Climate Change, Health, and Migration

Profiles of Resilience and Vulnerability in the Marshall Islands

Pacific RISA
a NOAA RISA team

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An oceanside Majuro home without a seawall during a king tide event in September, 2019. Image credit: David Krzesni.

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Cover photo: 2019 Annual Presidents' Day canoe race in Majuro, Republic of the Marshall Islands. Two men in a traditional Marshallese canoe pass behind a large fishing vessel. This juxtaposition captures Marshallese resilience in maintaining their culture and homeland in the face of prevalent threats to both. Image credit: David Krzesni.

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Pacific RISA supports Pacific Island and coastal communities in adapting to the impacts of climate variability and change. As one of eleven NOAA-funded RISA programs, Pacific RISA emphasizes the engagement of communities, governments, and businesses in developing effective policies to build resilience in key sectors such as water resource management, coastal and marine resources, fisheries, agriculture, tourism, disaster management, and public health.

Waves splashing over a seawall near a home in Majuro during a king tide event in September 2019. Image credit: David Krzesni.

Summary for Policymakers

The Republic of the Marshall Islands (RMI) is located in the central Pacific Ocean, just north of the equator, and is made up of 29 atolls spread over roughly 800,000 square miles of ocean. Tropical Pacific Island states like the RMI are often the first shock absorbers of the negative impacts of climate change, which include changing sea levels, extreme events like cyclones and typhoons, heat waves, drought, and ocean acidification. The public health sector is particularly influenced by a changing climate; meanwhile, the associated threats to food and water supplies, safe housing, livelihoods, and the very habitability of Pacific Island nations are factors that are expected to drive population movements throughout the region. The research reported here explored the nexus of climate change, health, and migration in the RMI and provide a better understanding of these relationships and inform research and policy agendas that build resilience and adaptive capacity.

Methods: This research asked two main questions: To what extent are climate and health factors associated with migration within the RMI and overseas? Are there shared views on climate change, health, and migration among residents of the RMI that can help characterize the impacts and vulnerabilities facing certain groups? We conducted a two-part analysis of survey data that were collected in 2017 from 199 households on three islands in the RMI: Majuro (n=99), Maloelap (n=50), and Mejit (n=50). To evaluate whether climate and health-related factors were associated with people's migration decisions (the first research question), we generated descriptive statistics and performed logistic regressions on the survey dataset. We also used regression modeling to assess the associations among variables related to health and climate change, as well as demographic variables. To answer the second question, we performed hierarchical clustering on the survey population based on their responses to questions about climate stressors and impacts, and obtained a three-cluster solution in which respondents within a cluster gave similar responses to the questions, whereas members of different clusters gave significantly different responses. Finally, we used ANOVA, Tukey's Honest Significant Difference test, and logistic regression to describe the unique characteristics of the clusters and determine whether the health and migration outcomes reported by members of each cluster were associated with other experiences or characteristics, such as place of residence or demographics.

Results: Across the surveyed population, respondents reported very high levels of climate impacts. Drought events had affected 91% of respondents, and heatwave (45%), flood (39%), and king tide (36%) events were the next most common. These stressors most commonly impacted the drinking water (84%), trees (63%), soil/land (57%), and crops (52%) around their households. When asked to rank non-climate stressors by how serious a problem they were for the household, inadequate health-care was ranked third (after a lack of job opportunities and poor education). The expectation to migrate was also very high, with more than half of respondents saying that they or someone in their household would or might migrate domestically or internationally in the future. Healthcare was a significant driver of both past and potential future migrations, whereas very few people said that climate impacts would cause them to migrate.

The clustering results further showed how people facing different types and degrees of climate and health impacts had unique profiles of resilience and vulnerability that were associated with different expectations to migrate. Members of the first cluster ("Cluster 1", n=86) had the highest incomes, were the least impacted by climate-related stressors, and also reported higher access to resources with less dependence on ecosystem services, such as local food and water provision, fuelwood, etc. This group was less likely to expect to migrate in general, but experiencing a household health impact due to climate stressors was associated with an increased expectation to migrate. On the other hand, Cluster 2 members (n=91) had lower incomes than Cluster 1, experienced more climate impacts, and reported greater freshwater shortages and less access to natural resources. They were the most likely group to expect to migrate in the future. Members of Cluster 3 (n=22) tended to live on the more remote, outer islands, had the lowest incomes, and faced higher heatwave and drought impacts. However, they were generally more satisfied with the natural resources available to them and were the least likely group to expect to migrate. These findings suggest that the nexus between climate change, health, and migration in the RMI is characterized by relationships that are not homogeneous throughout the RMI.

Conclusions: The households that participated in the survey have experienced high levels of climate stressors and impacts, especially related to drought, heat waves, flooding, and king tide events, and the severity of these impacts has been increasing. Over 50% of respondents said they or a member of their household would or might migrate in the coming decade, and seeking healthcare was a top driver of both past and potential future migrations. The clustering exercise found that these experiences and expectations to migrate were not homogenous across the surveyed population, however. Factors related to wealth, social status, agency, and vulnerability were strong differentiators between the three clusters and the climate and health impacts they experienced. The group with the highest incomes, home or land ownership rates, and education (members of Cluster 1) reported some of the fewest climate impacts and expressed lower expectations

Two boys relaxing beneath a tree in Majuro.
Image credit: David Krzesni.

to migrate. More vulnerable respondents (Cluster 2) experienced the impacts of climate change more strongly, had riskier or less secure housing, and were more likely to want to migrate as a result, but had fewer financial resources to do so. And although the third group (Cluster 3) had the lowest cash incomes and experienced more heat and drought impacts than Clusters 1 and 2, they felt safer from environmental threats and were generally more satisfied with the ecosystem services where they lived, and less likely to expect to migrate.

Policy implications: We draw three main policy implications from this analysis. First, migration is and will likely remain common within the RMI population. Marshallese culture is well-known for its oceangoing navigation and people throughout Micronesia have historically utilized migration as one of many ways to thrive and adapt to change. Migration should neither be approached as a problem that needs to be solved nor should it be seen as an unavoidable outcome. Nevertheless, steps should be taken to enhance opportunities for people to migrate—or not—without feeling that either is a foregone conclusion.

Second, inequities surrounding wealth, social status, agency, and vulnerability must be addressed directly to implement measures that reduce climate risk. Members of Cluster 2 living on Majuro had lower cash incomes and property rights, which prevented them from being able to protect their households from climate impacts. Exposure to heat stress and limited access to fresh water were also very salient concerns for certain groups, and in many cases were more severe threats than direct disasters that may be more intense but short lived, such as king tide or flooding events. Therefore, critical local infrastructure projects that ensure community access to drinking water could provide more immediate benefits to these groups than larger, longer-term resilience projects like seawalls. Comparatively small interventions, like installing cooling centers for heatwave events, could alleviate short-term stressors that may be driving out-migration. Furthermore, by taking small steps to address challenges faced by vulnerable subsets of the population, communal agency and resilience would likely improve the success of national-level adaptation plans with greater citizen input and engagement.

Lastly, enhancing opportunities for residents of the RMI to achieve what may now be seen as achievable only through migration would provide greater decision-making agency, as well as the potential for return migration. Expanded education, healthcare, and livelihood prospects with attention to long-term sustainability in the face of climate change could substantially reduce migration pressure. If, on the other hand, certain members of the population feel forced to migrate in the context of climate change, the disparities that exist today will only grow.

Recommendations for Policymakers

Migration will likely remain common within the RMI and abroad, and steps should be taken to enhance opportunities for both migration and remaining in-place so that people can freely choose without feeling that either option is a foregone conclusion.

Policy interventions should focus on vulnerable members of the population, including the elderly, lower income groups, and outer island residents. Critical infrastructure projects like ensuring community access to drinking water, and comparatively small interventions like installing cooling centers for heatwave events, could help alleviate stressors that may be driving out-migration.

Enhancing opportunities for residents to achieve what may now be seen as achievable only through migration—through expanded education, healthcare, and livelihood prospects—would provide greater decision-making agency, as well as the potential for return migration.

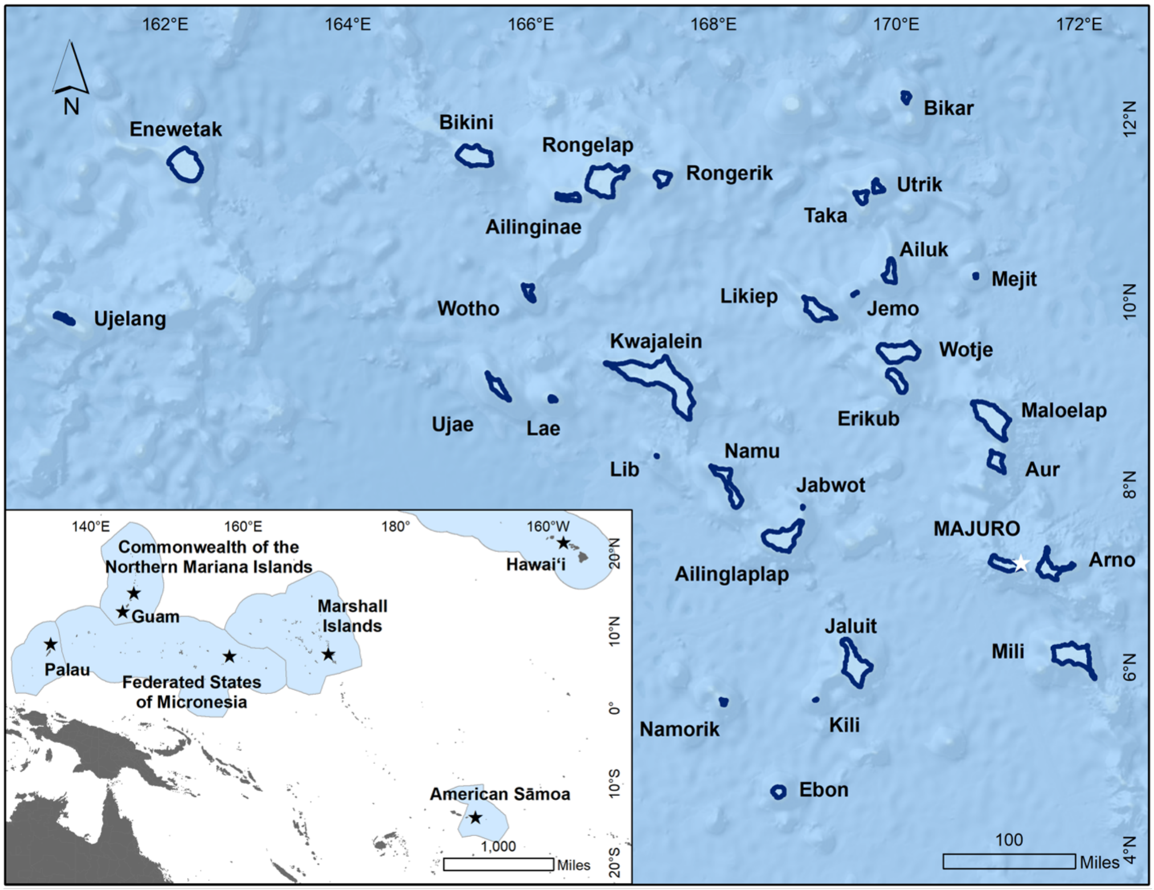

Figure 1. Top: Location of the RMI in the central tropical Pacific. Bottom: Aerial photo of Majuro, the capitol of the RMI. Image credit: Christopher Michel (licensed under Creative Commons).

Introduction

The Republic of the Marshall Islands (RMI) is a small Pacific Island nation composed of 29 low lying atolls with a resident population of about 53,000 (United Nations Population Division 2018) and a sizeable diaspora population in the United States of about 24,000 (US Census Bureau 2019; Figure 1). Spread over an ocean area approximately the size of Mexico (800,000 square miles), but with a total land area of 70 square miles, the RMI is considered to be among the most vulnerable countries to climate change (Woodward et al. 1998; Cocklin 1999; Owen et al. 2016; IOM 2017; Storlazzi et al. 2018). In addition to the threat of rising sea levels, the nation is vulnerable to droughts, wave-driven floods, and tropical storms that threaten homes, infrastructure, freshwater supplies, and agriculture (Nurse et al. 2014; Marra and Kruk 2017; Storlazzi et al. 2018).

Climate change and its far-reaching impacts are threatening ecosystems, livelihoods, and cultural traditions in the RMI. The island nation has limited natural resources that have historically sustained a small population subsisting on fishing and small-scale agriculture. With population growth and the degradation of ecosystem services as result of climate change, the RMI is increasingly dependent on imported food products (Ichiho et al. 2013; Ahlgren et al. 2014; Connell 2015). Agriculture is severely restricted due to a lack of arable land, overcrowding, limited fresh water, and salt spray from the ocean, and these effects are compounded by rising sea levels, flooding, droughts, and aquifer salinization and depletion such that the RMI is and will become increasingly food-insecure due to climate change (Barnett 2011). Drinking water supplies and infrastructure in the RMI are also inadequate and vulnerable to floods, droughts, and degraded aquifers (Burns 2003). Additionally, sewage system failures and water contamination have been associated with disease outbreaks, which compound the risks associated with flooding (Beatty et al. 2004).

The health sector in the RMI is highly impacted by a changing climate (WHO 2015; McIver et al. 2016). Extreme weather events have *direct* impacts on human health that are immediate and traumatic, causing loss of life and property (WHO 2015). For instance, when Tropical Cyclone Zelda struck the RMI in November 1991 with winds of 75–100 miles per hour, it resulted in several injuries and damage to buildings and essential infrastructure. Tropical Cyclone Anne, which struck the RMI in January 1998, resulted in a fatality when one resident drowned (CFE-DMHA 2019). The *indirect* effects of climate change on human health in the RMI are extensive (McIver et al. 2016). For example, water security and safety are closely tied to human health, and they are impacted by multiple climate stressors. Water, Sanitation, and Hygiene (WASH) issues in already challenging circumstances (such as poor infrastructure) can be exacerbated by the impacts of climate change, including flooding and drought events (Trtanj et al. 2016). Extreme events can increase the risk for infectious and vector-borne disease outbreaks, such as cholera, dengue fever, and chikungunya (McMichael 2015). Diabetes and other lifestyle-related health problems prevalent in the region represent what are known as *diffuse* impacts of climate change, as they are inflamed by reduced food security and high temperatures that both reduce physical activity and have direct, negative effects (such as insulin regulation).

Challenges related to accessing adequate healthcare are prominent in the RMI and frequently require traveling to the nation's urban centers—the capital of Majuro and nearby Ebeye—or internationally. Healthcare is government subsidized but not always easily accessible, and services on the more remote, outer atolls are limited. The RMI has two overcrowded and understaffed hospitals located in densely populated Majuro and Ebeye (van der Geest et al. 2019a); however, these hospitals generally lack the technology, infrastructure, and funding to manage chronic or serious conditions (Yamada et al. 2009; Duke 2014; IOM 2017). Salaries of expatriate healthcare professionals and out-of-country referrals account for a significant portion of the national healthcare budget (Williams and Hampton 2005; Yamada et al. 2009), but many Marshallese make the decision to seek care elsewhere on their own (Yamada et al. 2009).

Due to a variety of factors, internal (from outer islands to urban) and international migration is very common among the Marshallese population (Ahlgren et al. 2014). The former President of the RMI, Hilda Heine, has cited healthcare, education and job opportunities, and threats of climate change as a few main drivers of this trend (Taibbi and Saltzman 2018). Under the Compact of Free Association (COFA), Marshallese citizens can freely live and work in the United States, where many go to seek education, employment, and healthcare (IOM 2017; Yamada et al. 2017; van der Geest et al. 2019b). In Hawai‘i, for example, healthcare is the leading driver of Marshallese in-migration (Pobutsky et al. 2009). Owing primarily to the stipulations in the COFA, a substantial diasporic population now resides in Hawai‘i and the continental United States, becoming what many are calling “permanent non-immigrants” (Taibbi and Saltzman 2018), and the out-migration rate appears to only be increasing. Preliminary assessments of 2021 census data suggest that in the 10 years between 2011 and 2021, the RMI “lost” 25,000 people to international out-migration, which is over double the rate from 1999 to 2011 (Johnson 2021). The relationships between climate change, health, and migration are therefore deeply intertwined with the RMI’s past, present, and future (Brewington et al. 2021).

The issues surrounding this nexus in the RMI and other Pacific Island nations are expected to be further complicated and exacerbated as climate change progresses, with impacts felt unequally across population groups. Financial hardship, unemployment, and wealth inequality are widespread in the RMI, a nation whose median annual household income is less than $7,000 (SPC 2012). In other regions that are experiencing resource scarcity or weakened infrastructure, disparities in representation and interventions mean that those with greater financial capital and agency benefit more from migration or other adaptation and mitigation efforts, while the most vulnerable don’t see the same benefits (Marino and Ribot 2012). Further research in the RMI across diverse aspects of society is needed to improve resilience and identify optimal adaptation strategies, especially in the context of a changing climate and populations that are in motion.

Study Background and Research Questions

In 2016, researchers at the University of Hawai‘i and the Pacific Regional Integrated Sciences and Assessments (Pacific RISA) program initiated the RMI Migration Project to better understand the impacts of climate change on migration between the RMI and the United States (van der Geest et al. 2019a). Their work sought to answer the following central questions: To what extent are climatic stressors, and their impacts on ecosystems, livelihoods, and habitability already driving migration in RMI? What are the impacts of migration in source and destinations areas? How do migration reasons and consequences vary among different types of respondents? For six weeks in 2017, the study team conducted mixed social sciences fieldwork in the RMI where they surveyed 199 households on three islands: Majuro, Maloelap, and Mejit. The household survey was a multiple choice questionnaire that was translated into Marshallese, with one response per household (Appendix A). In addition to the survey instrument, they also employed a 40-question Q methodology to investigate shared views among participants about climate change, environmental stressors, migration, and other factors. Questions highlighted environmental, social, and economic factors that were hypothesized to influence migration decision-making. As van der Geest and others (2019a; 2019c) have reported, there were very high climate stressors and impacts experienced across the surveyed population. Few respondents indicated climate change and/or environmental impacts as a reason for migrating; however, a significant number did indicate health-related reasons, following work, education, and family visits (Figure 2).

Consistent with research in the field (for example, McLeman 2014) and in other Pacific Island nations (for example, Campbell et al. 2016; Milan et al. 2016; Oakes et al. 2016), we hypothesized that climate-related impacts may act as the “cause of the cause” in the RMI, such that although one may not explicitly state that they or members of their household migrated because of climate change, the cascading impacts of climate on health and livelihoods do influence migration decisions. To illustrate this, Figure 3 shows a conceptual diagram of the nexus between climate change, health, and migration, where each influencing factor is a driver or an outcome, and sometimes—in the case of health—both.

To better understand how climate change, health, and migration intersect, this analysis focused on two main questions: To what extent are climate and health factors associated with migration within the RMI and overseas? Are there shared experiences and perspectives on climate change, health, and migration among residents of the RMI? It is our hope that this research and findings can help shape policy responses and adaptation interventions to improve resilience and wellbeing in Pacific populations, now and into the future.

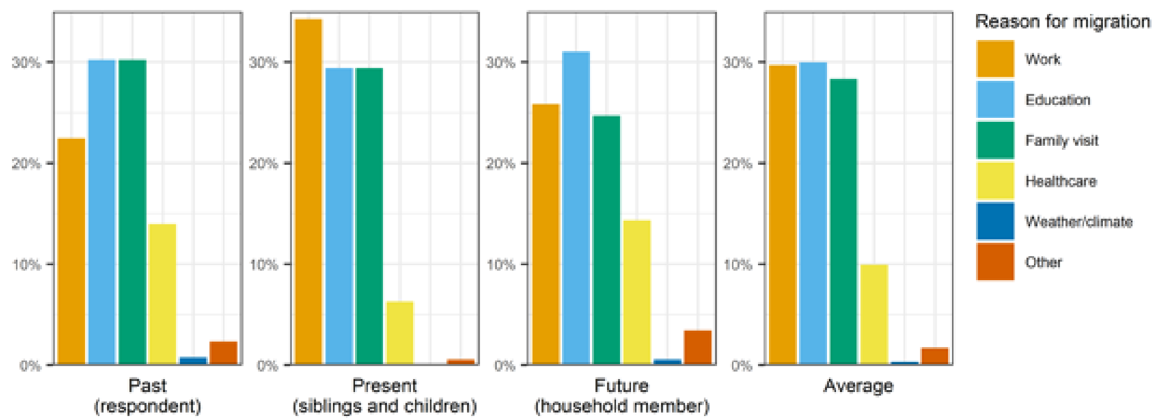

Figure 2. Top reasons for past, present, and future migrations for at least one year outside the island where they grew up, among 199 households surveyed in RMI. "Past" refers only to the respondent household's past migrations. "Present" refers only to children or siblings who presently live outside the island. "Future" refers to any member of the household who may migrate in the future.

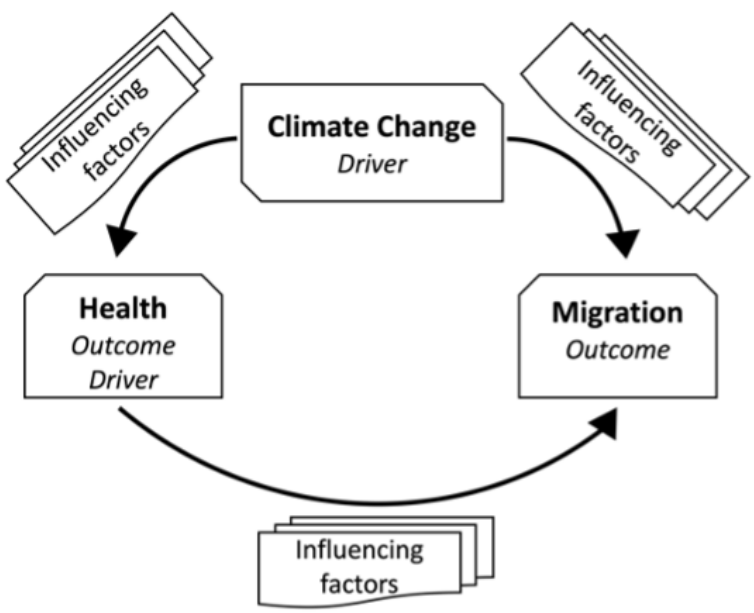

Figure 3. Conceptual diagram of the climate, health, and migration nexus, in which climate change is a driver of both health and migration outcomes, health is also a driver of migration outcomes, and various factors influence the strength of these relationships.

Methods

The RMI household survey data analyzed for this report included a total of 199 respondents from the islands of Majuro (n=99), Maloelap (n=50), and Mejit (n=50). The present analysis expanded on prior published work (van der Geest et al. 2019a; 2019c; 2020) with an emphasis on health and utilized a different approach to data analysis, including logistic regressions and cluster analysis.

Logistic regression

The survey asked participants whether and why they had migrated in the past, whether they had relatives who migrated, and if they expected to migrate in the future. In-line with a growing body of research showing that migrants rarely identify climate change as the primary driver of migration (McLeman, 2014), we selected survey questions related to climate change to explore associations between those variables and respondents' expectations that they or a member of their household would migrate in the future. The dependent variable, "expectation to migrate" was a binary 0/1 outcome of "Yes" or "Maybe" (1) or "No" (0) responses to the question "Do you think that you or one of your household members will migrate (in RMI or abroad) within the next 10 years?" (Appendix A, Question I2). Logistic regression modeling was then used to evaluate whether climate and health-related factors (the independent variables) were associated with expectation to migrate. We also used regression modeling to assess the associations among variables related to health and climate, as well as demographic variables.

Hierarchical clustering

We explored potential non-linearities and variance within the dataset using a hierarchical clustering method based on a subset of variables related to climate stressors and impacts. Hierarchical clustering is a method of grouping respondents together so that the within-group variance in means for each clustering variable is minimized and the between-group variance is maximized (Johnson 1967). Variables that were related to whether a household had been affected by climate stressors or other impacts, rankings of problems associated with climate change and the environment, and the state and trend in natural resources and ecosystem services were weighted according to their importance to the respondent. ANOVA was used to compare group means of each clustering variable and respondents were then grouped using only the variables that differed significantly between the groups. This step was repeated until all clustering variables maintained significant differences in group means. This produced a stable and good-fitting solution that was limited to the variables that most strongly distinguished the clusters from one another. The final, optimized three-cluster solution was validated using statistical fit indices and conceptual assessments by collaborators and subject matter experts.

Next, group means were compared using ANOVA and Tukey's Honest Significant Difference test for all additional study variables to better describe the unique characteristics of each cluster. We also mapped the locations of several variables that were either used in clustering or that differed significantly between the groups, post-clustering, to visualize the spatial differences among clusters and across the three study areas.

Finally, we explored the potential for unique within-cluster drivers of migration and health outcomes by running logistic regressions with one independent variable at a time and using dummy variables for cluster membership as interaction terms. For comparison, we also fit logistic regression across the whole dataset without the interaction terms for the same independent variables. By creating and comparing both sets of logistic regression models, we assessed independent variable relationships with outcomes across the whole dataset and within each cluster. Descriptive statistics were produced for relevant clustering and non-clustering variables to explore shared experiences and perspectives between and within clusters.

Results

Descriptive statistics

The mean age of the survey respondents was 40 (Standard deviation [SD]=13.0) made up of 68% men and 32% women. The mean income was around USD$5,800 (SD=$6,400; Table 1). Thirty-three percent of respondents earned income from the private sector, 44% from government, 49% from agriculture, and 51% from fishing. Although the survey questionnaire did not include options for income earned from copra (dried coconut to be exported for coconut oil production) and handicrafts, these were commonly indicated by respondents as income from other sources. About 45% of respondents completed high school and about 2.5% completed further post-secondary education. There were broadly high rates of home and land ownership: 92% of respondents owned a house, 64% owned the land their house was on, and 88% owned land outside of where they lived. Around $770 in remittances, which are non-commercial financial transfers from a relative or community member overseas, were received annually by about a third of respondent households.

Most respondents reported experiencing various climate stressors and impacts in recent years. The most prevalent stressor was drought, which had impacted 91% of respondents within the past five years (Figure 4). Heatwave (45%), flood (39%), and king tide (36%) impacts were the next most common. Storm surge (14%) and typhoon (5%) impacts were less commonly reported. The most prominent household impacts associated with climate stressors were on drinking water (84%), trees (63%), soil or land (57%), and crops (52%). About 38% of respondents had experienced a climate-related impact to their health.

Respondents also generally reported that climate-related impacts had been increasing in severity over the past 10 to 20 years (Table 2). On a scale from -1 (decreasing) to 1 (increasing), drought, king tide, and heatwave events were all perceived to be increasing with mean scores of 0.87, 0.55, and 0.49, respectively. Perceived increases in storm surge (0.13) and typhoon (0.01) severity were much lower. Respondents further ranked the top five problems that their household faced from a list of 12 options. On average, lack of jobs (2.4), not enough fresh water (2.2), poor education (2.0), and drought (2.0) were the highest ranked problems, followed by sea level rise (1.7) and poor healthcare services (1.4). Electricity/power cuts (0.2), lack of fish (0.3), and illegal dumping (0.3) ranked lowest among respondents' concerns.

Table 1. Descriptive statistics for selected demographic variables

	n	mean/percent*
Household income	181	$5,818
Income source: agriculture	198	49.49%
Income source: fishing	198	50.51%
Income source: government salary	198	44.44%
Income source: private sector salary	198	33.33%
Education completed: high school	195	45.13%
Education completed: university	195	1.54%
Education completed: graduate school	195	1.03%
Household owns house	199	91.96%
Household owns land that house is on	199	63.82%
Household owns land on outer islands or elsewhere	197	87.82%
Total amount of remittances received in past year	69	$771
Years lived in current location	111	19.70

*Percentages are reported for binary variables

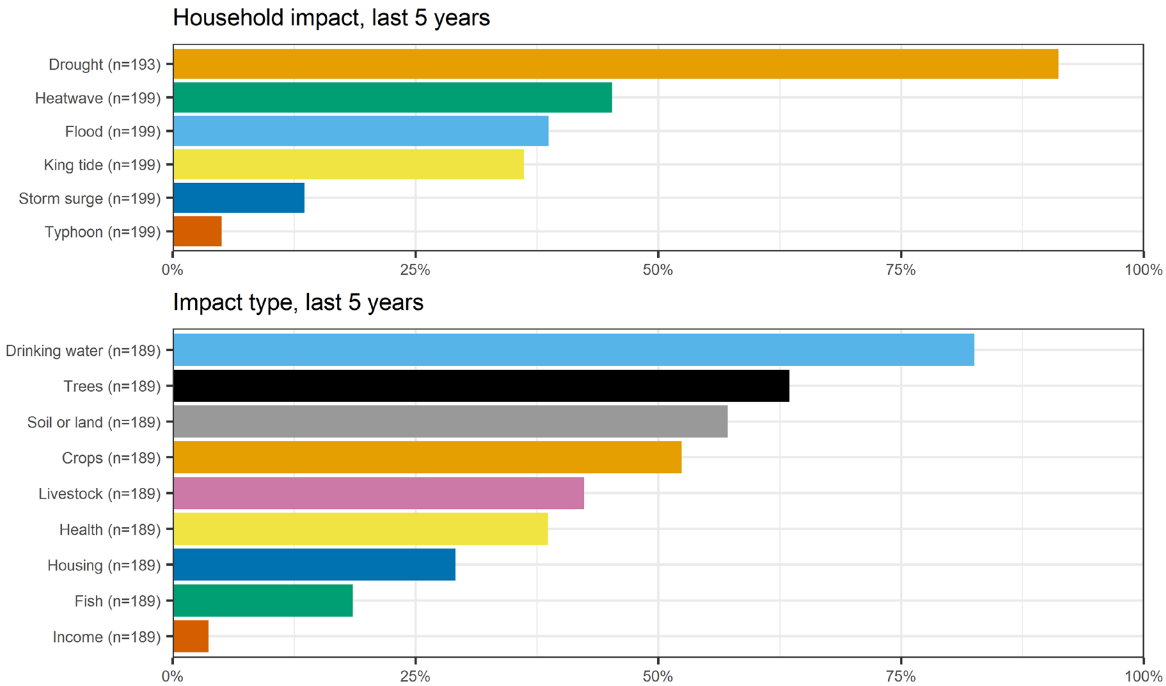

Figure 4. Climate-related impacts that were experienced by households in recent years.

Table 2. Perceptions of climate impacts trends and rankings of problems facing the household. Green shading indicates decreasing trends/lower problem rankings compared to the other clusters; orange indicates moderate trends/problem rankings; red indicates increasing trends/highest problem rankings.

		n	mean	Values
Climate trend	Drought	190	0.87	–1 (decrease) 0 (same) 1 (increase)
	King tide	178	0.55	
	Heat wave	182	0.49	
	Storm surge	146	0.13	
	Typhoon	151	0.01	
Problem ranking	Lack of jobs	196	2.38	0 (not among top 5 problems) 1 (lowest ranked problem) 5 (top problem)
	Not enough fresh water	199	2.21	
	Poor education	196	2.05	
	Drought	199	1.98	
	Sea level rise	199	1.73	
	Poor healthcare services	199	1.39	
	Overcrowding	196	0.97	
	Poor transport facilities	196	0.90	
	Out migration	196	0.52	
	Littering and illegal dumping	196	0.28	
	Not enough fish	199	0.27	
	No electricity or power cuts	196	0.21	

Climate- and health-related factors associated with migration

Generally the expectation to migrate was very common in the RMI, with 34% of respondents answering "Yes" when asked "Do you think that you or one of your household members will migrate (in RMI or abroad) within the next 10 years?", and another 19% answering " Maybe", indicating that over half of those surveyed saw migration as a possible or likely outcome in the future (Figure 5). Only about 5% of respondents expected that they themselves would be the one to migrate and another 5% answered that they might migrate. When asked where they would move, 16% of respondents indicated that they would migrate within the RMI and 28% planned to migrate to the United States. Respondents had also commonly migrated in the past with 67% having migrated short-term (between a month and a year) and 51% having migrated elsewhere within RMI (40%) or to the United States (10%) for over a year.

In general, the extent to which climate-related factors were associated with an expectation to migrate was relatively low. When asked about past, current, or future migrations, very few respondents indicated decision factors that were climate or environment-related. Indeed, only one participant said that they might migrate in the future because of environmental problems (Figure 5). Comparatively, respondents much more frequently reported health as a reason for migration. When asked why they migrated in the past or expected to migrate in the future, 9% of respondents indicated that health was a reason for at least one past move and 13% said healthcare would be a reason they would migrate in the future.

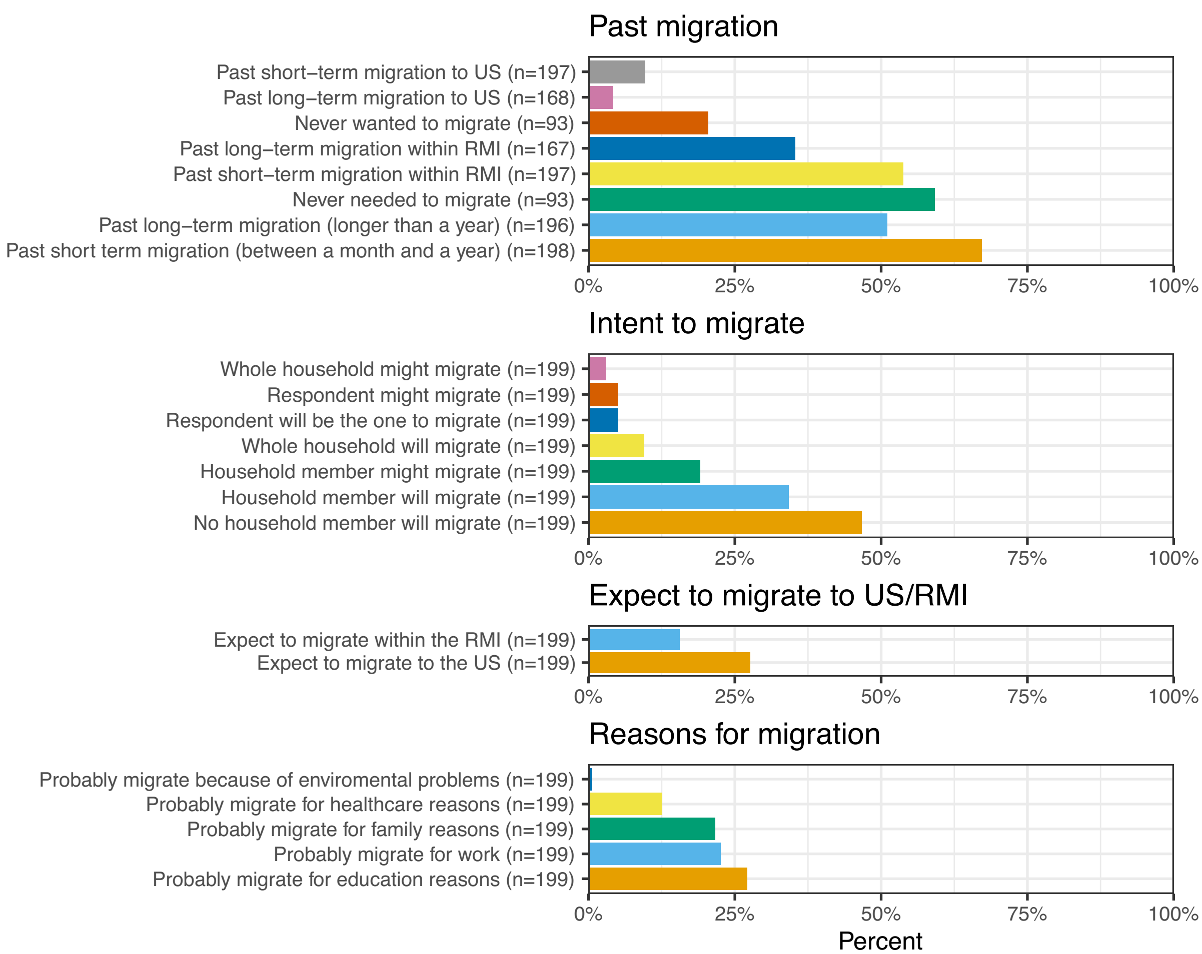

Figure 5. Details about household past migrations, intentions to migrate, migration destinations, and reasons for migration.

Despite the severity and trends in climate impacts, migration expectations, and relationships with health, the logistic regression model results over the full survey population produced highly inconsistent correlation patters and very high variance. This restricted our ability to determine a set of independent variables and controls, or create meaningful aggregates of highly inter-correlated variables to help explain the variance.

Shared views on climate change, health, and migration

The hierarchical cluster analysis led to a three-cluster solution based on the 21 variables that most significantly differed between them (AC=0.908; Table 3). Tukey's Honest Significance Difference testing was used to further characterize the cluster mean comparisons (Appendix B, Table 1). Each cluster portrayed a unique profile

Table 3. List of variables used for clustering and how they compared across the clusters. Green shading indicates lowest impacts/problem rankings compared to the other clusters; orange indicates moderate impacts/problem rankings; red indicates highest impacts/problem rankings

	Cluster 1 mean (SE) (n = 86)	Cluster 2 mean (SE) (n = 91)	Cluster 3 mean (SE) (n = 22)	Values
Household impact last 5 years: typhoon**	0.00 (0.00)	0.11 (0.03)	0.00 (0.00)	0 (no) 1 (yes)
Household impact last 5 years: storm surge***	0.02 (0.02)	0.28 (0.05)	0.00 (0.00)	
Household impact last 5 years: king tide***	0.06 (0.03)	0.71 (0.05)	0.09 (0.06)	
Household impact last 5 years: flood***	0.07 (0.03)	0.76 (0.05)	0.09 (0.06)	
Impact type, last 5 years: crops***	0.38 (0.06)	0.70 (0.05)	0.27 (0.10)	0 (no) 1 (yes)
Impact type, last 5 years: fish***	0.07 (0.03)	0.32 (0.05)	0.05 (0.05)	
Impact type, last 5 years: trees***	0.42 (0.06)	0.75 (0.05)	0.91 (0.06)	
Impact type, last 5 years: soil/land***	0.33 (0.05)	0.73 (0.05)	0.77 (0.09)	
Impact type, last 5 years: income*	0.08 (0.03)	0.01 (0.01)	0.00 (0.00)	
Impact type, last 5 years: food prices**	0.11 (0.04)	0.01 (0.01)	0.00 (0.00)	
Impact type, last 5 years: housing***	0.11 (0.04)	0.52 (0.05)	0.00 (0.00)	
Impact type, last 5 years: properties***	0.09 (0.03)	0.54 (0.05)	0.05 (0.05)	
Not enough freshwater problem ranking***	1.06 (0.16)	2.87 (0.20)	3.95 (0.24)	0 (not among top 5 problems) 1 (lowest ranked problem) 5 (top problem)
Sea level rise problem ranking***	1.33 (0.17)	1.74 (0.18)	3.32 (0.25)	
Not enough fish problem ranking***	0.15 (0.08)	0.15 (0.07)	1.18 (0.28)	
Heatwave trend**	0.35 (0.05)	0.62 (0.05)	0.50 (0.12)	-1 (decrease) 0 (same) 1 (increase)
Weighted state of provision of food***	-0.22 (0.10)	-0.26 (0.11)	0.82 (0.29)	-3 (worst) to 3 (best)
Weighted state of provision of fuelwood***	0.17 (0.20)	0.94 (0.19)	2.86 (0.14)	
Weighted trend in provision of water***	-0.69 (0.19)	-1.11 (0.23)	-2.17 (0.33)	
Weighted trend in provision of fuelwood***	-0.42 (0.18)	-0.11 (0.18)	2.05 (0.33)	
Weighted trend in provision of safety***	-0.02 (0.16)	-0.90 (0.17)	-0.53 (0.26)	

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

of resilience and vulnerability with respect to climate impacts, health outcomes, and expectations to migrate. Members of the first cluster ("Cluster 1", n=86) had experienced the least typhoon, king tide, and flood impacts in recent years, with low to moderate impacts to their properties, ecosystem services, and other assets except for income and food prices. They were the least likely to report that limited freshwater supplies, sea level rise, and a lack of fish were a problem for them. Members of Cluster 2 (n=92) experienced the most climate events with some of the highest impacts to their homes and property, as well as crops and fish. They also reported the strongest declining trend in perception of safety. Cluster 3 (n=22) was a small cluster whose climate events and impacts were only slightly more severe than those in Cluster 1, except for the impacts on soil and trees, which were the highest of any cluster. They were generally satisfied with the state and trend of food and fuelwood provision, but declines in water supplies were the most severe for this group. Across all clusters, respondents reported an increasing trend in heatwave events and declines in the provision of water supplies and perceptions of safety or protection from their environments.

The spatial distributions of the members of each cluster across the three survey locations of Majuro, Maloelap, and Mejit are shown in Figure 6. Cluster 1 was a primarily urban cluster that was highly concentrated on Majuro, especially near the southeastern and relatively more affluent neighborhood of Delap. Members of Cluster 1 living on Maloelap tended to live farther north on Kaven and Taroa. Cluster 2 members lived nearer to the coasts than those in Cluster 1 with larger concentrations on Maloelap and Mejit than on Majuro. Members of Cluster 3 tended to reside on the outer islands, and only one respondent lived on Majuro.

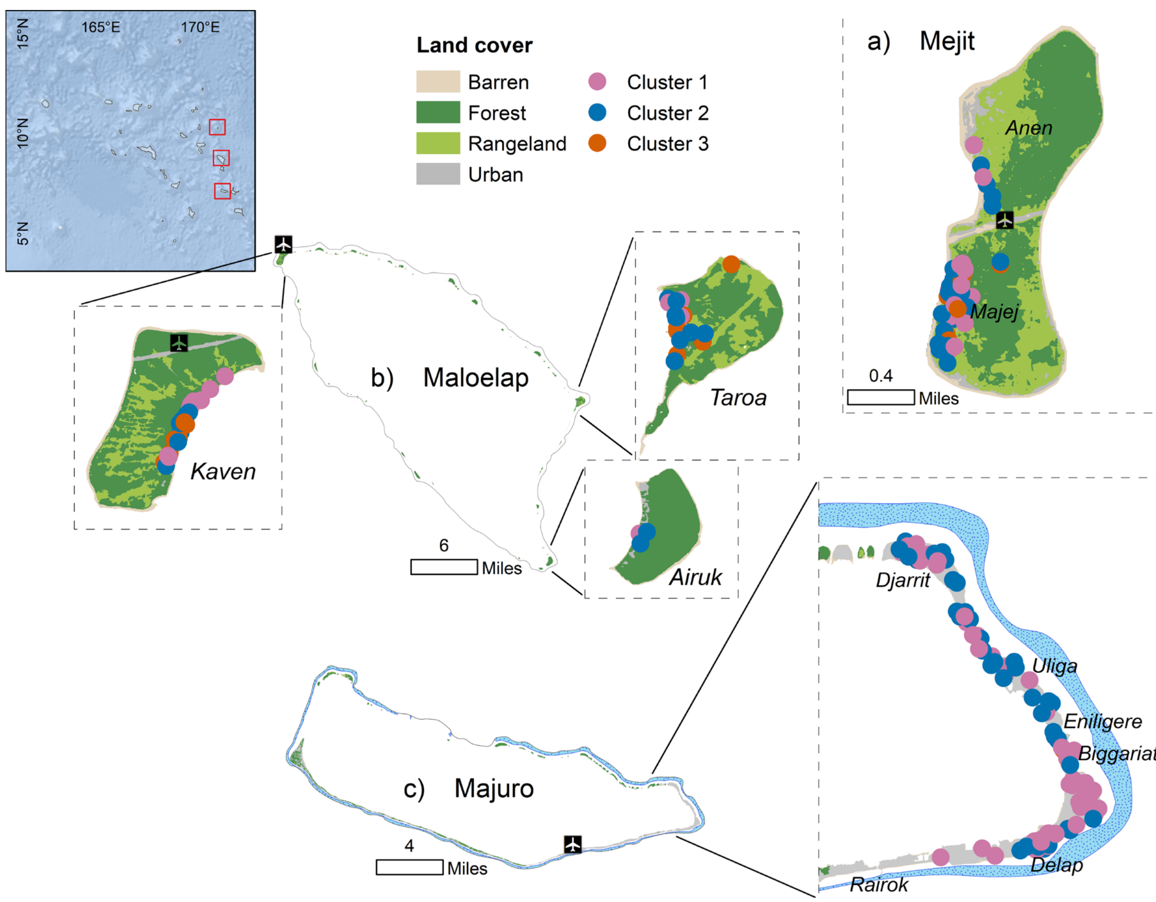

Figure 6. The locations of members of each cluster on a) Mejit; b) Maloelap; and c) Majuro, with land cover classes for each island. Red boxes in the upper left inset indicate the locations of the three study areas within the RMI.

Table 4. List of select variables not used for clustering that differed significantly across the clusters. Green shading indicates lowest impacts/problem rankings, or higher assets like income and home or land ownership, compared to the other clusters; orange indicates moderate impacts/rankings or assets; red indicates highest impacts/problem rankings, or lowest assets.

	Cluster 1 mean (SE) (n = 86)	Cluster 2 mean (SE) (n = 91)	Cluster 3 mean (SE) (n = 22)	Values
Household member will or might migrate**	0.50 (0.05)	0.64 (0.05)	0.23 (0.09)	0 (no) 1 (yes)
Household owns land that house is on**	0.56 (0.05)	0.64 (0.05)	0.96 (0.05)	
Household owns land on outer islands or elsewhere*	0.93 (0.03)	0.87 (0.04)	0.73(0.10)	
Lived in current location since birth*	0.15 (0.05)	0.04 (0.03)	0.33 (0.13)	
Household impact last 5 years: heat wave*	0.35 (0.05)	0.56 (0.05)	0.41 (0.11)	0 (no) 1 (yes)
Impact type, last 5 years: livestock***	0.26 (0.05)	0.56 (0.05)	0.41 (0.11)	
King tide trend***	0.46 (0.06)	0.70 (0.05)	0.13 (0.09)	−1 (decrease) 0 (same) 1 (increase)
Storm surge trend**	0.03 (0.02)	0.24 (0.05)	0.08 (0.08)	
Drought problem ranking***	1.53 (0.16)	2.00 (0.18)	3.68 (0.30)	0 (not among top 5 problems) 1 (lowest ranked problem) 5 (top problem)
Poor education problem ranking***	2.69 (0.24)	1.92 (0.23)	0.09 (0.09)	
Poor healthcare services problem ranking***	1.97 (0.21)	1.09 (0.17)	0.41 (0.18)	
Lack of jobs problem ranking***	2.85 (0.17)	2.32 (0.18)	0.82 (0.25)	
Perception that house is riskier than neighbors***	0.01 (0.06)	−0.56 (0.07)	−0.23 (0.11)	−1 (worse) 0 (same) 1 (better)
Level of education**	3.43 (0.19)	3.56 (0.16)	2.27 (0.33)	0 (no formal education) 8 (graduate school)
Household income***	$8,250 (735)	$4,730 (700)	$1,360 (240)	US Dollars
Remittances received in past year***	$544 (72.0)	$741 (119.0)	$4,650 (4,350)	
Income source: agriculture***	0.34 (0.05)	0.54 (0.05)	0.91 (0.06)	0 (no) 1 (yes)
Income source: fishing**	0.40 (0.05)	0.53 (0.05)	0.82 (0.08)	
Income source: government salary***	0.61 (0.05)	0.35 (0.05)	0.18 (0.08)	
Income source: private sector salary***	0.46 (0.05)	0.29 (0.05)	0.05 (0.05)	

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

The clusters also differed significantly in characteristics beyond the set of variables used to create them. Select variable means are shown in Table 4; Tukey's Honest Significance Difference test results for all variables not used for clustering that differed significantly across the clusters are found in Appendix B, Table 2. Cluster 1 was comprised of respondents with relatively higher incomes, primarily from private sector and government sources. They were more highly educated, tended to own land more frequently, and reported feeling safer in their homes than the other two clusters. Members of Cluster 2 had lower incomes from a mix of employment and agriculture/fishing, and received limited remittances from family and friends overseas. They appeared to be more transient, with few having lived in their current locations their whole lives. They perceived their housing to be risky and also reported the lowest access to natural resources. This cluster experienced the most direct climate impacts and was also the most likely to expect to migrate. Members of Cluster 3 had the lowest incomes and were much more dependent on natural resources and agriculture, rarely earning incomes from government or private sector sources and receiving more remittances than members of the other clusters. Almost all members of this cluster wrote in copra and/or handicrafts as an income source. They were the most likely to own the home where they lived and the least likely to expect to migrate, compared to members of Clusters 1 and 2.

Spatial differences by island and cluster

The three clusters exhibited spatial differences both within and across the three study areas of Majuro, Maloelap, and Mejit. Six variables are presented here: climate-related health impacts, heatwave impacts, fresh water problem ranking, flood impacts, household income, and expectation to migrate. First, negative health outcomes due to climate stressors were more prevalent among all cluster members living on Mejit and Majuro than they were among residents of Maloelap (Figure 7).

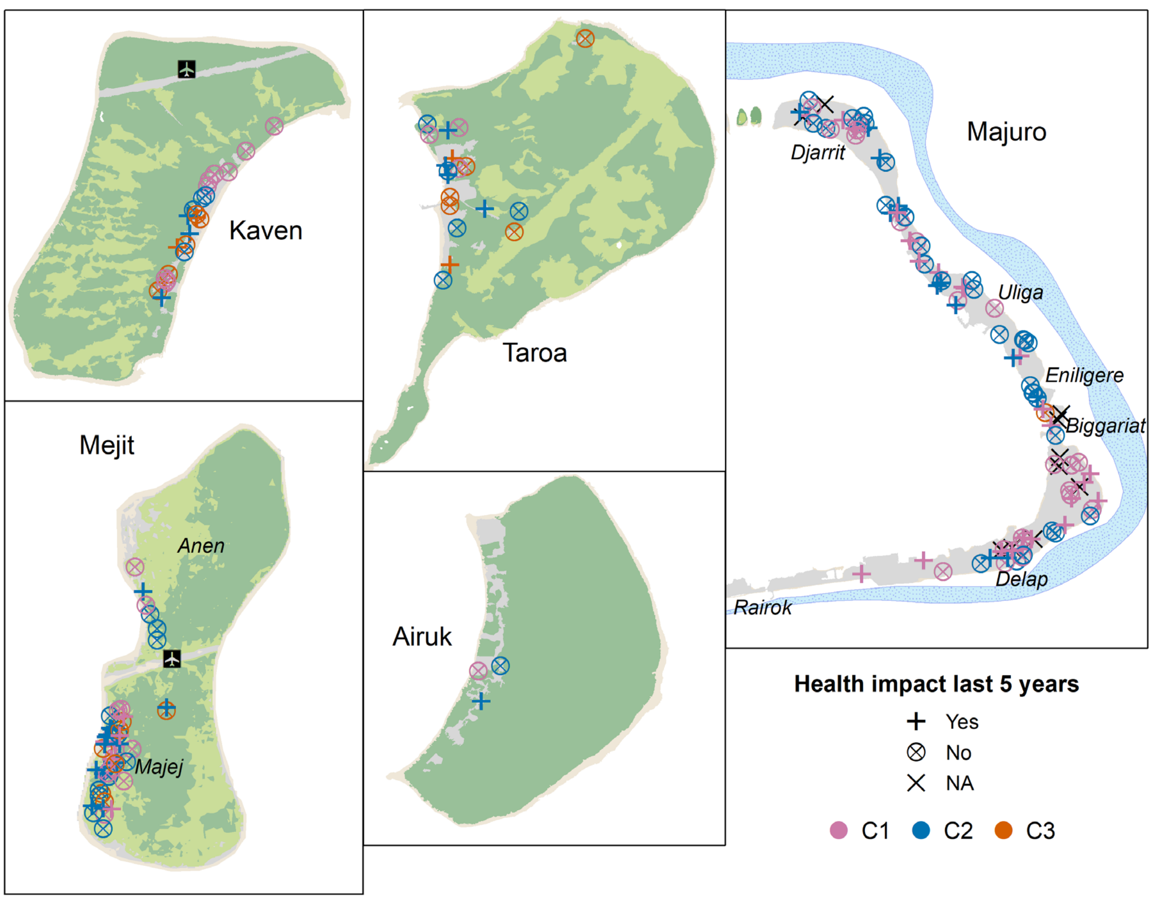

Figure 7. Distribution of prevalence of health impacts in the last five years by cluster and island (Kaven, Taroa, and Airuk are part of Maloelap).

Even members of Cluster 1, which represented respondents who were less impacted by climate-related stressors overall, reported very prevalent health impacts on Majuro that were most commonly tied to water shortages and heat stress. One participant described the indirect and diffuse impacts of a changing climate on their health: *"During the drought we had only one water catchment and it was empty, so we had to walk all the way to the [College of the Marshall Islands Reverse Osmosis] unit to fetch water and carry them back. Even I carried large water containers which caused my health to deteriorate because I am old and it was too hot to walk outside."*

Fewer heatwave impacts were reported on Majuro compared to the other two study sites (Figure 8). Members of Cluster 2 reported experiencing more heatwave impacts than the other two clusters, especially those who lived on the outer islands. Residents of Mejit in the northern part of the RMI reported the highest prevalence of heatwave impacts, and generally, the northern islands and atolls ex-

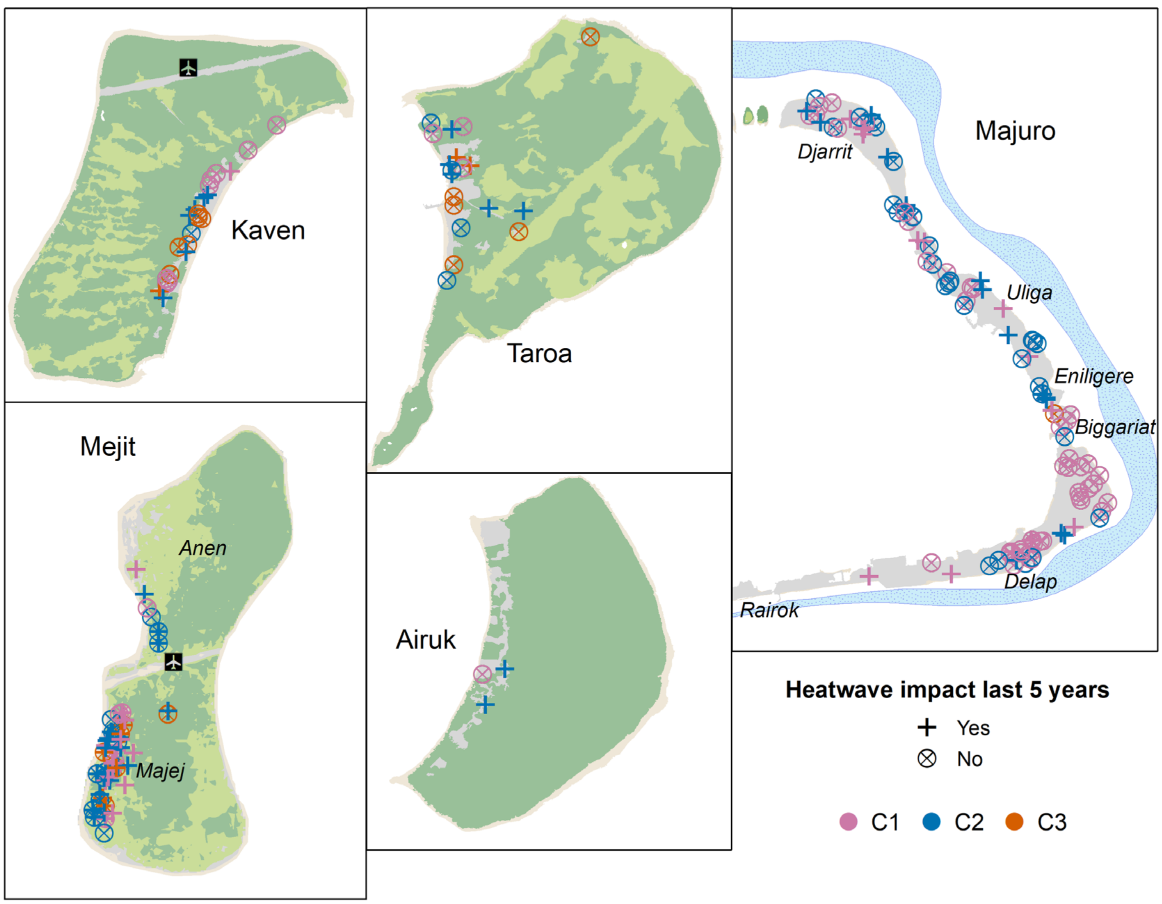

Figure 8. Distribution of prevalence of heatwave impacts in the last five years by cluster and island (Kaven, Taroa, and Airuk are part of Maloelap).

perience lower rainfall and higher average temperatures than those in the south (CFE-DMHA 2019). A member of Cluster 2 on Mejit shared how these impacts affected their livelihood: *"Because of frequent droughts and heat, coconut trees died which [made] it hard for us to work. We used to make copra from morning till evening, but now we work sometimes each day. Lack of copra because droughts."* The far-reaching effects of drought are felt nationwide, however, and frequently lead to negative health outcomes. A member of Cluster 1 on Majuro referred to one recent event, saying, *"The drought was [so] long that we drank from water wells and that our children [were] frequently sick because of the heat."*

Members of Cluster 1 who lived on Majuro (especially in the Delap and Djarrit/Rita areas) or Maloelap tended to rank problems with freshwater access low relative to the other problems on the list (Figure 9). Members of Clusters 2 and 3 on Kaven and Mejit, on the other hand, ranked freshwater access as a more severe problem. Freshwater problem ranking outcomes were not geographically determined: in nearly all locations, respondents who ranked this as one of their biggest problems lived near others who did not. This was exemplified in write-in responses. For example, one member of Cluster 3 stated, *"We have only one water catchment, it ran out so we had to drink from our neighbor's catchment which was a shameful thing for us to do."* A member of Cluster 1 ex-

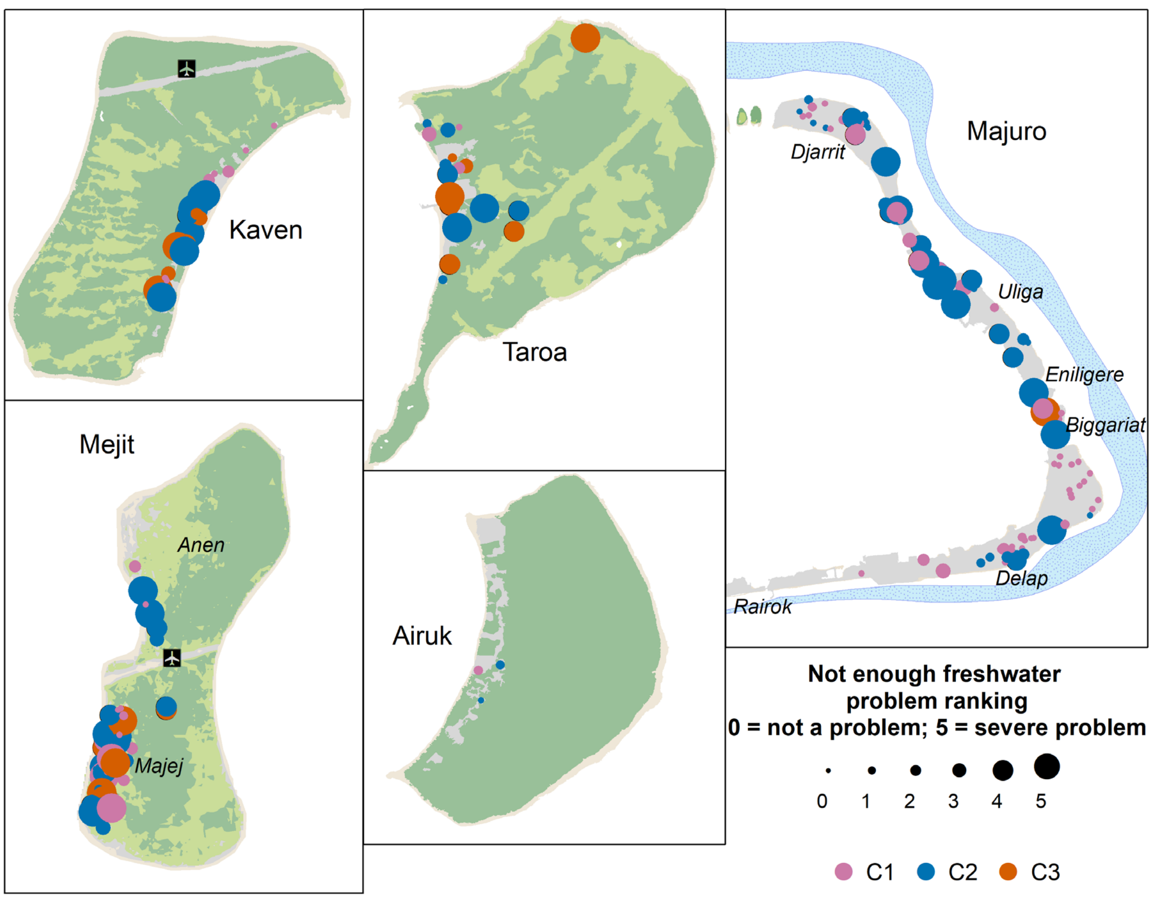

Figure 9. Distribution of "not enough fresh water" problem ranking by cluster and island (Kaven, Taroa, and Airuk are part of Maloelap).

plained that, *"There is enough drinking water from three tanks and we resort to well water for bathing and washing during droughts."* Another member of Cluster 1 stated that, *"Our water catchments were empty and we had to spent [sic] [a] lot of money to pay [for] drinking water."* Some respondents also mentioned drinking well water that was salty and unfit for drinking, which they associated with health problems. Others described relying on reverse osmosis systems installed by government or aid organizations. Many respondents also mentioned how the lack of fresh water caused hygiene issues, including conjunctivitis outbreaks. Several mentioned not having enough water for their crops or livestock.

Broadly, respondents living on the lagoon sides of Majuro and Maloelap reported experiencing more flood impacts in recent years (Figure 10). There was also higher prevalence of recent flood impacts among members of Cluster 3 who lived closer to the coasts, but similar to the freshwater problem described above, those affected by

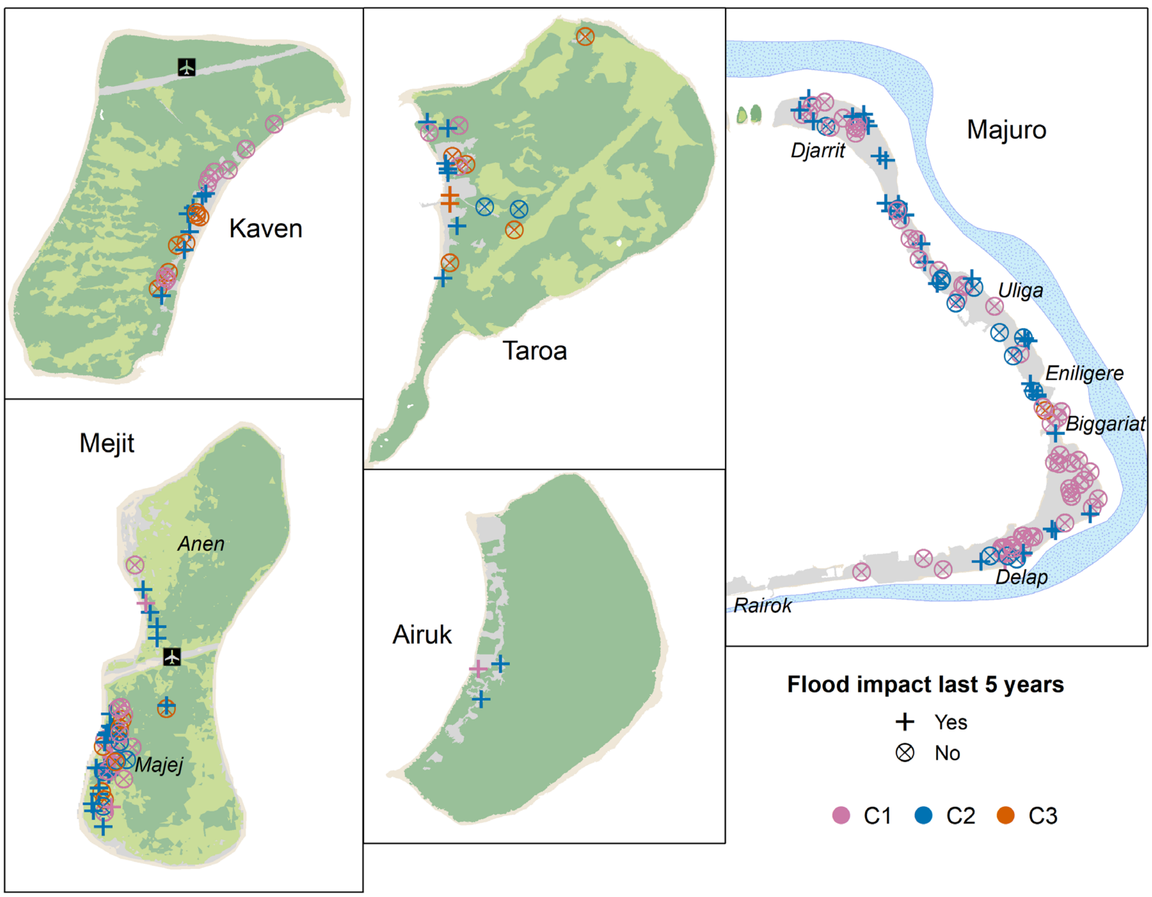

Figure 10. Distribution of respondents who experienced flood impacts in the last five years by cluster and island (Kaven, Taroa, and Airuk are part of Maloelap).

flooding lived near those who were not. One participant provided an important insight into the differential impacts of seawalls between neighbors, stating that, "*With the high school seawall deflecting waves to our shore during storm surges and king tides, our shoreline is rapidly eroding*." Respondents also mentioned water coming into their homes and washing garbage and debris onto their land, as well as the compound effects of multiple king tide events occurring in succession: "*Our house is very close to the shore*," said one member of Cluster 2. "*If another king tide comes it will be washed away because the first time when [the] last king tide came, water ran straight into my house and everything in it [was] damaged*."

There was greater income disparity on Majuro between the clusters than on the other two islands (Figure 11). Respondents also earned higher incomes on Majuro, which had a mean annual household income of $10,223 compared to $2,802 on Maloelap and $1,400 on Mejit. It is im-

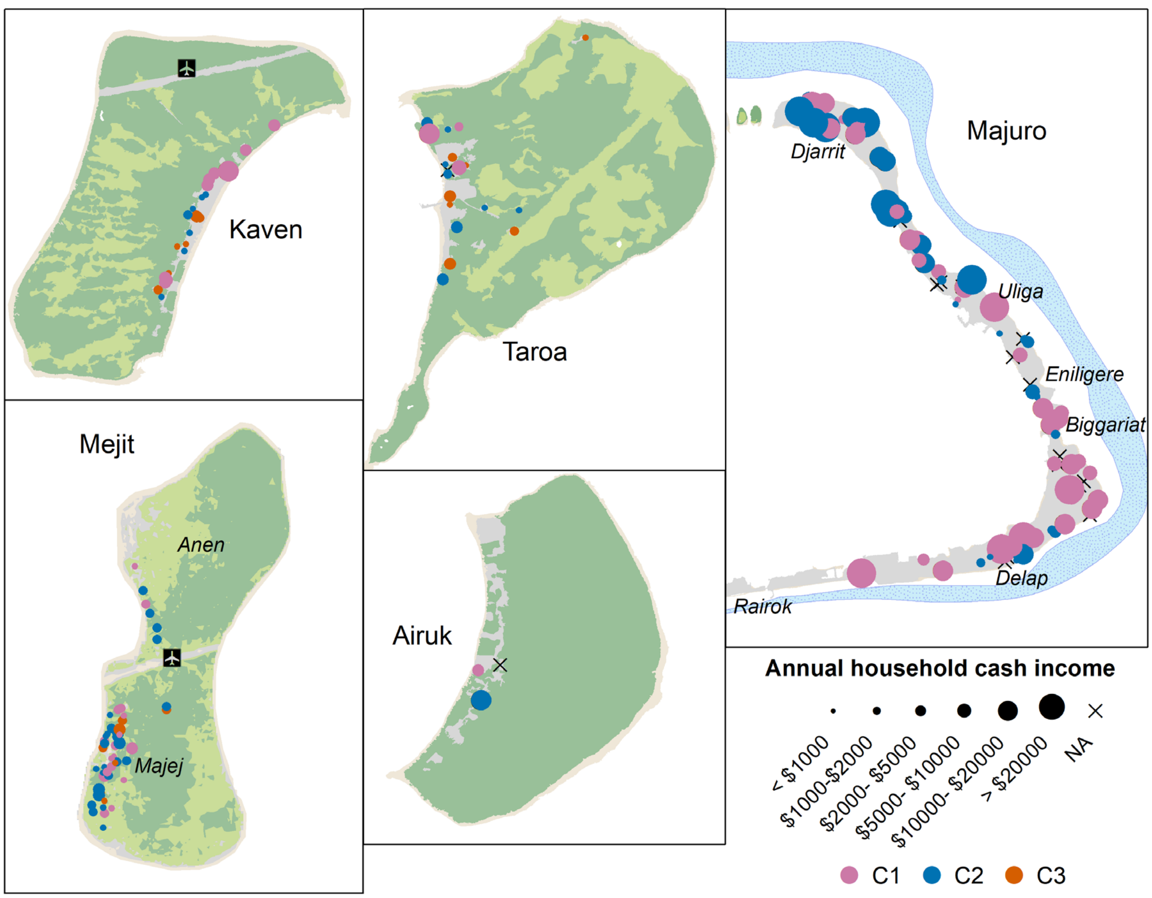

Figure 11. Distribution of mean annual household cash income by cluster and island (Kaven, Taroa, and Airuk are part of Maloelap).

portant to remember, however, that while higher incomes may afford some protection against certain stressors, even the mean annual income for Cluster 1 ($8,250) is only roughly equivalent to the nation's minimum wage of $4.00 per hour. The wealthiest of respondents therefore still faced big challenges that were often apparent in their write-in responses. A member of Cluster 1 from Majuro offered an insight into this relative wealth disparity when talking about their household's response to drought and heat: *"We needed to buy drinking water when our tank ran out during droughts. Also very hot because of all the surrounding houses. So I bought an air con which means I pay more for electricity."*

Finally, there was a somewhat higher prevalence of expectation to migrate among residents of Majuro, with lower prevalence on the remaining outer islands (Figure 12). This corresponded with the generally low expectation to migrate among members of Cluster 3, compared to Clusters 1 and 2 (particularly those residing on Majuro).

Differential migration drivers and health outcomes by cluster

Logistic regressions using cluster membership as an interaction term revealed unique associations between the independent variables related to potential climate and health stressors, and dependent variables related to migration and health outcomes. We first describe variables that were significantly associated with different expectations to migrate among members of each cluster. Responses of "Yes" or "Maybe" to the question, "Do you think that you or one of your household members will migrate (in RMI or abroad) within the next 10 years?" were analyzed separately and then grouped together to evalu-

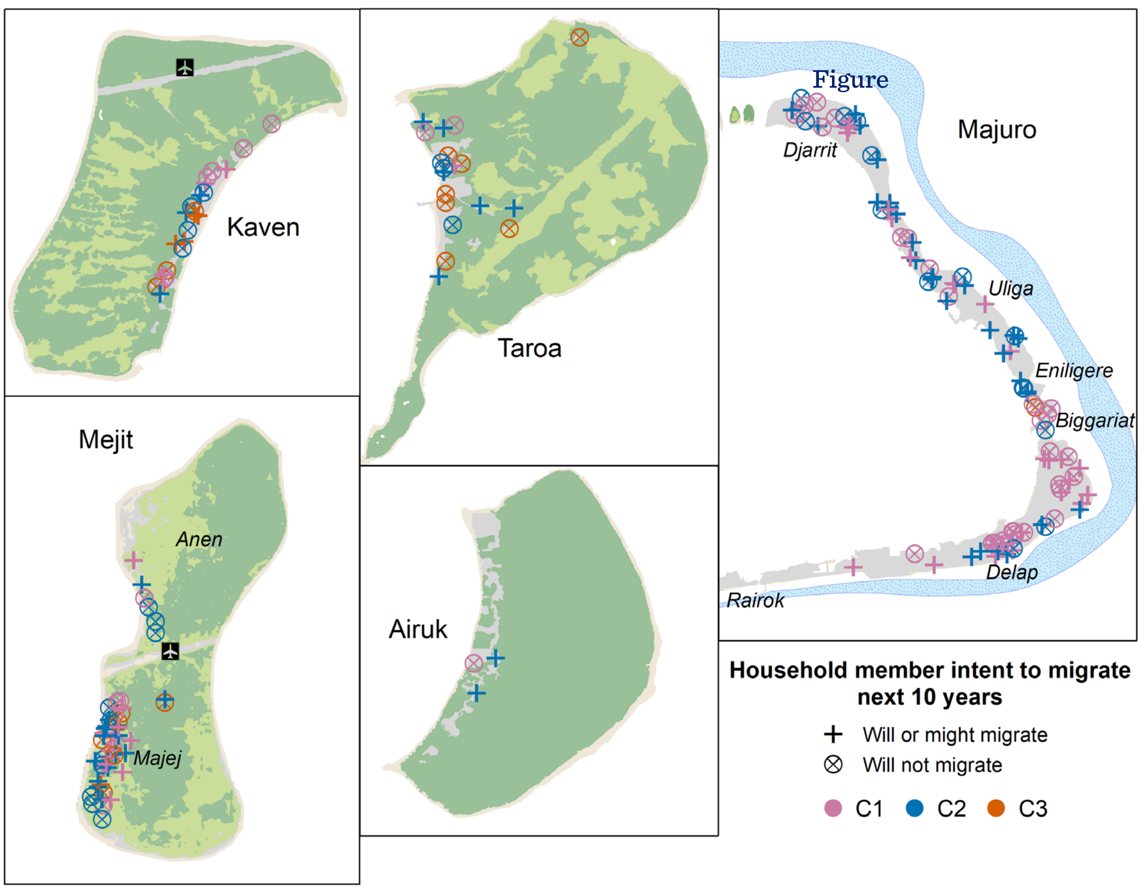

Figure 12. Distribution of expectation to migrate in the next 10 years by cluster and island (Kaven, Taroa, and Airuk are part of Maloelap).

ate whether there were certain stressors significantly associated with the expectation that someone definitively *will* migrate in the future versus someone considering a future migration (Table 5). In certain instances, an independent variable had a significantly different effect between Clusters 1 and 2, such as having a high school education and elevation. For members of Cluster 1 alone, having experienced a health impact as a result of climate change in the last five years was significantly associated with an increased expectation to migrate. Only one variable was significantly associated with expectation to migrate among members of Cluster 3.

Other factors were significantly associated with the likelihood of experiencing a household health impact within the clusters, but with different relationships be-

Table 5. Factors significantly associated with different expectations to migrate, by cluster. Orange shading indicates an associated increase in the dependent variable; blue indicates an associated decrease.

	Cluster 1 (n=86)	**Cluster 2** (n=91)	**Cluster 3** (n=22)
Expectation that a household member will migrate	Living on Mejit		Receive water from government system
	Increasing drought trend		
	Household impact last 5 years: heat wave		
	Income source: government		
	Decline in income	Decline in income	
	Negative perception of food provision		
...might migrate	Married		
	Larger household size		
	Higher household risk		
	Level of education: completed high school	Level of education: completed high school	
...will or might migrate	Higher elevation	Higher elevation	
		Increasing drought trend	
		Increasing king tide trend	
	Impact last 5 years: heat wave		
	Impact type, last 5 years: health		
	Income source: government		
	Negative perception of food provision		
		Lack of jobs problem ranking	
		Poor education problem ranking	
		Owning a boat	

Note: Appendix B, Tables 3—12 and Figures 1—10 contain full regression results for significant variables on the outcome "will or might migrate" over the whole dataset and with a cluster interaction term.

tween them (Table 6). There were opposite directions of association between Clusters 1 and 2 for all seven of the significant factors that they shared, including multiple income sources, and the state of local education and ecosystem services provision. Among members of Cluster 3, only one factor was significantly associated with an increased likelihood of a health impact: living on the lagoon side of the island.

Table 6. Factors significantly associated with the likelihood that a household member will experience a health impact, by cluster. Orange shading indicates an associated increase in the dependent variable; blue indicates an associated decrease

Cluster 1 (n=86)	Cluster 2 (n=91)	Cluster 3 (n=22)
Living on lagoon side	Living on lagoon side	Living on lagoon side
	Living on ocean side	
Larger household size	Larger household size	
Income source: agriculture	Income source: agriculture	
Income source: fishing	Income source: fishing	
Income source: private sector	Income source: private sector	
Poor education problem ranking	Poor education problem ranking	
More food from local environment	More food from local environment	
Overcrowding problem ranking		
	Livestock impacts	
Drinking water source: government supply		
	Impact type, last 5 years: trees	

Note: Appendix B, Tables 13—28 and Figures 11—22 contain full regression results for significant variables on the outcome "household health impact" over the whole dataset and with a cluster interaction term.

Discussion

Health as both a driver of migration and an outcome of climate change

This analysis showed that health is a very strong *driver* of migration for people in the RMI. Many respondents in the survey expected to migrate for health reasons (13%) or had already migrated for periods of more than a year for health reasons (9%). Another 16% reported that their most recent short-term (less than a year) migration was for medical reasons. However, the degree to which health *outcomes* due to climate change were related to migration decision-making was more difficult to interpret. We therefore used a hierarchical clustering analysis methodology to generate three distinct profiles of climate impacts and vulnerabilities among the survey population, and found that respondents indeed faced very different sets of circumstances that were associated with unique migration and health outcomes. Logistic regressions using cluster membership as an interaction term, for example, showed that across the full dataset, experiencing a household health impact due to climate stressors was associated with an increased expectation to migrate, but this relationship was only significant for members of Cluster 1 (Table 5; Appendix B, Table 9 and Figure 7).

Other factors were significantly associated with experiencing a negative health *outcome* within the clusters, yet only one appeared to be related to climate stressors. For members of Clusters 2 and 3, living on the lagoon side of the atoll was significantly associated with an increased likelihood of a health impact. The direction of association was the opposite for members of Cluster 1 living on the lagoon side, who saw a decreased likelihood of a health outcome. Lagoon sides of atolls are comparatively low-lying and more susceptible to impacts like storm surge and tidal flooding, so among these two relatively lower income groups, households with higher exposure to climate impacts may have been less able to take protective measures like building a seawall and more likely to experience negative health outcomes. In fact, the opposite direction of association was true of all seven of the variables shared by Clusters 1 and 2 in Table 6. This may reflect that members of Cluster 1 were more resilient due to their relatively more affluent, urban status. Taking income source as another example, members of Cluster 1, who received more of their total income from the private sector, might be less impacted by changes to other secondary income sources and therefore less likely to experience a health impact (because they can afford care) than they would be if their main source of income were reduced. These findings suggest that the nexus between climate change, health, and migration in the RMI is characterized by direct and indirect relationships that are not homogeneous throughout the RMI. Figure 13 conceptualizes these differences according to the three clusters identified in this analysis.

Inequities in wealth, social status, and agency

Members of Cluster 1 were comparatively wealthier and faced significantly lower climate and health-related impacts than the other two clusters. Most also owned land on the outer islands. They appeared to feel less vulnerable and were less likely to migrate. In contrast, members of

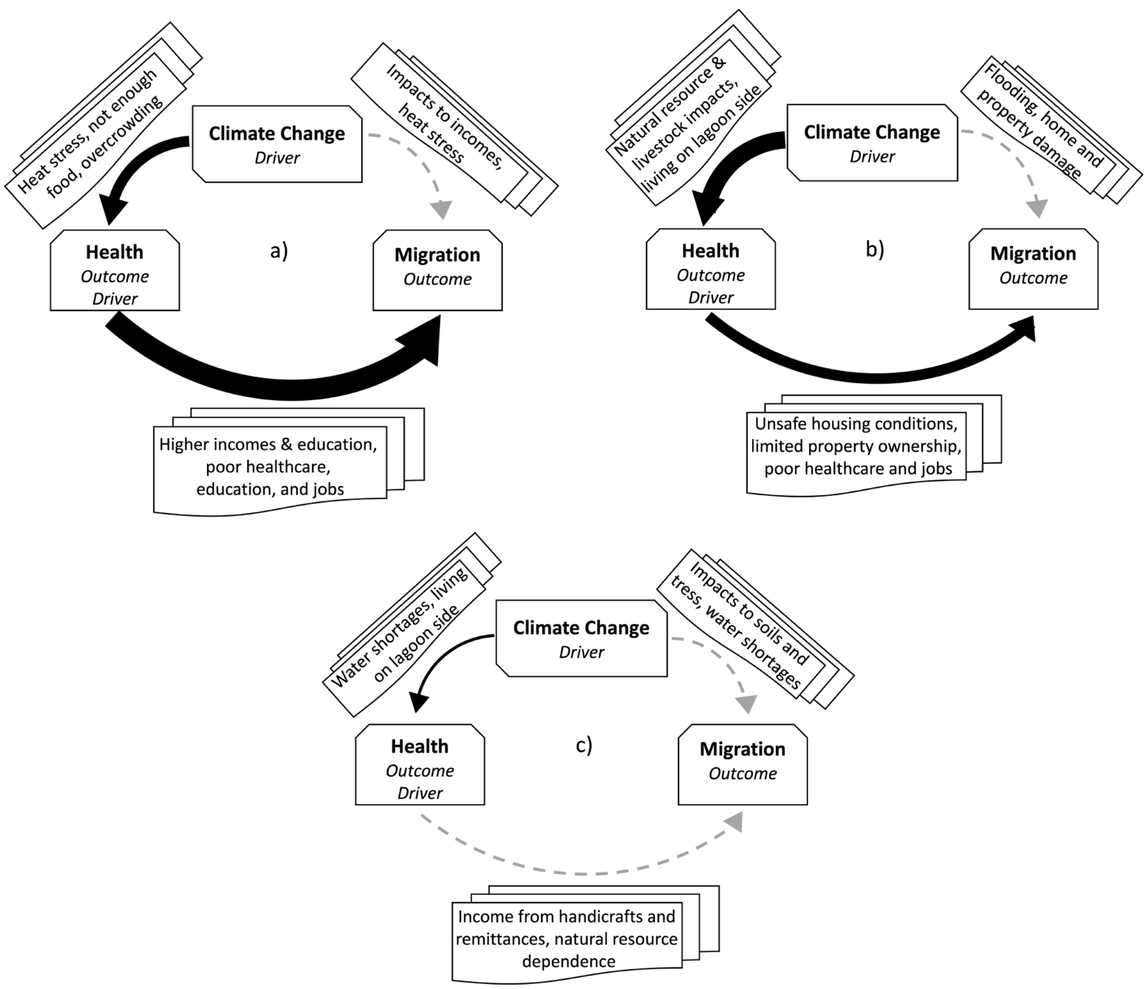

Figure 13. The different relationships and influencing factors between climate change, health, and migration for a) Cluster 1, b) Cluster 2, and c) Cluster 3. The thickness of the black lines indicates the relative strength of a relationship compared to the others. The gray dotted lines show a relationship that was not statistically significant in this analysis.

Cluster 2 had lower incomes and faced more prevalent climate impacts related to storms and the ocean, as well as similar (but slightly lower) impacts of heat waves, droughts, and access to fresh water. They reported a worse state of natural resources and felt much less safe, particularly with respect to their housing situation. They were also much more likely to expect to migrate. Overall, this may be the most vulnerable group because they appeared to be facing heat and drought challenges similar to Cluster 3 but with additional storm and ocean-related stressors, and less natural capital in terms of resources. The relatively small Cluster 3 consisted mostly of people with comparatively very low incomes who were the least likely to migrate. The most prevalent stressors for this group were related to heat and drought, particularly access to drinking water, but they also seemed to have sufficient access to natural resources. Despite being impacted by heat waves and water shortages, they overall seemed to feel somewhat neutral about their risk and safety compared to their more urban counterparts in Cluster 2.

Findings such as these suggest that a broader concept of wealth that encompasses more than income is needed. It may be more accurate, for example, to conceive of wealth in RMI as a combination of cash income, land ownership, social status, and access to natural resources. In more urban environments, cash income is likely a more dominant driver of both wealth and poverty. And especially in urban environments, access to natural resources, including local foods like coconuts, pandanas, and breadfruit, is often constrained by property ownership. The limited natural resources that are available in highly urbanized places, such as Majuro, are also disproportionately impacted by environmental degradation resulting from natural disasters and climate change (Barnett 2011; Ahlgren et al. 2014; IOM, 2017). In write-in responses, some respondents described a lack of ownership or control over the land they lived on as a factor inhibiting their ability to make their household more resilient to climate change, such as building a seawall or securing their home's roof. For respondents living on the outer islands, however, disparities in cash incomes were lower and many had greater access to natural resources. Members of Cluster 3, who largely lived on the outer islands on their own or their family's land also reported the highest levels of satisfaction with the natural resources available to them, for example. As a result, it is possible for a resident of Majuro who is renting a home and doesn't have access to fruit trees to possess less "tangible" wealth than a resident of the outer islands who may be making much less in terms of cash income. Such inequities were important distinguishers between the different profiles of resilience and vulnerability to climate impacts.

These disparities were also visible in migration agency, including migration for health reasons. The status of having completed a high school education serves as a good example. This variable was significantly associated with an *increased* expectation to migrate among members of Cluster 1, and a decreased expectation for members of Cluster 2 (Table 5). For members of Cluster 1 facing fewer stressors and having higher incomes, and potentially more secure livelihoods, education may have enhanced their agency such that migration was an available option. Conversely, for members of Cluster 2 facing greater stressors and lower incomes, having completed high school may have increased resilience and earning potential, reducing the urgency of making a decision to migrate in the future.

Among members of Cluster 1, there were overall more consistent patterns of association between the climate and health stressors faced by respondents and their expectations to migrate than among members of Clusters 2 and 3. Having higher cash incomes, prevalence of land ownership, and access to natural resources likely also offered members of Cluster 1 greater agency in deciding not to migrate; as noted in write-in responses, members of this cluster could afford to adapt in-place to heat waves and water shortages, for example. Conversely, members of Cluster 2, often having lower incomes and fewer resources, may have considered migration as less of a possibility, even when facing the same stressors, if they did not have adequate resources to do so. They may have also had less capacity to adapt to climate-related impacts than members of Cluster 1 and therefore less decision-making agency. Among members of Cluster 3, respondents' low expectations to migrate may have simply been related to other drivers or barriers not captured in the survey. These differences in agency and equity demonstrated that throughout the RMI, the impacts of climate change and people's experiences of them were not homogeneous.

Conclusions

There are profoundly concerning impacts of climate change facing the RMI that are experienced differently across the population and associated with different migration and health outcomes. In this study, we analyzed survey data from 199 households across three islands in the RMI and identified numerous relationships between climate stressors, health impacts, and migration decisions. However, there was high uncertainty and variability in this preliminary set of results over the full surveyed population. We therefore chose a hierarchical clustering approach to explore these non-linearities, which allowed us to define three unique profiles of resilience and vulnerability, with associated health and migration drivers and outcomes. Our key findings are summarized below.

First, the surveyed households experienced high levels of climate stressors, especially drought, heat waves, flooding, and king tide events, which mainly impacted household drinking water supplies, trees, soils, and crops. Furthermore, the severity of these impacts has been increasing. When asked to rank the top problems their household was facing, respondents' top issues were a mix of climate impacts, livelihood concerns, and social services. A lack of available jobs, poor education, and drought were the highest ranked problems, followed by sea level rise and poor healthcare services.

Second, the expectation to migrate was very high across the survey population. Overall, more than 50% of respondents said they or a member of their household would or might migrate in the coming decade. Seeking healthcare was also one of the top drivers of both past and potential future migrations, whereas climate change and environmental factors were rarely cited as *direct* migration motivations. However, there were climate-related factors that were *indirectly* related to migration decisions for the survey population (such as heat waves and impacts to freshwater resources).

Third, the clustering exercise revealed how people facing different sets of climate change stressors and impacts often had significantly different circumstances and associated expectations to migrate, as well as health outcomes. Although members of Clusters 1 and 2 were generally likely to expect to migrate, for example, only among members of Cluster 1 was experiencing a household health impact due to climate stressors associated with an increased expectation to migrate. In another example, having a high school education increased the expectation that members of Cluster 1 would migrate, whereas the opposite association was found for members of Cluster 2. The patterns of association between climate change, health impacts, and migration expectations among members of Cluster 1 are more commonly understood as "push" and "pull" factors (for example, European Communities 2000), which raises important questions about how migration decisions and experiences are conceptualized across diverse groups. For Cluster 3, only climate impacts to drinking water supplies and residing in a flood-prone area were associated with an increased expectation to migrate and negative health impacts, respectively, and more information is needed about this smaller group of mostly outer island residents.

Finally, wealth, social status, land ownership, and availability of natural resources were strong differentiators between the clusters that significantly influenced vulnerability and decision-making agency, with associated migration and health outcomes. The group with the highest incomes, land ownership, and education (Cluster 1) reported some of the least climate impacts and lowest intentions to migrate, perhaps because they possessed adaptation options (for example, the ability to buy an air conditioning unit or make improvements to their homes) that were not available to other groups. Members of Cluster 1 were also less likely to experience a household health impact than members of Cluster 2, likely due to greater access to and ability to afford care. Members of Cluster 2, on the other hand, experienced the impacts of climate change more strongly, had less secure housing, and were more likely to expect to migrate as a result, but had fewer financial resources to do so. Climate impacts to incomes, food sources, and ecosystem services increased this group's likelihood of experiencing a negative health outcome. And although the third group, Cluster 3, had lower cash incomes and experienced more heat and drought impacts than Clusters 1 and 2, they were generally more satisfied with the state of natural resources and ecosystem services, and less likely to intend to migrate. Nevertheless, living on the lagoon side of an atoll was significantly associated with an increased likelihood of a negative health impact, which may indirectly capture additional vulnerabilities among members of this group living in areas more exposed to tidal flooding and storm surge.

Research and policy implications

We offer three main research and policy implications based on this analysis. First, migration is and will likely remain a common activity within the RMI population. Marshallese culture is well-known for its oceangoing navigation and historically, people throughout Micronesia have utilized migration as one of many ways to thrive and adapt within a changing region. Migration should neither be approached as a problem that needs to be solved nor should it be seen as an unavoidable outcome that all Marshallese people will experience. Nevertheless, steps should be taken to enhance opportunities for both migration and remaining in-place so that people can freely choose without feeling that either option is a foregone conclusion.

Second, future research and policy interventions in the RMI should focus on vulnerable segments of the population. Issues surrounding wealth, social status, and the agency to implement measures to reduce climate risk, must be addressed head on. This was particularly true for Cluster 2 respondents living on Majuro, whose limited property rights prevented them from being able to protect their homes and households from climate impacts. We also observed that exposure to heat and limited access to fresh water were very salient concerns for certain groups, and in many cases were more severe threats than direct disasters that may be more intense but short-lived. Therefore, critical infrastructure projects like ensuring community access to drinking water, could provide more immediate benefits to these groups than larger, longer-term resilience projects like seawalls. Comparatively small interventions, like installing cooling centers for heatwave events, could also alleviate short term stressors that may be driving out-migration. Furthermore, by taking small steps to address challenges faced by vulnerable subsets of the population, communal agency and resilience would likely improve the success of national-level adaptation plans with greater input and engagement from people who may be too overwhelmed with day-to-day struggles to focus on long-term, large-scale interventions.

Lastly, enhancing opportunities for residents of the RMI to achieve what may now be seen as achievable only through migration would provide greater decision-making agency, as well as the potential for return migration (Hezel and Levin 1990). Expanded education, healthcare, and livelihood prospects with attention to long-term sustainability in the face of climate change would substantially reduce migration pressure. If, on the other hand, certain members of the population feel forced to migrate in the context of climate change, the disparities that exist today will only grow.

Recommendations for Policymakers

Migration will likely remain common within the RMI and abroad, and steps should be taken to enhance opportunities for both migration and remaining in-place so that people can freely choose without feeling that either option is a foregone conclusion.

Policy interventions should focus on vulnerable members of the population, including the elderly, lower income groups, and outer island residents. Critical infrastructure projects like ensuring community access to drinking water, and comparatively small interventions like installing cooling centers for heatwave events, could help alleviate stressors that may be driving out-migration.

Enhancing opportunities for residents to achieve what may now be seen as achievable only through migration—through expanded education, healthcare, and livelihood prospects—would provide greater decision-making agency, as well as the potential for return migration.

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Three men observe a high tide event in Majuro from a seawall. Image credit: David Krzesni.

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Appendix A:

Survey Instrument

Appendix B:

Supplementary Tables and Figures

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Appendix A: Survey Instrument

A. Interview information

A1. Date of interview: _ _/ _ _/ _ _

A2. Name of interviewer:

A3. Name of village or town:

A4. Name of Island:

A5. House GPS: Lat _ _._ _ _ _ Lon: _ _ _._ _ _ _

A6. Location: Lagoon-side | Ocean-side | Between

↓↓ To be filled in at time of data entry ↓↓

A7. Date of data entry: _ _/ _ _/ _ _

A8. Name of data entry officer:

A9. Questionnaire number:

B. Respondent and household information

B1. Name of respondent: ______________

B2. Respondent's telephone number: ______________

B3. Sex: 1=Male | 2=Female | 3=Transgender

B4. Birth year (write age if easier): ________ | -77=Don't know

a. If unknown: Please estimate age: ________

B5. Marital status: 1=Single | 2=Married | 3=Widowed | 4=Separated | 5=Common-law marriage | 6=Other, specify ________

B6. Place of birth: 1=This village | 2=Elsewhere on the island/atoll, specify village ________ | 3=Elsewhere in RMI, specify the island/atoll ________ | 4=US, specify state ________ | 5=Abroad, specify country ________

a. If not in this village: How long have you lived here, in this village? ________

B7. Where did you live most of your youth (0-18)? 1=In this village | 2=Elsewhere on this island/atoll, specify village ________ | 3=Elsewhere in RMI, specify island/atoll ________ | 4=US, specify state ________ | 5=Abroad, specify country ________

B8. Education level (highest attained): 1=No formal education | 2=Elementary (1-6) | 3= Junior High (7-8) | 4=Some high school | 5=High school diploma | 6=Some college | 7=Associates degree | 8=Undergraduate degree | 9=Graduate school

B9. Religion: 1= Assembly of God | 2= Ba'hai | 3=Baptist | 4=BNJ | 5=Full Gospel | 6=Catholic | 7=Mormon | 8=Protestant | 9=7th Day Adventist | 10=Atheist | 11= Other, specify ________

B10. Are you the head of this household? 1=Yes | 2=No | 3=My household does not have one head

a. If no: What is your relation to the household head? 1=I am the spouse | 2=A son | 3=A daughter | 4=Other, specify ________

> This questionnaire has several questions about the respondent's household. Please explain to the respondent who are considered household members.
> **HOUSEHOLD DEFINITION**: Group of people who live in the same house; who eat from the same kitchen most of the time; who share most resources. We consider children who are studying elsewhere as part of the household if the parents still cater for them. We consider seasonal and temporary migrants as part of the household if they have been home at least 6 of the last 12 months.
> *Jet ro rej joke ilo juon wot em; ekka aer mona ippan doon; im jake jobol eo kijien menin jeramman ko. Jej watok ajri ro rej jokwe joko jet im jikuul ejja uwaan wot rimwiin ne jineir im jemeir rej kabe wot aer aikuj. Jej watok ro mottar rej diwoj-delone aelon kein ejja uwaan wot remwiin ne raar jokwe ie iumwin 6 allon iloaan yio eo ej jemlok.*

B11. How many people are part of your household? ________
Jete uwaan armej in mwiin mom?

B12. Could you count the number of household members by gender and age group?
Komaron ke bwinetok oran emmaan im kora kab yio ko aer kajjojo?

Age group	Male	Female
0-19 years		
20-64 years		
65+ years		

B13. What economic activities and sources of income do you and your household members have? [multiple options] 1=Agriculture | 2=Fishing | 3=Government salary | 4=Private sector salary | 5=Own business | 6=Remittances from migrants | 7=Income from properties (rent) | 8=Income from savings and investments | 9=Other, specify ________
Kain jerbal rot ko am im rein rej joke mwiin? 1=Ekkat | 2=Enod | 3=Salary jan Kien| 4=Salary jan company ko | 5=Wor an make business | 6=Jaan ko jan nuki ro elkin | 7=Jaan ko walok jan imon rent ko | 8=Jaan ko walok jan jerbal ko jet | 9=Un ko jet, kalikkar ta

B14. Please estimate the total annual cash income of your household? [this includes cash income of all members from all economic activities] 1=Less than $1000 | 2=$1000-$2000 | 3=$2000-$5000 | 4=$5000-$10,000 | 5=$10,000-$20,000 | 6=More than $20,000 | -77=Don't know
Jouuj im antone tok dettan aolepen jaan eo ej delontok mwiin mom ilo juon yio?

B.15 Compared to other households in your village/town, would you say that your income is:
1=Less | 2=Average| 3=More
Ne kwonaj keidii jonan jaan ej tobrak miin mom nan moko jet ilo bukon in ta

B16. How has your household's income changed over the past 10 year? 1=Increased | 2=Stayed more or less the same | 3=Decreased
Ta oktak eo kwoj loe ilo jonan jaan eo ej delontok mwiin mom ilo yio ko jonouul remootlok?

C. Problem ranking

C1. I will read out 12 problems that people in the Marshall Islands might face. Could you select the 5 problems that are most important to you and your household? Please rank them from 1 to 5 (the most serious problem is 1; the least serious is 5). *Ij kio iten kollaajraki 12 aban ko armej ro ilo Majol in remaronn jelmai. Komaron ke kelet 5 iaer im kwoj lo bwe renaj lap aer aorok im naj jelet kwe im ro ilo mwiin mom? Im kollaajraki jino jan aban eo naj eddo tata lal lok nan eo emera tata.*

Problem	Rank	Problem	Rank	Problem	Rank
Poor education *Ejabwe jelalokjen*		Lack of job opportunities *Ejabwe jikin jerbal*		Poor transport facilities *Ejabwe ilan makitkit*	
Overcrowding *Elap an lon armej*		Littering/illegal dumping *Elap jakobej*		Drought *Mora kin an jab wot*	
Not enough fresh water *Ejabwe dennin daak*		Out-migration *Ri-etal nan likin Majol in*		No electricity (or power cuts) *Ejjelok jarom ak emoj tim jarom*	
Sea level rise *Laplok boka*		Poor healthcare services *Enana jikin takto*		Not enough fish *Ejabwe ek*	

C2. If out-migration is listed as one of the five most important problems: Why do you consider out-migration a problem for your island? *Ne kwar kelete "Ri-etal an likin Majol" einwot juon ian aban ko, komeleleik etke kwoj lomnak ke ej juon aban eo ej jelet ri anin*?

D. Land and housing

D1. Does your household own the house you live in? 1=Yes | 2=No
Momi ke mwiin?

D2. Does your household own the land that the house is built on? 1=Yes | 2=No
An ke rimiin bwidej in mwiin ej jutak ie?

D3. Do you or other household members own land on other islands, atolls or abroad? 1=Yes | 2=No
Ewor ke am ak rane jet mwiin bwidej ene ko jet ak lal ko likin?

a. If yes: Where? [mention the island, atoll, or place abroad] *Ne aet: Ia? [kalikkar en eo ak lal eo]* _________

D4. Compared to the other houses in your village/town, is your house of higher or lower quality? 1=Higher quality | 2=Average | 3=Lower quality
Ne kwonaj keiiri jonan emman in an mwiin nan moko jet eilo bukon in?

D5. Compared to other houses in the village, is the location of your house relatively risky or safe in case of natural disasters, such as floods and cyclones? 1=Riskier| 2=Average | 3=Safer
Ne kwonaj keiiri ijin mwiin mom ej pad ie nan moko jet ilo bukon in, ie jonan an kauwotata ne *ewor jorran ko einwot typhoon ak lan ko jet?*

a. If 1 or 3: Please explain what makes it riskier or safer: ________

D6. Does your house have electricity? 1=Yes | 2=No

D7. What is the source of your drinking water? [multiple options] 1=Tank | 2=Groundwater (well, pump)| 3=Water bins | 4=Gov't water supply system | 5=Village water supply system | 6=Reverse osmosis | 7=Buy drinking water in shop | 8=Other, specify ________
Komij idaak jan ia? - 1=Baantoon | 2=Aeboj lal | 3=Nien dan jiddik ko | 4=Den eo jan Kien | 5=Juon jikin den an aolepen bukon in | 6=Den jan kein ukok den ko | 7=Den ko wiaiki | 8=Un ko jet, kalikkar ta

D8. Does your house have a private pit latrine or toilet? 1=Yes | 2=No
Mwiin mom ej kojerbal mon kobbojak kaajliin ke em kottoor?

D9. Does your household own any of the following things? [and how many]: 1=TV ___ 2=phone ___ 3=Bicycle ___ | 4=Motorbike ___ | 5=Car ___ | 6=Fridge ___ | 7=Boat ___ | 8=Tablet/Computer ___ | 9=CB Radio ___
Ewor ke an rimiin men kein?

E. Environmental stressors

In the following questions I will ask you about different extreme weather events, such as typhoons and floods, and how these have affected your household. *Ilo kajitok kein ibojak in liwaj inaj kajitok kin jorraan ko einwot typhoon, ibwijleplep im joraan ko belaakur einwot jool eo ilo bwidej eo im aebojlal ko.*

E1. Has your household been affected by any of the following phenomena in the past five years? [multiple options] 1=Drought | 2= Heat wave | 3= Storm surge | 4= Typhoon | 5=King tide | 6=Other environmental stressors, specify ________ | 7=None
Emoj ke an mwiin mom ion men kein iloaan yio ko 5 remootlok? 1=Maro | 2= Okmaanan | 3=Nol | 4=Typhoon | 5= Ialaplep | 6=Jorran in mejatoto im lojet ko jet (kalikkari)

E2. How did these stressors affect your household?
Ie wawein an jorraan in mejatoto im lojet jelet rimiin mom?

E3. Could you indicate which of the following types of impact your household experienced from these stressors in the past 5 years? [multiple options] 1=Impact on crops | 2=Livestock | 3=Fish | 4=Trees | 5=Soil /land | 6=Other income | 7=Food prices | 8=Housing | 9=Properties | 10=Drinking water | 11=Impact on health | 12=Loss of life | 13=Other, specify ________
Komaron ke kalikkar iowi wot iaan men kein ilal rimiin raar jelmaei iloaan yio ko 10 remootlok itok wot jan joraan in mejatoto ak lojet eo? (maron lonlok jan juon uwaa) 1=mennin ekkat ko | 2=piik im bao | 3=ek ko| 4=wojke ko | 5=bwidej eo | 6=jaan ko walok jan jerbal einwot salary im mon wia mweuk | 7=wonaan mona ko ilo imon wia ko | 8= imon jokwe ko | 9=weto ko | 10=dennin idaak ko | 11=ejmour | 12=mej im jako an armej | 13=Un ko jet, kalikkar ta

E4. In the table below, please indicate how the severity of each item has changed over the past 10-20 years. *Iloaan yio ko 10 lok nan 20 remootlok, jouj im kalikar jonan an oktak eddo in [......]*
[Skip the table if respondent has not lived here long enough, say less than 5 years]

Stressors	Change	Explain
Drought *Mare*	1|2|3 | -77	
Heat waves *Okmaanan*	1|2|3 | -77	
Typhoon *Lan ellap*	1|2|3 | -77	
King tides *Uwe in den ilo ien ielaplep*	1|2|3 | -77	
Storm surges *Nol*	1|2|3 | -77	
Other environmental stressors, specify	1|2|3 | -77	

1=Increased | 2=Stayed more or less the same | 3=Decreased | -77=I don't know

E5. Has your household taken any of the following measures to prevent impacts of future hazards? [multiple options] 1=Relocated to a safer place | 2=Used safer building materials | 3=Constructed physical barriers around house/farm (e.g. dikes. Walls) | 4=Planted trees for protection | 5=Changed to more resistant crops | 6=Changed to less risky economic activities | 7=Sent a household members outside the village to earn money | 8=Other measure, specify ________ | 9=None, explain why not ________
Emoj ke an rimiin bok juon ian bunten ne kein ilal nan bobrae joraan ko ilju im jeklaj? (maron lonlok jan juon uwaak) 1=Emakit nan juon jikin emmanlok | 2=Kojerbal mennin ekkal ko rebenlok | 3=Kajutak ak ekkal men ko rej jebool e moko einwot oror deka ak jikin kottoor ko) | 4=Ekkat wojke ko nan jelitak | 5=Oktak nan mennin ekkat ko remaron jelmae jool I 6=Oktak nan jerbal in kwalok jaan ko eddiklok joraan walok jeni | 7=Jilkin lok juon ian rimiin nan likin bukon in nan apok jerbal | 8= Un ko jet, kalikkar ta

F. Importance, state, and trends in ecosystem services

In the following questions I will ask you about the natural resources on your island [where you live now], how important they are, whether there are any changes in these resources and what the causes may be. *Kio inaj kajjitok ippam kin mennin jeraamman ko en in. Ta aorok ier, ewor ke oktak nan i, im ta ko rekomman bwe en wor oktak nan i.*

F1. Please estimate how much of the food that your household eats comes from the local environment (for example from your own trees, crops or animals, or from fishing)? 1=(Almost) nothing | 2=Less than half | 3=Approximately half | 4=More than half | 5=(Almost) everything
Ilo am baj antoone, ie jonan an mona ko kijen rimwiin walon jen mennin jeraamman ko en in?

F2. For the ecosystem services in the table, please indicate how important they are for your quality of life, their current state on your island and how they changed over the past 10 years.
[Skip the last two columns if respondent has not lived here long enough, say less than 5 year]

Ecosystem Service	**Importance for your quality of life** **1=Very important** **2=A bit important** **3=Not very important**	**State** **1=Good/providing enough;** **2=A bit good/providing, but not enough;** **3=Bad/hardly providing**	**Trend (past 10 years)** **1=Improved;** **2=Stayed the same;** **3=Deteriorated** **Ilowaan yio ko 10 rej jemloklok…**	**If deteriorated (3), what do you think caused this?**
Provision of food	*Ie aorok in mona ko rej walok jen belak ko belakir nan rimwiin?*	*Ebwe ke mona?*	*ej laplak ke, jonan wot ke, drik lok?*	*Ta wunleplep eo?*
Fuelwood	*Ie aorok in kane ko rej walok jen belak ko belakir nan rimwiin?*	*Ebwe ke kane kein?*	*ej laplak ke, jonan wot ke, drik lok?*	*Ta wunleplep eo?*
Water	*Ie aorok in den ko rej walok jen belak ko belakir (einwot wot im aiboj lal) nan rimwiin?*	*Ebwe ke den kein rej walok jen wot im aiboj lal?*	*ej laplak ke, jonan wot ke, drik lok den kein?*	*Ta wunleplep eo?*
Safety	*Ie aorok in men ko rej jiban bobae koj jen an uwe tok den in lojet nan ion ene (einwot jelitak, wod, im kappe ko) nan rimwiin?*	*Ebwe ke an jelitak, wod, im kappe kein bobrae jen joraan ko walok?*	*ej laplak ke, jonan wot ke, drik lok an men kein bobrae jen joraan ko walok?*	*Ta wunleplep eo?*

G. Migration history

In the following questions I will ask you about your own and your parents' migration experiences in the past. There will be questions about where you migrated to, how long, for what purpose, and more.

Ilo kajjitok kein ilal, inaj kajitok ippam kin makitkit jan jikin nan jikin eo am e-koba jinom im jemom ilo tore ko remootlok. Enaj wor kajjitok ko kin ia ko emakitkit nani, ie toon, na ta, im ebar lon.

G1. Have any of your parents ever lived outside the island where they grew up for a year or more? 1=Yes | 2=No | 77=Don't know
Ewor ke ian jinom ak jemom emoj aer jokwe likin aelon eo rekar drik im ritto lok ie ella jan juon yio?

a. If yes: In which place did they live longest? 1=RMI, specify atoll/island ________ | 2=US, specify state ________ | 3=Other, specify country ________
Ne aet, ia eo ekar totata aer jokwe ie

G2. Have you migrated from the island where you grew up for periods of at least one month, but shorter than a year? 1=Yes | 2=No
Emoj ke am emakitkit jan aelon eo kwar drik im ritto lok ie iumwin tore ko tarrin juon allon ak ekadu jan juon yio?

a. If yes: Where did you go the last time? 1=RMI, specify island ________ | 2=US, specify state ________ | 3=Other, specify country ________
Ne aet: Ia eo kwaar etal nane eliktata?

b. What was the reason or purpose of your last trip? [multiple options] 1= Work | 2= Education | 3=Medical | 4=To visit family | 5=Other, specify________
Ta unin trip eo am eliktata [maron lon lok jan juon iuwwak] 1=Jerbal | 2=Jikuul | 3=Takto | 4=Lolok nuku | 5=Ko jet (kalikkar)

c. How many times have you gone on such a short-migration trip (more than a month, less than a year)? ______
Jete alen am kommane kain trip in jerbal rot in me e-aitok jan juon allon ak ekadulok jan juon yio?

G3. Have you ever lived outside the island where you grew up for a year or more? 1=Yes | 2=No
If no, skip table below and go to question G4] [If yes, fill in table and skip question G4+5
Emoj ke am pad im jokwe likin aelon eo kwar drik im ritto lok ie etolok jan juon yio?

Please fill in table below for each stay of over a year outside the island where you grew up.

Destination 1=RMI, specify island 2=US, specify state 3=Other, specify country	**When did you leave?** Year	**How long did you stay?** Number of years	**Reason/purpose** 1= Work 2= Education 3=Medical 4=To be with family 5= For reasons related to weather, floods, environment… specify 6=Other, specify [multiple options]	**With whom did you migrate?** 1=Alone 2=With whole household 3=With some HH members

G4. If respondent never migrated for a year or more: Why did you never migrate? [multiple options] 1=Never wanted to migrate| 2=Never needed to migrate | 3=Couldn't migrate
Ta eo bwe kwon kar jab emmakitkit jan aelon in? (maron lonlok jan juon uwaak) 1=Ejjelok ao kar konan| 2=Ejjelok unin ao kar emakit | 3=Ikar jab maron emakit

G5. If respondent couldn't migrate: What was the reason that you couldn't migrate? [multiple options] 1= Lack of money | 2= Health reasons | 3= No contacts/jobs at destination | 4= Responsibilities at home, specify ________ |5= Other reasons, specify ________
Ta kar un eo bwe kwon kar jab maron emakit (maron lonlok jan juon uwaak)? 1= Ejabwe jaan | 2=Un ko kijien ejmour | 3=Ejjelok ijela kajjien ak ejjab alikkar jerbal ijo | 4=Eddo ko ao ijo jiku, (kalikkar ta) | 5=Un ko jet (kalikkar ta)

G6. If respondent did migrate for a year or more: How did your migration experiences influence the economic situation and well-being of you and your household? 1=Very positive influence | 2=Quite positive influence | 3=Neutral | 4=Quite negative influence | 5=Very negative influence
Ie wawein an makitkit ko am jelet jokkin mour im jokane eo am im ro ilo mweo imom? 1=*Lukkun emman* | 2=*Ebwe an emman* | 3=*Ejjelok oktak* | 4=*Ebwe an nana* | 5=*Elukkun nana*

a. Please explain what made it positive or negative:

b. If positive: Where there also negative consequences? Please explain:

c. If negative: Were there also positive consequences? Please explain:

H. Migrant relatives and remittances

I will now ask you about children, brothers and sisters who currently live in other places than your island. *Ilo kajjitok kein ilal, inaj kajjitok kin makitkit ko an ro nejum, jeim/jatum emmaan im kora ro im rej kio jukjuk im amnak ijoko jet jelokin aelon in.*

H1. How many living brothers [share at least one parent] do you have? ________
Jete jeim ak jatum laddik?

H2. How many living sisters [share at least one parent] do you have? ________
Jete jeim ak jatum leddik?

H3. How many living children do you have? Boys: ________ Girls: ________
Jete nejum laddik?________ leddik? ________

Fill in table for siblings and children who presently live outside the island where you grew up:

Relation to respondent 1=Brother 2=Sister 3=Son 4=Daughter	**Where does s/he live?** 1=RMI, specify island 2=US, specify state 3=Abroad, specify country	**Education** 0=none 1=elementary 2=high school 3=college or higher 4=Other, specify	**Purpose/ reason to migrate** 1=For work 2=Education 3=Healthcare 4=Family 5=For reasons related to weather, floods, environment… specify 6=Other, specify	**Have you ever supported them with money since they left?** 1=Yes 2=No	**Have they ever supported your household with money since they left?** 1=Yes 2=No	**Remittances frequency** 1=At least once a month 2=At least once a year 3=Less than once a year

If you have siblings or children in Hawaii, may you please provide their name, where in Hawaii they live, and if possible their contact info (for example phone number, email address, Facebook)? This project is also conducted in Hawaii, and talking with your relatives in Hawaii will be very useful.
Elane ewor jeim ak jatum ak nejum ilo Hawaii, kwo meron ke joij im ba tok etaer, tu ia ilo Hawaii rej jokwe, im elane emman wawein ad meron tobar er (waanjonak, telephone number, email, facebook)? Project in ej bar komman ilo Hawaii, im je meron loe jet wonmaanlok ko jen ad bar konono ippen ro nukun ilo Hawaii.

H5. How does the migration of your siblings and children influence the economic situation and well-being of you and your household? 1=Very positive influence | 2=Quite positive influence | 3=Neutral | 4=Quite negative influence | 5=Very negative influence
Ie wawein an jako in an ro jeim im jatum jelet jeramman im jokane eo am im rimiin mom?
1= Lukkun emman | 2=Ebwe an emman | 3=Ejjelok oktak | 4=Ebwe an nana | 5=Elukkun nana

a. Please explain what made it positive or negative:

b. If positive: Where there also negative consequences? Please explain:

c. If negative: Where there also positive consequences? Please explain:

H6. If respondent has supported migrants: How much did you give in the past 12 months? [in US$] ________
Jete jaan in jiban kwaar jilkinlok iloaan allon ko 12 remootlok?

H7. What was the last time you received any remittances? [number of days, weeks, months or years ago] ________
0=Never --> SKIP H9. H10. H11. and H12.
Naat eo eliktata eaar wor tok am jaan jan likin?

H8. How much did you receive the last time? [in US$] ________
Jete eo kar jilkintok nan kwe eliktata?

H9. Please estimate the total amount of remittances in the past 12 months [in US$]: ________
Jouj im antoone jete eo kar jilkintok jan likin iloaan allon ko 12 remootlok?

H10. How has the amount of remittances you received changed over the past 10 years? 1=Increased | 2= Stayed more or less the same | 3=Decreased
Ie wawein an oktak dettan ko jilkintok nan kwe jan ilikin iloaan yio ko 10 remootlok?

H11. For what purposes have you used money that you received from migrant relatives (not only this year, in general)? [multiple options] 1=To buy food | 2=To pay for other daily needs | 3=To buy clothes and other goods | 4=To invest in economic activities, specify ________ | 5=To invest in housing | 6=To pay school fees | 7=To pay hospital bills | 8=Other-specify ________
Nan ta ko kwaar kojerbali jaan ko nukum ilkin raar jilkin tok? (ejjab wot loan yio in ak jabrewot tore) 1=Nan wia mona | 2=Nan kollaki aikuj ko jet walok jan raan nan raan | 3= Nan wia nuknuk im aikuj ko jet | 4=Nan wia koj ak share ko ilo jerbal im makitkit ko rej kwalok jaan (kaiikkar ta) ________ | 5=Nan ekkal em | 6=Nan kolla wonaan jikuul | 7=Nan kolla wonaan takto | 8= Un ko jet, kalikkar ta

I. Migration intentions and inability to migrate

In the following questions I will ask about your household's future migration plans. But I will start with a question about things that may make it harder to migrate. *Inaj kajitok ippam kin plan ko an rimiin nan emakitkit raan kane tok. Ak inaj jino kin juon kajjitok kin ta menko remaron mennin kabanban nan diwojlok ak makitkit.*

I1. Has it ever happened that a household member wanted to migrate, but couldn't? 1=Yes | 2=No
Ewor ke juon tore juon iaan rimiin raar konan emakitkit ak dwiwojlok ak raar jab maron?

a. If yes: What was the reason? [multiple options] 1=Lack of money | 2=Health reasons | 3=No contacts/jobs at destination | 4=Responsibilities at home, specify ________ |5=Other reasons, specify ________
Ne aet: ta un eo (maron lonlok jan juon uwaak) 1=Ejabwe jaan | 2=Un ko kijien ejmour | 3=Ejellok ijela kajien ak ejjab alikkar jerbal ijo | 4=Eddo ko ao ijo jiku (kalikkar ta) | 5=Un ko jet, kalikkar ta

I2. Do you think that you or one of your household members will migrate (in RMI or abroad) within the next 10 years? 1=Yes | 2=No | 3=Maybe [bolen]   If 'no', go to Section J
Kwoj lomnak kwe ak juon ian rimiin mom naj makitkit (loaan wot Majol in ak nan likin) iloaan yio kein 10 rej pedo tok?

a. If 1 or 3: Who would migrate? [multiple options] 1=The whole household | 2=Me | 3=My spouse | 3=My son(s) | 4=My daughter(s) 5=My brother(s) | 6=My sister(s) | 7=Other(s), specify ________

I3. Where would you probably migrate to? 1=RMI, specify island ________ | 2=US, specify State ________ | 3=Other, specify country ________

I4. What would probably be the reason or purpose to migrate? [multiple options] 1=For work | 2=For education | 3=For healthcare | 4=To be with family in destination area | 5=Because of environmental problems, such as salinity or flood risks | 6=Other, specify ________
Naj ta bolen unleplep eo nan emakitkit? 1=Nan jerbal | 2=Nan jikuul | 3=Nan takto | 4=Pad ippan nuku ijo ij jibadok lok | 5=Kin joraan ko nan belaak ko einwot laplok an jool bwidej ak kauwotata ko jan ibwijleplep | 6=Un ko jet, kalikkar ta

I5. If you or your household members would migrate in the future, how do you think it will influence your economic situation and well-being? 1=Very positive influence | 2=Quite positive influence | 3=Neutral | 4=Quite negative influence | 5=Very negative influence
Ne kwe ak ro mwiin baj diwojlok ilju im jeklak, kwoj lomnak ie wawein an naj jelet jokjok in mour im jokumman eo am im ro ilo mweo imom?

a. If positive or negative: Please explain why you think it will be positive or negative:

b. If positive: Do you expect that there will also be negative consequences? Please explain:

c. If negative: Do you expect that there will also be positive consequences? Please explain:

J. Governance

In the following questions I will ask about things that the government and other organizations have done and what they should do to improve living conditions on the island [where you currently live].
Inaj kajitok kin ta menko Kien im douluul ko jet emoj aer kommani im ta ko ekkar aer kommani nan kokmanmanlok jokkin mour aelon in kwoj jokwe ie kio.

J1. Has the government or other organizations done anything to protect people against impacts of sea level rise, storms, floods and drought? 1=Yes | 2=No
Emoj ke an Kien ak douluul ko jet kommane jabrewot jokjok ko nan kejbarok armej jan laplok in boka, lan laplap, ibwijleplep, im mora ko walok jan an jab wot?

a. If yes, what have they done?

J2. What do you think the government and other organizations should do to protect people against such impacts?
Kwoj lomnak ta eo ekkar an Kien im douluul ko jet kommane nan kojbarok armej jan joraan rot kein?

Appendix B: Supplementary Tables and Figures

Table 1. Tukey's Honest Significant Difference test results for variables used for clustering. Blue shading indicates a significant ($p < 0.05$) positive difference between clusters; orange indicates a significant negative difference

		Cluster contrast		
		2–1	3–1	3–2
	aov.p	Estimate (p)	Estimate (p)	Estimate (p)
Household impact last 5 years: typhoon	0.002	0.110 (0.002)	0.000 (1.000)	–0.110 (0.079)
Household impact last 5 years: storm surge	0.000	0.251 (0.000)	–0.023 (0.950)	–0.275 (0.001)
Household impact last 5 years king tide	0.000	0.656 (0.000)	0.033 (0.922)	–0.623 (0.000)
Household impact last 5 years: flood	0.000	0.688 (0.000)	0.021 (0.965)	–0.667 (0.000)
Heatwave trend	0.002	0.269 (0.002)	0.150 (0.467)	–0.119 (0.615)
Impact type, last 5 years: crops	0.000	0.322 (0.000)	–0.109 (0.607)	–0.431 (0.000)
Impact type, last 5 years: fish	0.000	0.253 (0.000)	–0.020 (0.972)	–0.273 (0.006)
Impact type, last 5 years: trees	0.000	0.326 (0.000)	0.488 (0.000)	0.162 (0.286)
Impact type, last 5 years: soil/land	0.000	0.396 (0.000)	0.444 (0.000)	0.048 (0.900)
Impact type, last 5 years: income	0.042	–0.068 (0.053)	–0.079 (0.192)	–0.011 (0.967)
Impact type, last 5 years: food prices	0.009	–0.094 (0.012)	–0.105 (0.097)	–0.011 (0.973)
Impact type, last 5 years: housing	0.000	0.411 (0.000)	–0.105 (0.525)	–0.516 (0.000)
Impact type, last 5 years: properties	0.000	0.446 (0.000)	–0.047 (0.881)	–0.493 (0.000)
Not enough freshwater problem ranking	0.000	1.810 (0.000)	2.900 (0.000)	1.090 (0.017)
Sea level rise problem ranking	0.000	0.411 (0.202)	1.990 (0.000)	1.580 (0.000)
Not enough fish problem ranking	0.000	0.003 (1.000)	1.030 (0.000)	1.030 (0.000)
Weighted state of provision of food	0.000	–0.032 (0.977)	1.040 (0.000)	1.070 (0.000)
Weighted state of provision of fuelwood	0.000	0.779 (0.007)	2.700 (0.000)	1.920 (0.000)
Weighted trend in provision of water	0.010	–0.424 (0.310)	-1.480 (0.008)	-1.050 (0.079)
Weighted trend in provision of fuelwood	0.000	0.307 (0.443)	2.470 (0.000)	2.160 (0.000)
Weighted trend in provision of safety	0.001	–0.873 (0.000)	–0.502 (0.378)	0.371 (0.581)

Table 2. Tukey's Honest Significant Difference test results for variables not used for clustering that differed significantly between clusters. Blue shading indicates a significant ($p < 0.05$) positive difference between clusters; orange indicates a significant negative difference

		Cluster contrast		
		2–1	3–1	3–2
	aov.p	Estimate (p)	Estimate (p)	Estimate (p)
Household member will migrate	0.029	0.024 (0.938)	−0.270 (0.045)	−0.294 (0.025)
Household member will or might migrate	0.002	0.137 (0.148)	−0.273 (0.052)	−0.410 (0.001)
Past flood recorded	0.005	0.223 (0.004)	0.000 (1.000)	−0.223 (0.314)
Household impact last 5 years: heat wave	0.016	0.212 (0.013)	0.060 (0.865)	−0.151 (0.398)
King tide trend	0.000	0.241 (0.004)	−0.327 (0.040)	−0.568 (0.000)
Storm surge trend	0.002	0.205 (0.001)	0.053 (0.862)	−0.152 (0.297)
Impact type, last 5 years: livestock	0.000	0.297 (0.000)	0.146 (0.419)	−0.151 (0.379)
Drought problem ranking	0.000	0.465 (0.116)	2.150 (0.000)	1.680 (0.000)
Poor education problem ranking	0.000	−0.768 (0.039)	−2.600 (0.000)	−1.830 (0.001)
Overcrowding problem ranking	0.041	−0.633 (0.045)	−0.652 (0.262)	−0.018 (0.999)
Poor healthcare problem ranking	0.000	−0.877 (0.002)	−1.560 (0.000)	−0.679 (0.210)
Lack of jobs problem ranking	0.000	−0.523 (0.079)	−2.030 (0.000)	−1.500 (0.000)
Weighted state of provision of safety	0.028	−0.442 (0.084)	0.276 (0.669)	0.718 (0.069)
Perception that house is riskier than neighbors	0.000	−0.568 (0.000)	−0.239 (0.250)	0.328 (0.072)
Preventative measures: changed economic activities	0.004	−0.200 (0.010)	−0.300 (0.038)	−0.100 (0.672)
Preventative measures: earn outside income	0.013	0.160 (0.021)	−0.040 (0.925)	−0.200 (0.136)
Preventative measures: other	0.001	−0.180 (0.001)	0.002 (1.000)	0.182 (0.091)
Preventative measures: none	0.028	−0.173 (0.025)	−0.031 (0.954)	0.142 (0.359)
Location: Maloelap	0.000	0.079 (0.414)	0.474 (0.000)	0.395 (0.000)
Location: Majuro	0.000	−0.167 (0.050)	−0.594 (0.000)	−0.427 (0.001)
Household income	0.000	−3530 (0.001)	−6890 (0.000)	−3360 (0.055)
Income source: agriculture	0.000	0.197 (0.017)	0.568 (0.000)	0.371 (0.003)
Income source: fishing	0.002	0.127 (0.195)	0.418 (0.001)	0.291 (0.034)
Income source: government salary	0.000	−0.260 (0.001)	−0.430 (0.001)	−0.170 (0.293)
Income source: private sector salary	0.000	−0.173 (0.034)	−0.413 (0.001)	−0.240 (0.071)
Household income change, past 10 years	0.003	−0.348 (0.003)	−0.309 (0.169)	0.039 (0.971)
Level of education completed	0.003	0.122 (0.870)	−1.160 (0.008)	−1.280 (0.002)
Household owns land that house is on	0.002	0.079 (0.502)	0.396 (0.001)	0.317 (0.014)
Household owns land on outer islands or elsewhere	0.034	−0.060 (0.435)	−0.201 (0.027)	−0.141 (0.162)
Household eats local more than half of the time	0.018	0.025 (0.943)	0.341 (0.015)	0.316 (0.025)
Probably migrate for work	0.027	−0.003 (0.999)	−0.256 (0.028)	−0.253 (0.029)
Probably migrate for education	0.009	−0.017 (0.963)	−0.314 (0.008)	−0.297 (0.013)
Total amount of remittances received	0.000	197 (0.689)	4110 (0.000)	3910 (0.000)
Remittances used to pay hospital bills	0.010	0.117 (0.038)	−0.070 (0.623)	−0.187 (0.035)

Table 2. (continued)

		Cluster contrast		
		2–1	3–1	3–2
	aov.p	Estimate (p)	Estimate (p)	Estimate (p)
Drinking water source: groundwater	0.000	−0.0594 (0.290)	0.282 (0.000)	0.342 (0.000)
Drinking water source: rainwater bins	0.000	0.005 (0.994)	0.486 (0.000)	0.481 (0.000)
Drinking water source: government supply	0.001	−0.19 (0.001)	−0.165 (0.120)	0.025 (0.951)
Drinking water source: reverse osmosis	0.040	0.09 (0.327)	0.246 (0.038)	0.156 (0.259)
Drinking water source: shop	0.001	−0.153 (0.05)	−0.384 (0.001)	−0.231 (0.065)
Participant has lived in same location since birth	0.013	−0.107 (0.242)	0.182 (0.145)	0.290 (0.010)
Never needed to migrate	0.016	0.148 (0.369)	0.412 (0.012)	0.264 (0.162)
Participant location: inland	0.008	−0.268 (0.006)	−0.129 (0.562)	0.139 (0.491)
Participant location: ocean side	0.001	0.223 (0.003)	−0.038 (0.923)	−0.261 (0.020)
Participant location: coast	0.008	0.268 (0.006)	0.129 (0.562)	−0.139 (0.491)

Logistic regressions using cluster membership as an interaction term

Tables 3-12 and Figures 1-10 contain logistic regression results with the outcome variable "will or might migrate" and using a dummy variable for cluster membership as an interaction term. "Will or might migrate" means that a respondent answered "Yes" or "Maybe" to the question: Do you think that you or one of your household members will migrate (in RMI or abroad) within the next 10 years? 1=Yes | 2=No | 3=Maybe

Table 3. Logistic regressions of independent variable "Income source: government salary" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	0.44 * (0.20)	0.69 (0.37)
Income source: government salary	−0.72 * (0.29)	-1.16 * (0.47)
Cluster2		0.13 (0.47)
Cluster3		-1.95 ** (0.68)
Income source: government salary:Cluster2		0.47 (0.65)
Income source: government salary:Cluster3		1.32 (1.37)
N	198	198
Pseudo R2	0.04	0.14

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.
Standard errors are in parenthesis

Notes: The first two rows of column 2, (intercept), and the IV being tested in the model, refer to Cluster 1. The intercept and interaction terms for Clusters 2 and 3 would be added/subtracted to Cluster 1 coefficients to create separate logistic regressions for each cluster.

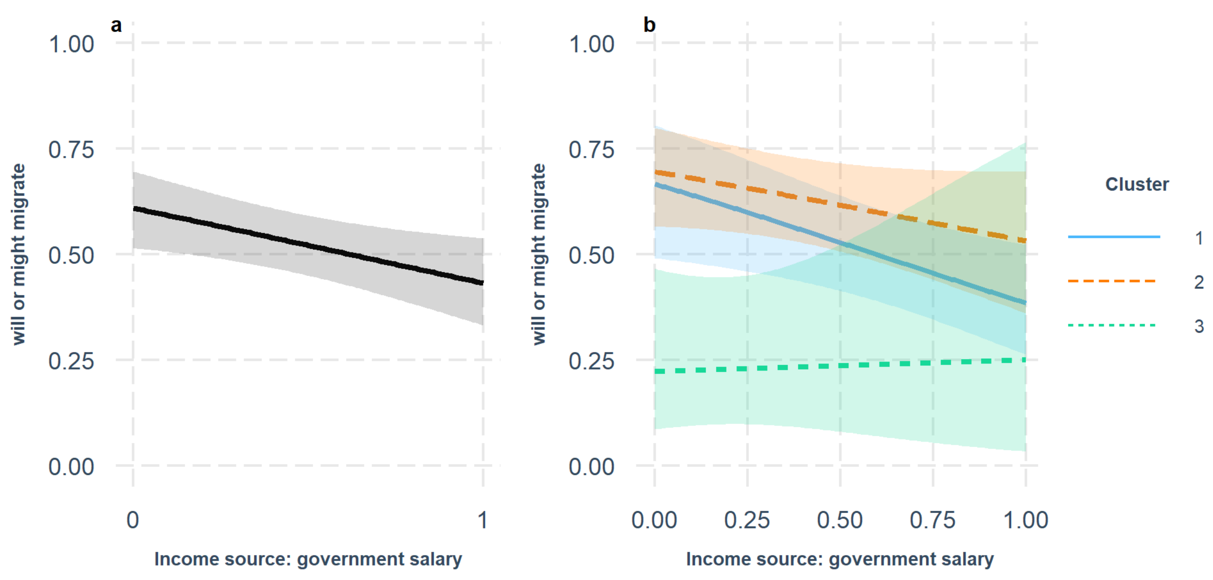

Figure 1. Basic regression results for independent variable "Income source: government salary" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 4. Logistic regressions of independent variable "Drought problem ranking" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	0.68 ** (0.23)	0.11 (0.32)
Drought problem ranking	−0.27 ** (0.09)	−0.07 (0.15)
Cluster2		1.25 * (0.50)
Cluster3		−0.28 (1.33)
Drought problem ranking:Cluster2		−0.30 (0.21)
Drought problem ranking:Cluster3		−0.23 (0.38)
N	199	199
Pseudo R2	0.06	0.14

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

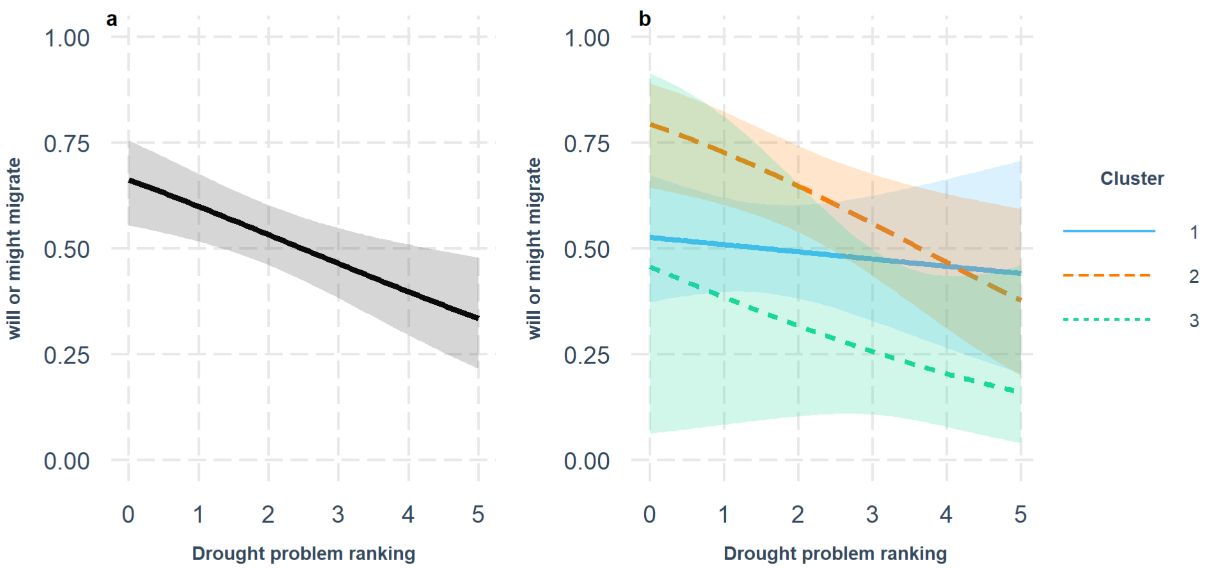

Figure 2. Basic regression results for independent variable "Drought problem ranking" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 5. Logistic regressions of independent variable "Poor education problem ranking" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	−0.11 (0.20)	0.16 (0.35)
Poor education problem ranking	0.11 (0.07)	−0.08 (0.10)
Cluster2		0.01 (0.45)
Cluster3		-1.60 * (0.66)
Poor education problem ranking:Cluster2		0.32 * (0.15)
Poor education problem ranking:Cluster3		8.08 (441.37)
N	196	196
Pseudo R2	0.02	0.15

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

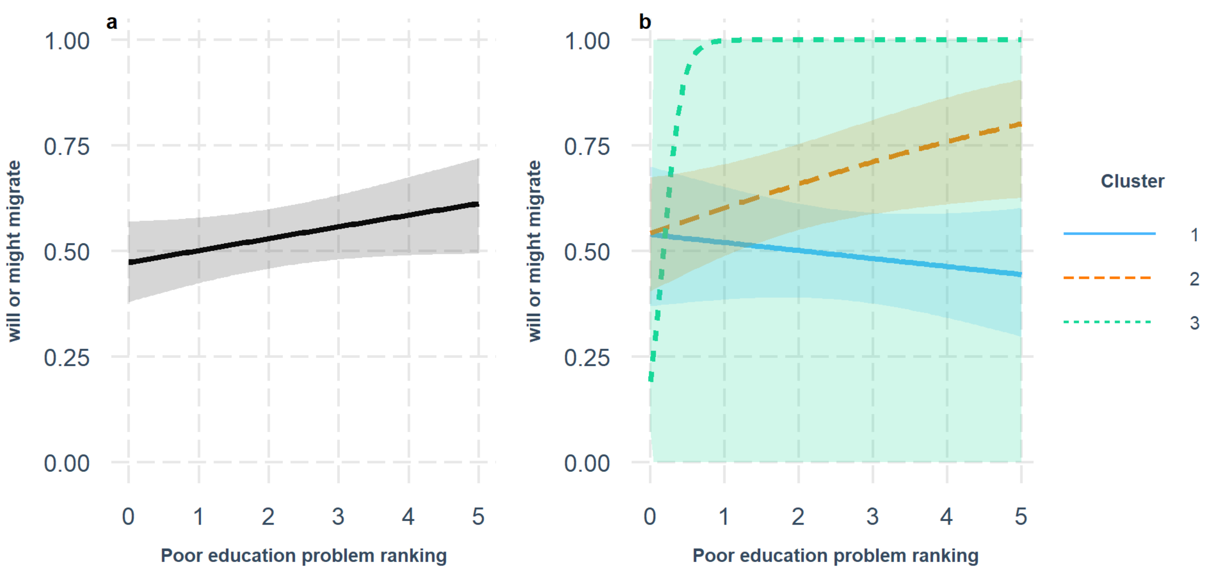

Figure 3. Basic regression results for independent variable "Poor education problem ranking" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 6. Logistic regressions of independent variable "Lack of jobs problem ranking" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	−0.36 (0.25)	0.16 (0.45)
Lack of jobs problem ranking	0.20 * (0.09)	−0.07 (0.14)
Cluster2		−0.41 (0.59)
Cluster3		-1.68 * (0.80)
Lack of jobs problem ranking:Cluster2		0.46 * (0.20)
Lack of jobs problem ranking:Cluster3		0.39 (0.42)
N	196	196
Pseudo R2	0.04	0.15

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

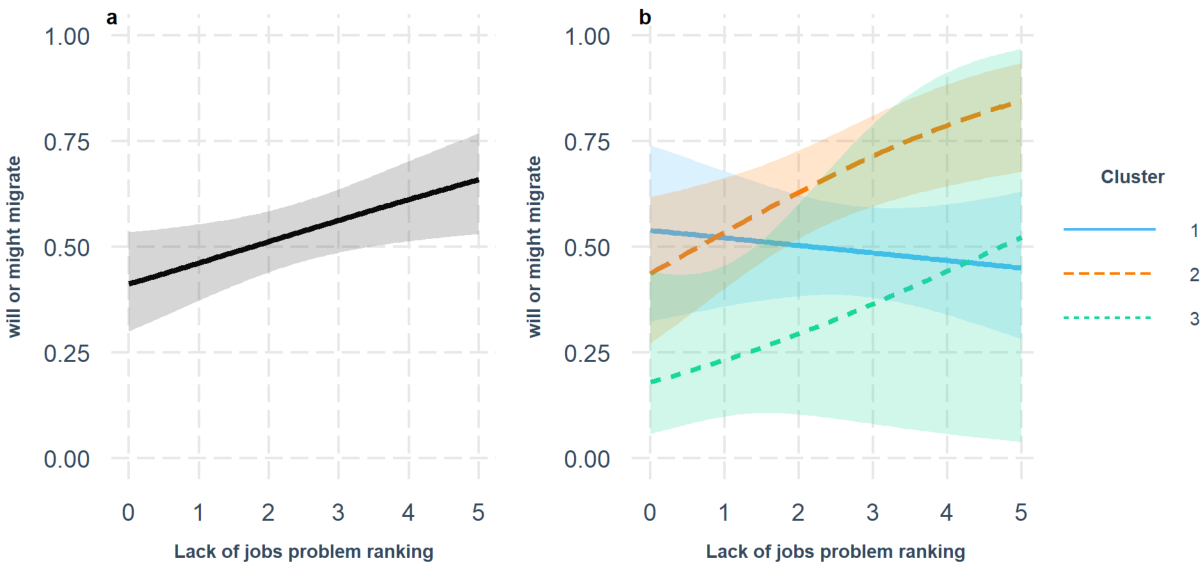

Figure 4. Basic regression results for independent variable "Lack of jobs problem ranking" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 7. Logistic regressions of independent variable "Household owns a boat" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	0.17 (0.16)	−0.18 (0.24)
Household owns a boat	−0.18 (0.27)	1.08 (0.61)
Cluster2		1.05 ** (0.35)
Cluster3		−1.14 (0.61)
Household owns a boat:Cluster2		−2.06 ** (0.75)
Household owns a boat:Cluster3		−0.45 (1.48)
N	197	197
Pseudo R2	0.00	0.15

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

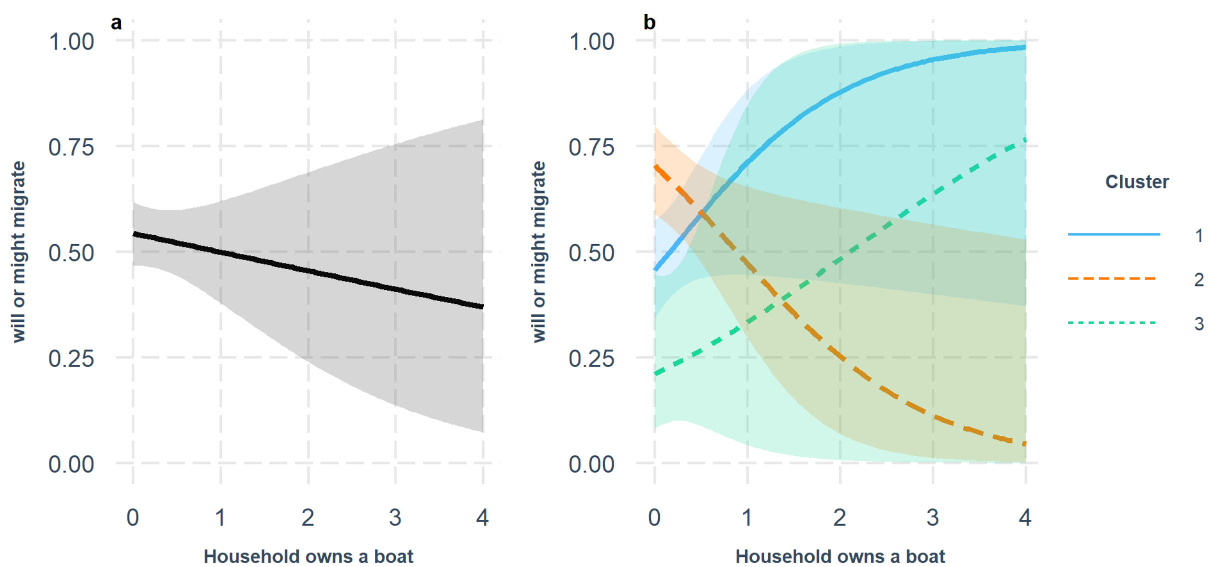

Figure 5. Basic regression results for independent variable "Household owns a boat" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 8. Logistic regressions of independent variable "Household impact last 5 years: heat wave" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	−0.09 (0.19)	−0.36 (0.27)
Household impact last 5 years: heat wave	0.50 (0.29)	1.05 * (0.47)
Cluster2		0.87 * (0.42)
Cluster3		−0.45 (0.66)
Household impact last 5 years: heat wave:Cluster2		−0.96 (0.65)
Household impact last 5 years: heat wave:Cluster3		−2.32 (1.31)
N	199	199
Pseudo R2	0.02	0.12

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

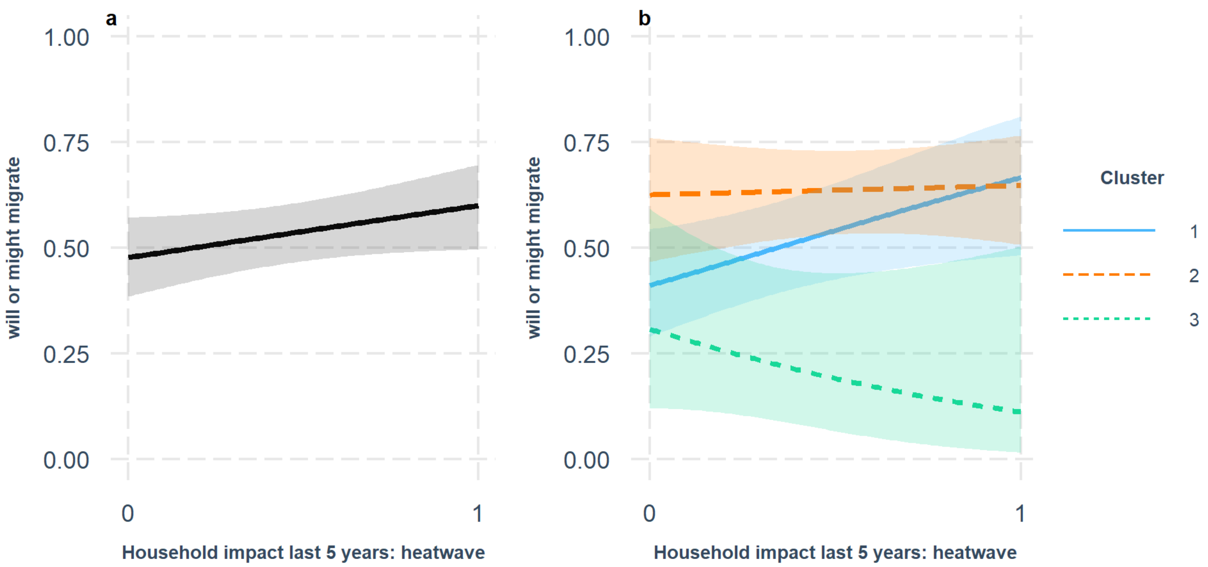

Figure 6. Basic regression results for independent variable "Household impact last 5 years: heat wave" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 9. Logistic regressions of independent variable "Impact type, last 5 years: health" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	−0.14 (0.19)	−0.22 (0.30)
Impact type, last 5 years: health	0.91 ** (0.31)	0.97 * (0.49)
Cluster2		0.57 (0.41)
Cluster3		-1.39 * (0.70)
Impact type, last 5 years: health:Cluster2		−0.41 (0.67)
Impact type, last 5 years: health:Cluster3		0.64 (1.28)
N	189	189
Pseudo R2	0.06	0.13

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

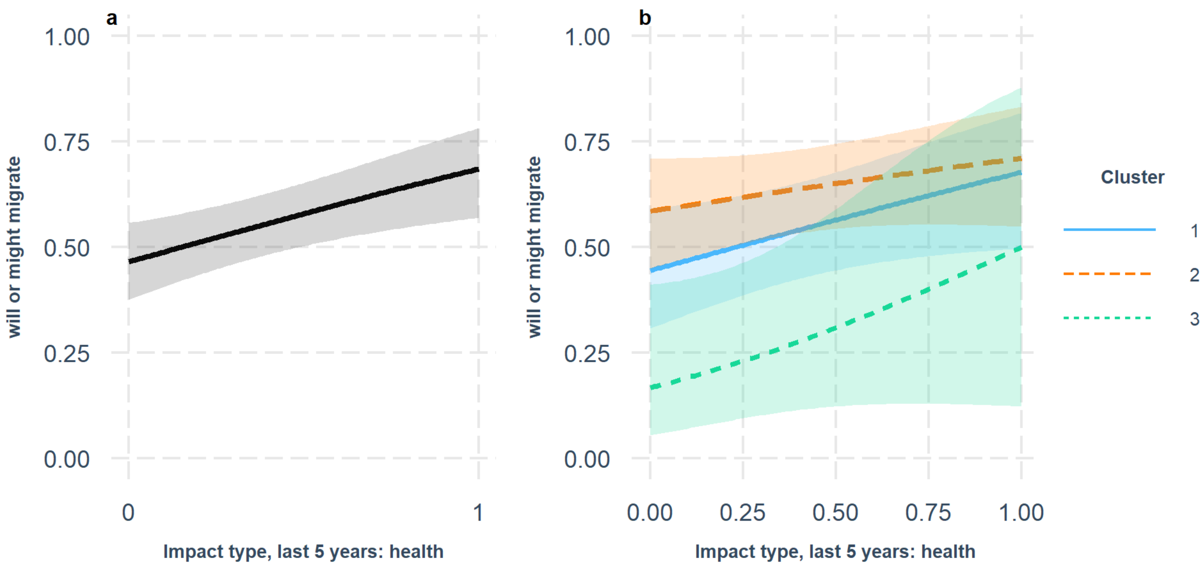

Figure 7. Basic regression results for independent variable "Impact type, last 5 years: health" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 10. Logistic regressions of independent variable "Drought trend" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	0.75 (0.43)	−0.34 (0.59)
Drought trend	−0.62 (0.46)	0.48 (0.63)
Cluster2		2.73 * (1.20)
Cluster3		14.90 (882.74)
Drought trend:Cluster2		−2.50 * (1.24)
Drought trend:Cluster3		−16.23 (882.74)
N	190	190
Pseudo R2	0.01	0.12

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

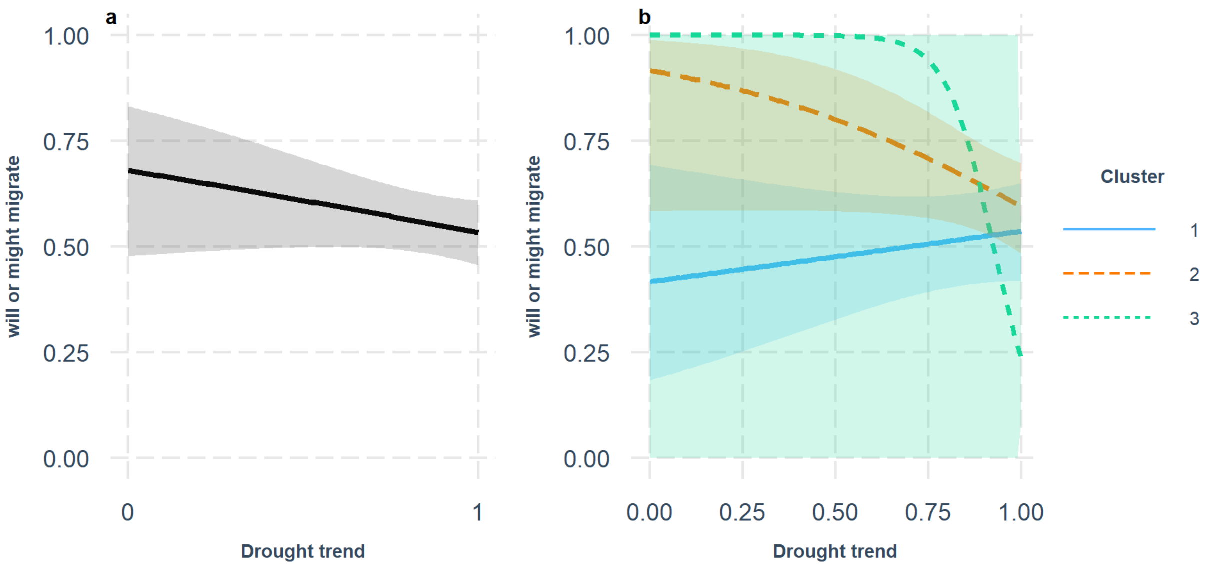

Figure 8. Basic regression results for independent variable "Drought trend" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 11. Logistic regressions of independent variable "King tide trend" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	0.62 ** (0.23)	0.25 (0.31)
King tide trend	−0.62 * (0.31)	−0.19 (0.46)
Cluster2		2.24 ** (0.80)
Cluster3		−0.72 (0.65)
King tide trend:Cluster2		−2.26 * (0.91)
King tide trend:Cluster3		−14.91 (1029.12)
N	178	178
Pseudo R2	0.03	0.16

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

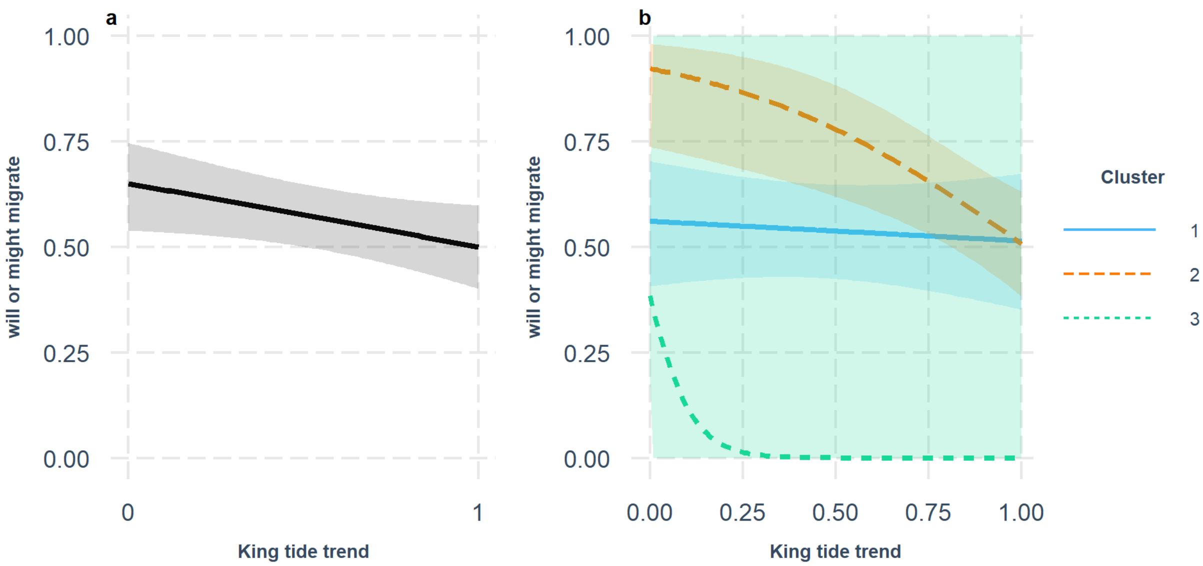

Figure 9. Basic regression results for independent variable "King tide trend" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Table 12. Logistic regressions of independent variable "Household elevation" on the outcome "will or might migrate"

	Basic Regression	Cluster Interaction
(Intercept)	−0.58 (0.38)	−1.55 ** (0.59)
Household elevation	0.27 * (0.13)	0.62 ** (0.21)
Cluster2		2.17 ** (0.84)
Cluster3		−1.15 (2.05)
Household elevation:Cluster2		−0.63 * (0.30)
Household elevation:Cluster3		−0.13 (0.64)
N	196	196
Pseudo R2	0.03	0.15

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

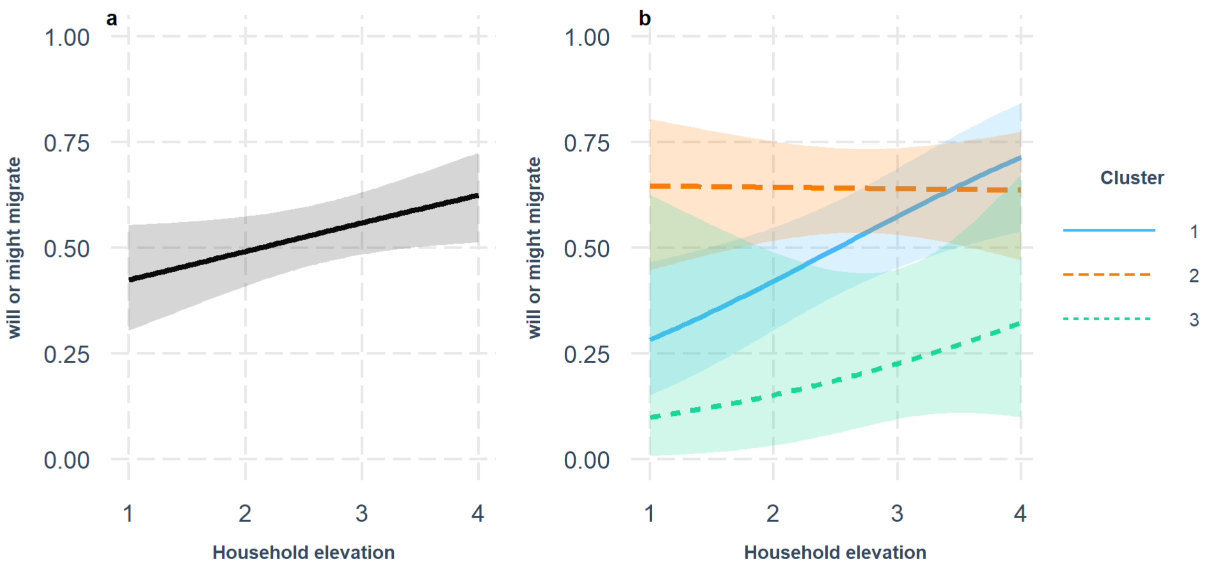

Figure 10. Basic regression results for independent variable "Household elevation" on the outcome "will or might migrate" a) over the whole dataset and b) with a cluster interaction term.

Logistic Regressions Using Cluster Membership as an Interaction Term

Tables 13-24 and Figures 11-22 contain logistic regression results with the outcome variable "Impact on health" and using a dummy variable for cluster membership as an interaction term, in answer to the question: Could you indicate which of the following types of impact your household experienced from these stressors in the past 5 years? [multiple options] 1=Impact on crops | 2=Livestock | 3=Fish | 4=Trees | 5=Soil / land | 6=Other income | 7=Food prices | 8=Housing | 9=Properties | 10=Drinking water | 11=Impact on health | 12=Loss of life | 13=Other, specify

Table 13. Logistic regressions of independent variable "Participant location: lagoon side" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.27 (0.22)	0.51 (0.37)
Participant location: lagoon side	-0.34 (0.35)	-1.54 * (0.64)
Cluster2		-1.04 * (0.48)
Cluster3		-2.71 * (1.12)
Participant location: lagoon side:Cluster2		1.79 * (0.80)
Participant location: lagoon side:Cluster3		2.89 * (1.41)
N	145	145
Pseudo R2	0.01	0.12

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

Notes: The first two rows of column 2, (intercept), and the IV being tested in the model, refer to Cluster 1. The intercept and interaction terms for Clusters 2 and 3 would be added/subtracted to Cluster 1 coefficients to create separate logistic regressions for each cluster.

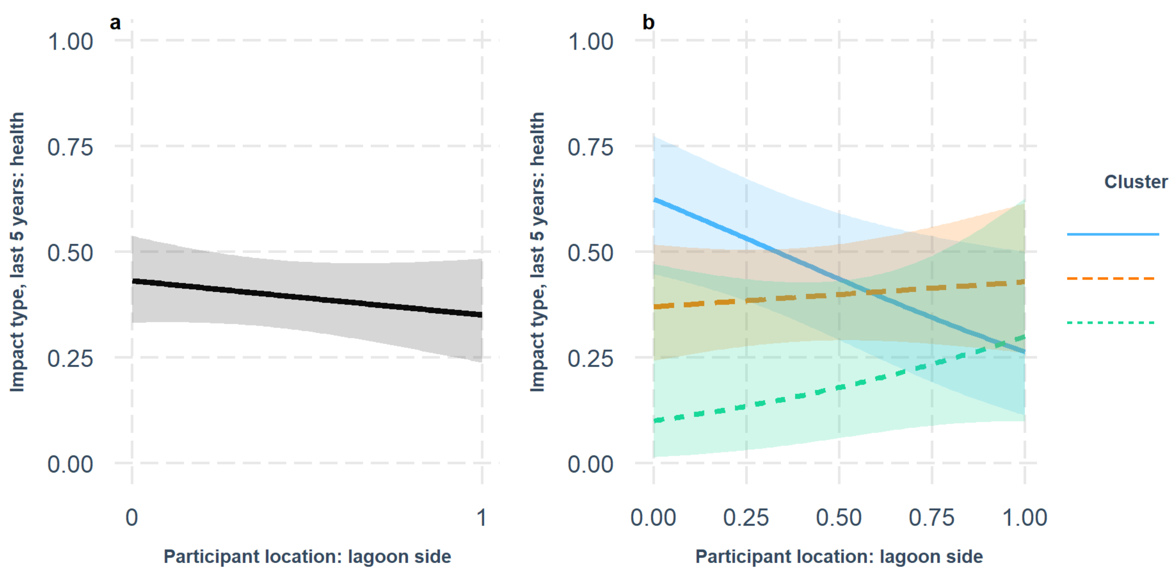

Figure 11. Basic regression results for independent variable "Participant location: lagoon side" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 14. Logistic regressions of independent variable "Participant location: ocean side" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.26 (0.19)	−0.13 (0.29)
Participant location: ocean side	−0.84 (0.47)	1.23 (1.19)
Cluster2		0.09 (0.40)
Cluster3		-1.19 (0.63)
Participant location: ocean side:Cluster2		-2.75 * (1.34)
Participant location: ocean side:Cluster3		-14.47 (882.74)
N	145	145
Pseudo R2	0.03	0.13

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

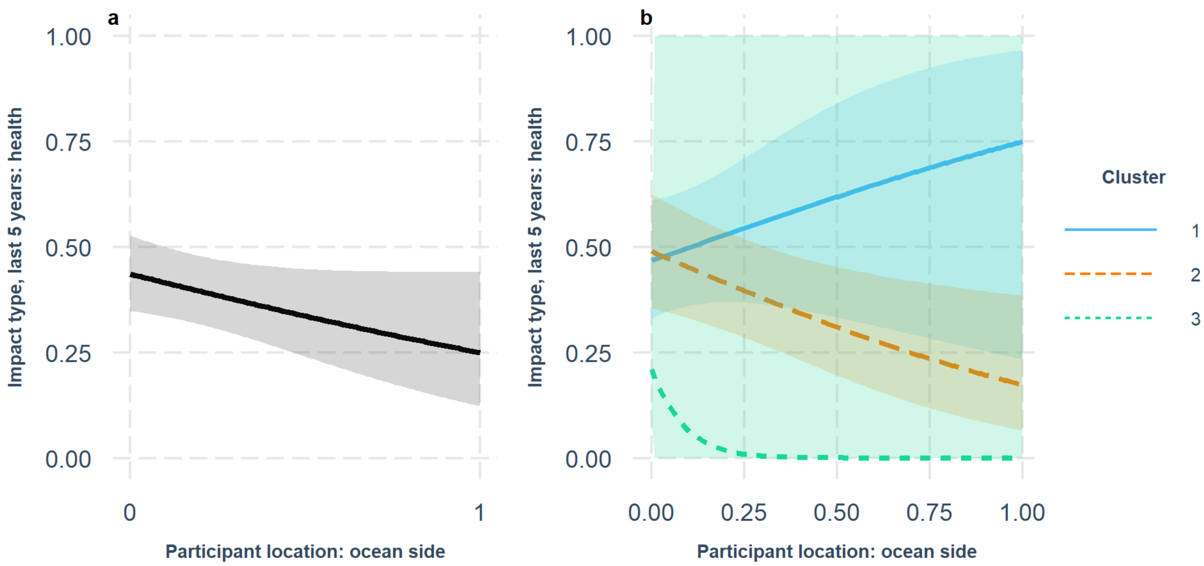

Figure 12. Basic regression results for independent variable "Participant location: ocean side" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 15. Logistic regressions of independent variable "Household size" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.98 ** (0.35)	−2.00 ** (0.63)
Household size	0.08 (0.05)	0.26 ** (0.10)
Cluster2		2.30 ** (0.85)
Cluster3		0.05 (1.46)
Household size:Cluster2		−0.35 ** (0.12)
Household size:Cluster3		−0.19 (0.22)
N	189	189
Pseudo R2	0.02	0.12

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

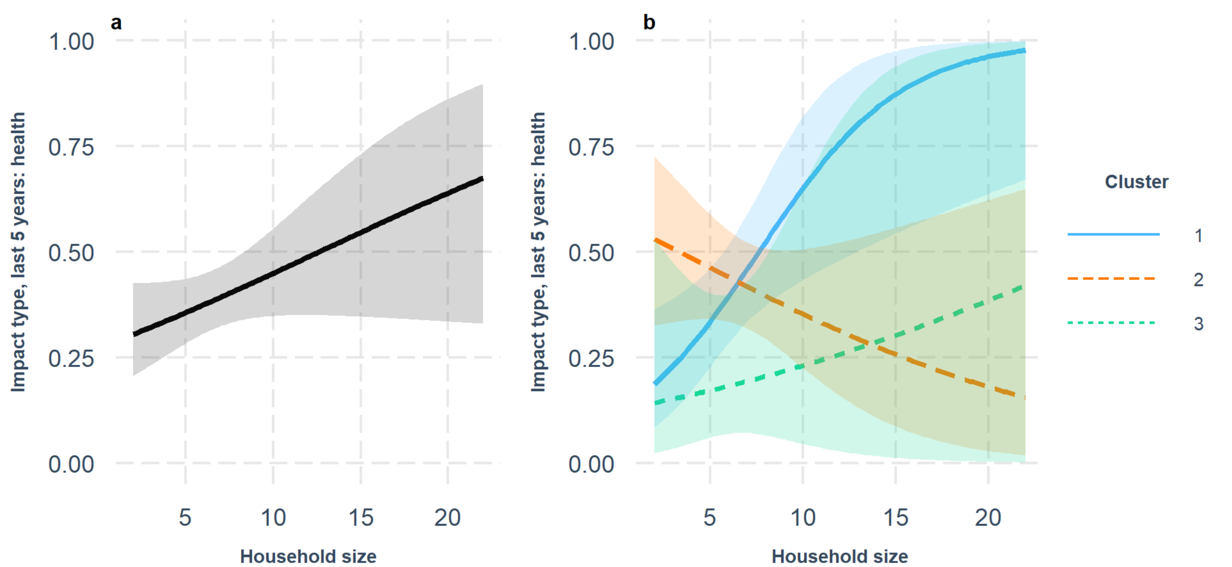

Figure 13. Basic regression results for independent variable "Household size" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 16. Logistic regressions of independent variable "Income source: agriculture" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.36 (0.21)	0.17 (0.30)
Income source: agriculture	−0.18 (0.30)	−1.52 ** (0.55)
Cluster2		−1.09 * (0.45)
Cluster3		−15.74 (1029.12)
Income source: agriculture:Cluster2		2.56 *** (0.70)
Income source: agriculture:Cluster3		15.70 (1029.12)
N	188	188
Pseudo R2	0.00	0.14

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

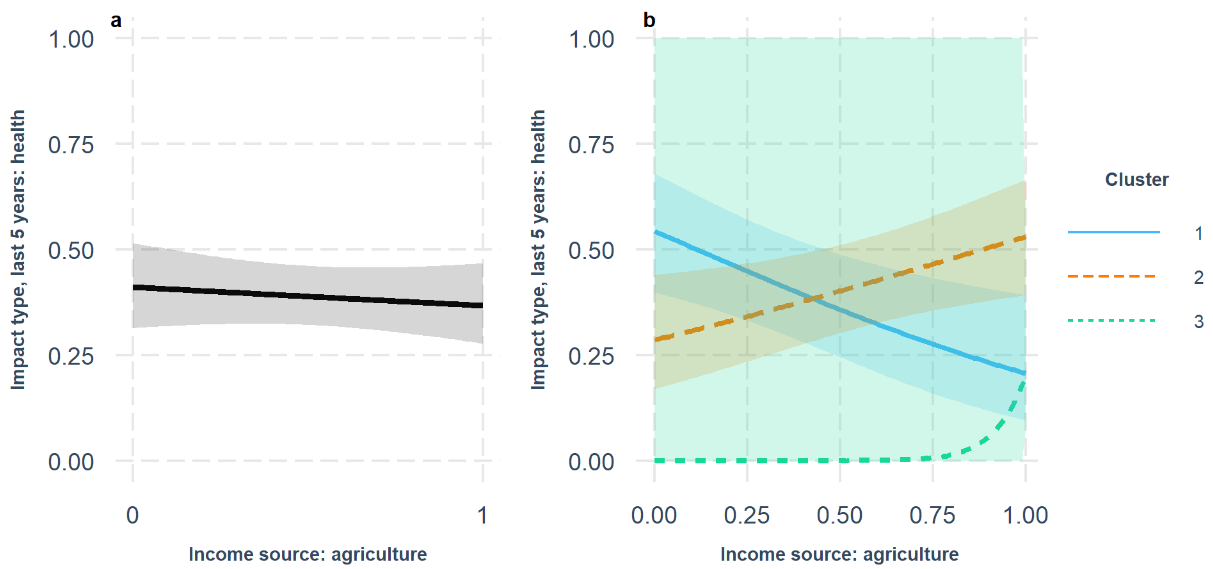

Figure 14. Basic regression results for independent variable "Income source: agriculture" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 17. Logistic regressions of independent variable "Income source: fishing" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.48 * (0.22)	0.10 (0.31)
Income source: fishing	0.05 (0.30)	−1.08 * (0.50)
Cluster2		−1.04 * (0.46)
Cluster3		−16.66 (1199.77)
Income source: fishing:Cluster2		2.19 ** (0.67)
Income source: fishing:Cluster3		16.39 (1199.77)
N	188	188
Pseudo R2	0.00	0.12

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

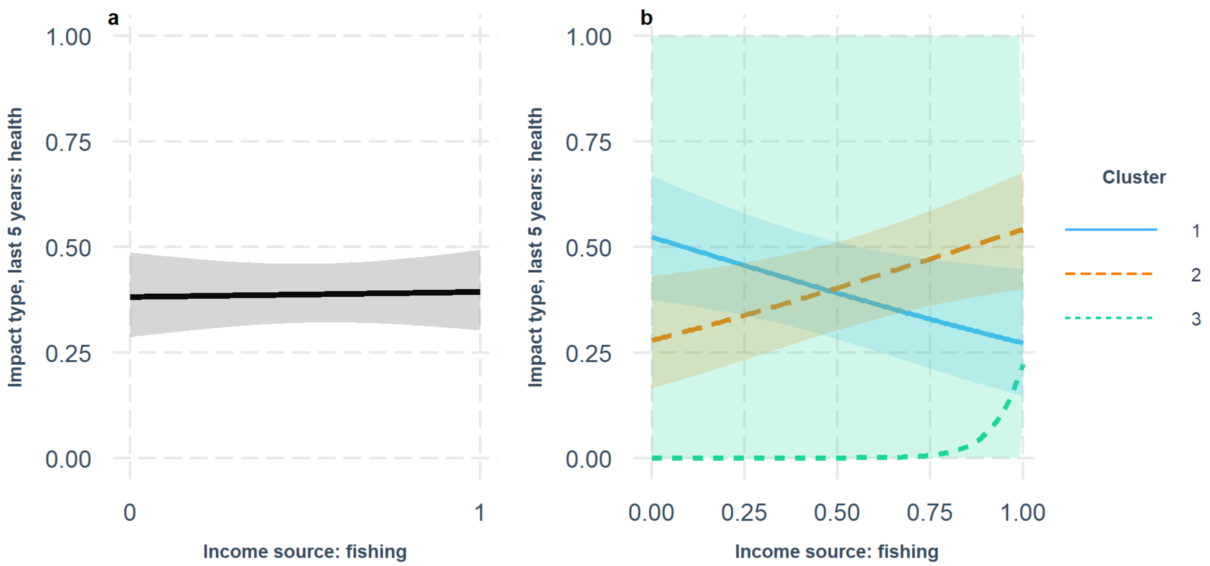

Figure 15. Basic regression results for independent variable "Income source: fishing" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 18. Logistic regressions of independent variable "Income source: private sector salary" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.65 *** (0.19)	−1.16 ** (0.36)
Income source: private sector salary	0.58 (0.32)	1.72 *** (0.51)
Cluster2		1.01 * (0.44)
Cluster3		−0.28 (0.66)
Income source: private sector salary:Cluster2		−2.38 *** (0.71)
Income source: private sector salary:Cluster3		−14.84 (882.74)
N	188	188
Pseudo R2	0.02	0.13

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

Figure 16. Basic regression results for independent variable "Income source: private sector salary" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 19. Logistic regressions of independent variable "Poor education problem ranking" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.18 (0.20)	0.97 * (0.42)
Poor education problem ranking	−0.13 (0.07)	−0.51 *** (0.13)
Cluster2		−1.28 * (0.50)
Cluster3		−2.42 *** (0.69)
Poor education problem ranking:Cluster2		0.51 ** (0.16)
Poor education problem ranking:Cluster3		−6.05 (441.37)
N	186	186
Pseudo R2	0.03	0.16

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.
Standard errors are in parenthesis

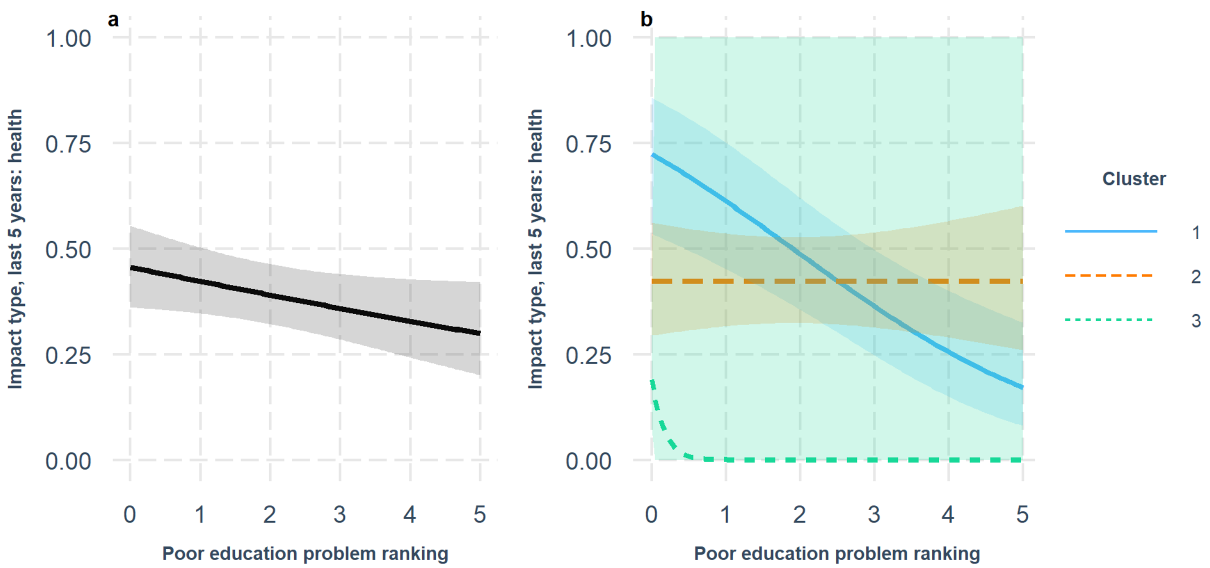

Figure 17. Basic regression results for independent variable "Poor education problem ranking" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term

Table 20. Logistic regressions of independent variable "Overcrowding problem ranking" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.54 ** (0.17)	−0.68 * (0.29)
Overcrowding problem ranking	0.11 (0.09)	0.27 * (0.13)
Cluster2		0.41 (0.38)
Cluster3		−0.73 (0.68)
Overcrowding problem ranking:Cluster2		−0.34 (0.19)
Overcrowding problem ranking:Cluster3		−0.44 (0.53)
N	186	186
Pseudo R2	0.01	0.07

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

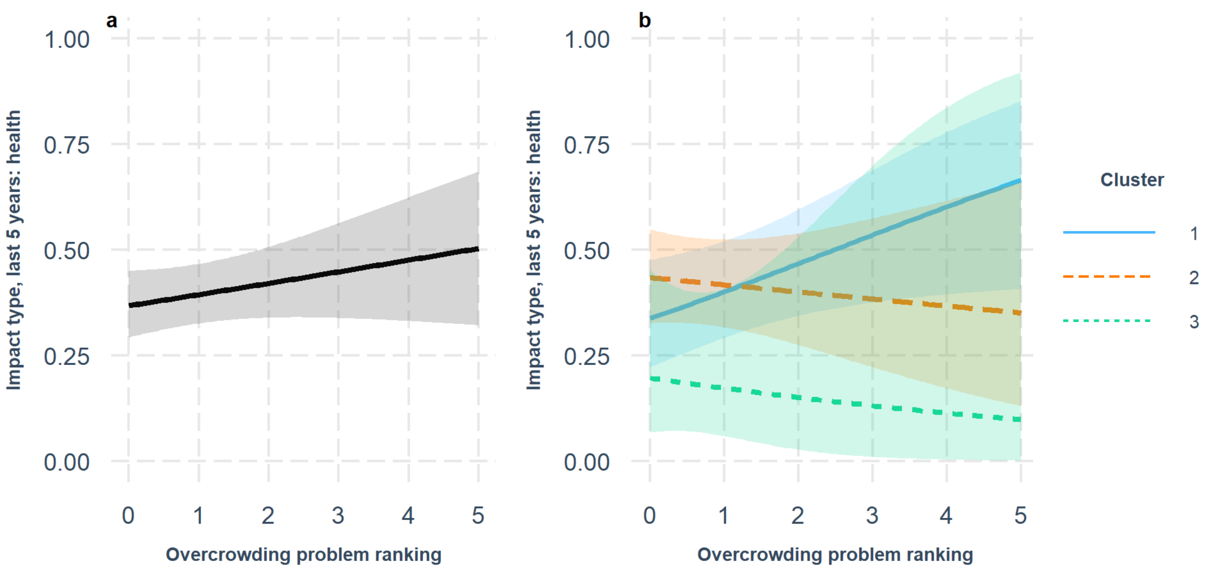

Figure 18. Basic regression results for independent variable "Overcrowding problem ranking" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 21. Logistic regressions of independent variable "Drinking water source: government supply" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	-0.53 ** (0.16)	-0.69 * (0.28)
Drinking water source: government supply	0.46 (0.42)	1.23 * (0.55)
Cluster2		0.48 (0.36)
Cluster3		-1.04 (0.69)
Drinking water source: government supply:Cluster2		-17.59 (979.61)
Drinking water source: government supply:Cluster3		0.50 (1.64)
N	189	189
Pseudo R2	0.01	0.12

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.
Standard errors are in parenthesis

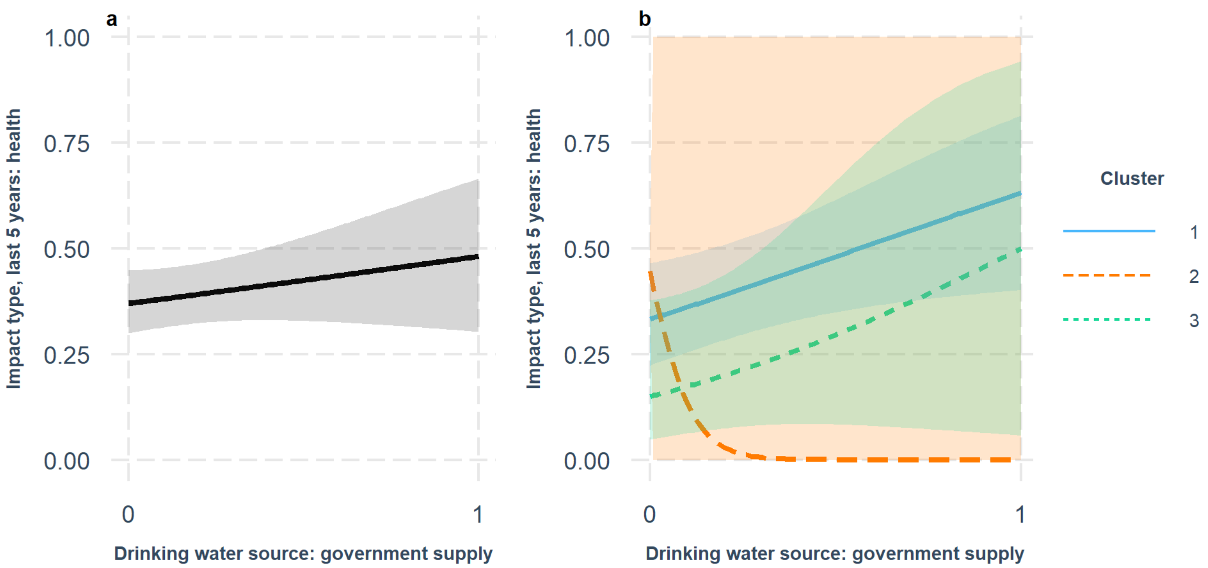

Figure 19. Basic regression results for independent variable "Drinking water source: government supply" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 22 Logistic regressions of independent variable "Impact type, last 5 years: livestock" on the outcome "Impact type, last 5 years: health"

	Basic Regression	**Cluster Interaction**
(Intercept)	−0.71 *** (0.20)	−0.29 (0.27)
Impact type, last 5 years: livestock	0.56 (0.30)	−0.33 (0.54)
Cluster2		−0.95 * (0.47)
Cluster3		−0.92 (0.71)
Impact type, last 5 years: livestock:Cluster2		1.84 * (0.72)
Impact type, last 5 years: livestock:Cluster3		−0.54 (1.36)
N	189	189
Pseudo R2	0.02	0.12

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

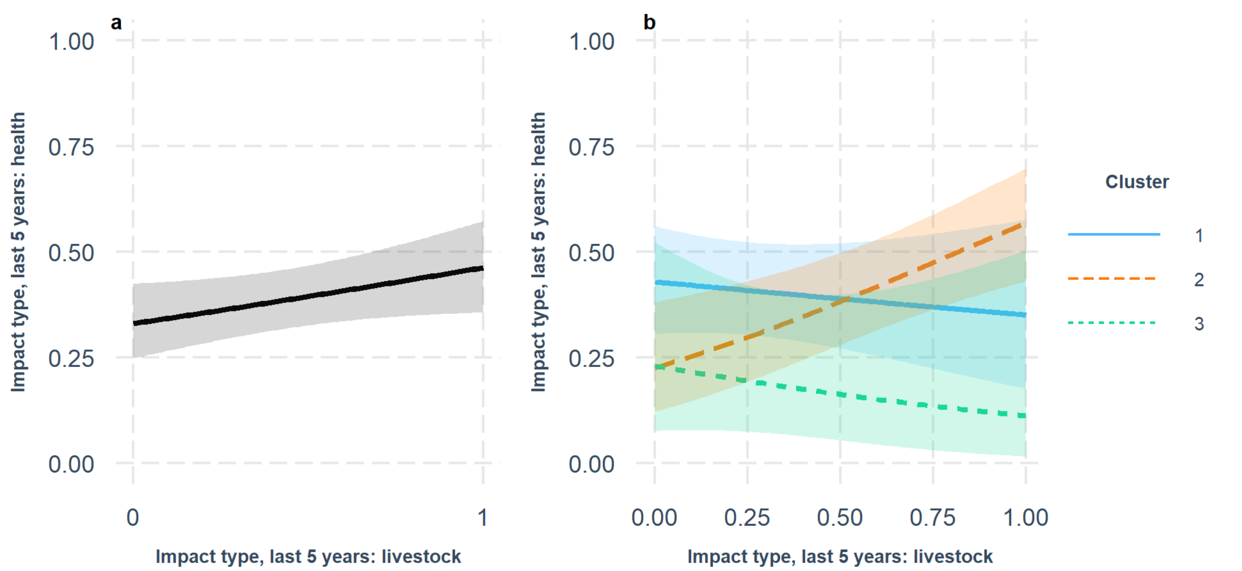

Figure 20. Basic regression results for independent variable "Impact type, last 5 years: livestock" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 23 Logistic regressions of independent variable "Impact type, last 5 years: trees" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.76 ** (0.26)	−0.37 (0.31)
Impact type, last 5 years: trees	0.46 (0.32)	−0.01 (0.47)
Cluster2		−1.19 (0.63)
Cluster3		−15.20 (1029.12)
Impact type, last 5 years: trees:Cluster2		1.57 * (0.76)
Impact type, last 5 years: trees:Cluster3		14.19 (1029.12)
N	189	189
Pseudo R2	0.02	0.10

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

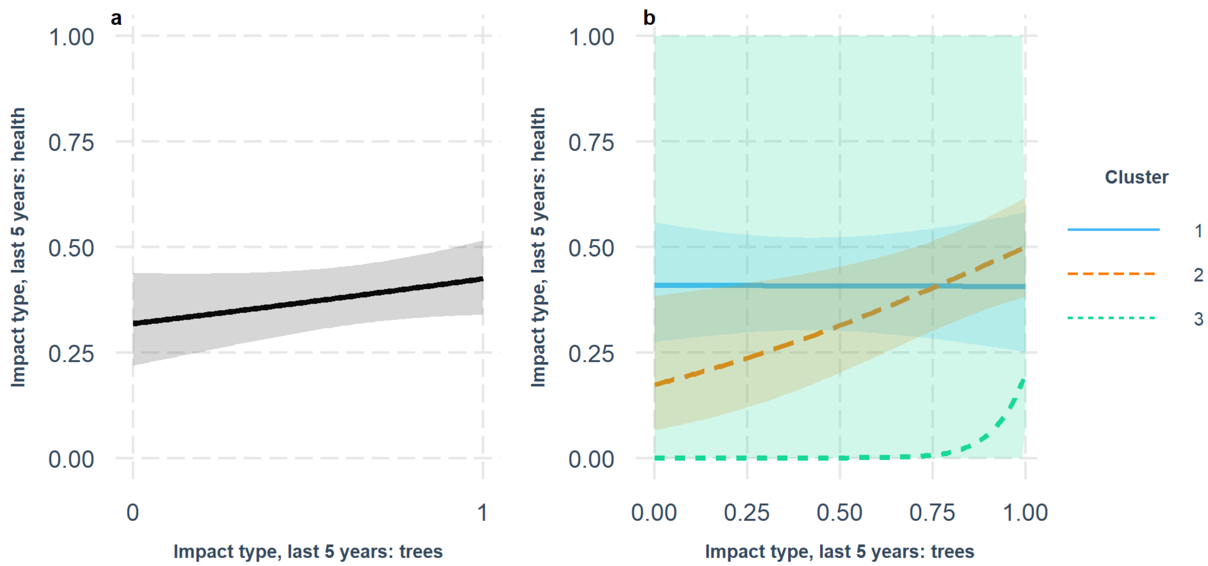

Figure 21. Basic regression results for independent variable "Impact type, last 5 years: trees" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

Table 24. Logistic regressions of independent variable "Percent of diet from local food" on the outcome "Impact type, last 5 years: health"

	Basic Regression	Cluster Interaction
(Intercept)	−0.22 (0.25)	0.38 (0.39)
Percent of diet from local food	−0.66 (0.59)	−2.84 ** (1.10)
Cluster2		−1.19 * (0.55)
Cluster3		−1.10 (1.23)
Percent of diet from local food:Cluster2		4.34 ** (1.42)
Percent of diet from local food:Cluster3		1.45 (2.51)
N	177	177
Pseudo R2	0.01	0.11

*** p < 0.001; ** p < 0.01; * p < 0.05.
Standard errors are in parenthesis

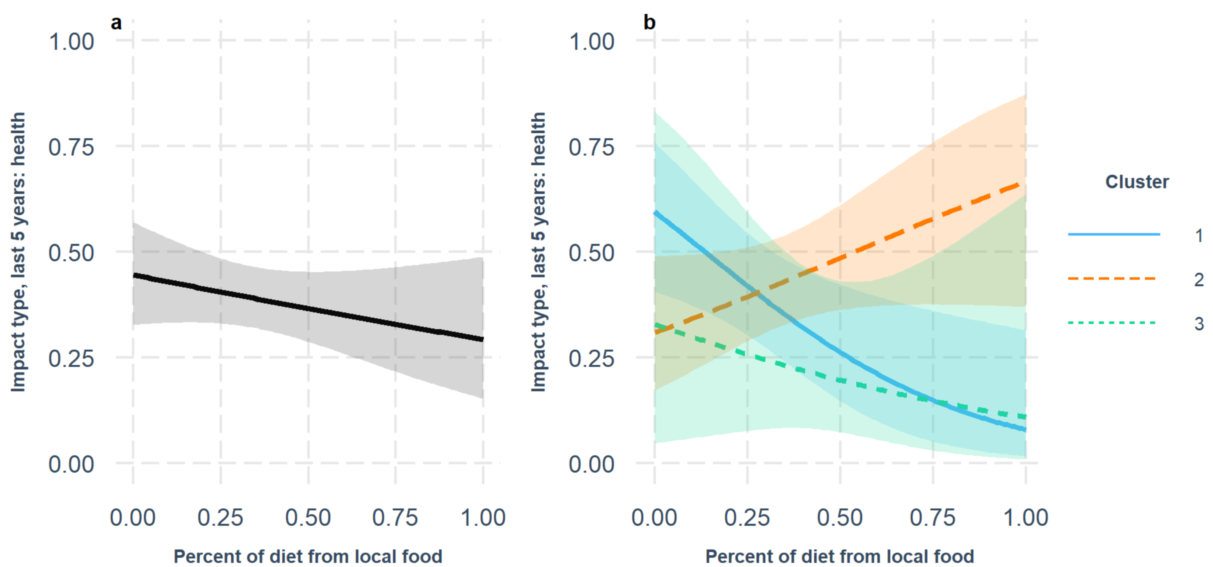

Figure 22. Basic regression results for independent variable "Percent of diet from local food" on the outcome "Impact type, last 5 years: health" a) over the whole dataset and b) with a cluster interaction term.

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