangan Bencana. Bencana Alam di Indonesia. Available online: http://dibi.bnpb.go.id/DesInventar/main.jsp (accessed on 17 June 2018).
50. Fussell, E.; Hunter, L.M.; Gray, C.L. Measuring the environmental dimensions of human migration: The demographer's toolkit. *Glob. Environ. Chang.* **2014**, *28*, 182–191. [CrossRef]
51. Galobardes, B.; Shaw, M.; Lawlor, D.A.; Lynch, J.W.; Davey Smith, G. Indicators of socioeconomic position (part 1). *J. Epidemiol. Community Health* **2006**, *60*, 7–12. [CrossRef]
52. Tacoli, C. Crisis or adaptation? Migration and climate change in a context of high mobility. *Environ. Urban.* **2009**, *21*, 513–525. [CrossRef]
53. Kim, N. How much more exposed are the poor to natural disasters? Global and regional measurement. *Disasters* **2012**, *36*, 195–211. [CrossRef] [PubMed]
54. Findlay, A.M. Migrant destinations in an era of environmental change. *Glob. Environ. Chang.* **2011**, *21*, S50–S58. [CrossRef]