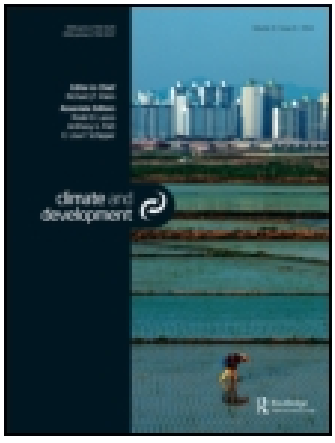

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Where the rain falls: Evidence from 8 countries on how vulnerable households use migration to manage the risk of rainfall variability and food insecurity

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Up to present, research relating environmental change to human mobility has found out that environmental factors can play a role in migration without being conclusive. Further, in the context of climate change, scholarly literature on migration ranges across a host of climatic stressors and geographies, making it difficult to date to solve the debate whether migration is a form of adaptation or an indicator of limits to adaptation. To address both of these debates, original research was undertaken to answer the question 'under what circumstances do households (HHs) use migration as a risk management strategy when facing rainfall variability and food insecurity?'. This research administered a HH survey ($n = 1300$) and participatory research ($n = 2000$ respondents) in districts in eight countries (Guatemala, Peru, Ghana, Tanzania, Bangladesh, India, Thailand, and Vietnam). The findings reveal that the answer to how climatic stressors affect migration decisions and the degree to which migration improves the adaptive capacity of those HHs lie in the vulnerability of the HH and its sensitivity to climatic factors. The data reveal for the first time in a comparable global study distinct HH profiles of 'resilience' and 'vulnerability'. At the same time, the article distinguishes between 'content' migration – rather associated with resilient HHs – and 'erosive' migration – rather associated with vulnerable HHs. However, the article also highlights that there are not always clear cuts but very often grey areas and overlaps among the HHs of the study when applying these typologies. Moreover, the article relates these profiles to an agent-based modelling approach applied in the Tanzania case to explore under what scenarios rainfall variability and food security have the potential to become significant drivers of human mobility in particular regions of the world in the next two to three decades.

Keywords: adaptation; climate change; vulnerability; migration

1. Introduction

Since at least the mid-1980s, scientists have linked environmental change to human mobility (see El-Hinnawy, 1985). Early debates emerged around future projections and predictions of the number of 'environmental migrants' (see, for example, Myers, 2005). More recently, conceptual and empirical work has examined broad relationships between environmental factors and migration in different situations (see, for example, Jäger, Frühmann, Günberger, & Vag, 2009; Warner, Erhart, de Sherbinin, Adamo, & Chai-Onn, 2009). These studies have identified broad patterns as a point of departure for further, more nuanced work on the interactions of climatic and socio-economic factors. Research since that time has determined that environmental factors do play a role in human mobility (Afifi & Jäger, 2010) and emphasizes that some people who are more exposed to environmental stressors – particularly farmers, herders, pastoralists, fishermen, and others who rely on natural resources and the weather for their livelihoods – may be the least able to move very far away, if at all (Betts, 2010; de Sherbinin, Warner, Erhart, & Adamo, 2011).

The question then of interactions between global (and local) climatic change and human migration is not *whether* environmental drivers are the *sole causal* factors causing mobility (Myers, 1993, 1997, 2002), but instead a question about the role of migration in managing risks associated with changing environmental conditions (see, for example, Black, Bennett, Thomas, & Beddington, 2011; Hugo, 2008, Piguet, 2010). A debate has unfolded about whether migration is a 'positive' adaptation measure (Barnett & Webber, 2010; Foresight, 2011), or whether it is a sign that *in situ* adaptation is decreasingly feasible. To address this debate, research presented here frames migration as a risk management option vis-à-vis climatic stressors (Stark & Levhari, 1982). This is in line with wider framing of climate change as a risk management issue (Intergovernmental Panel on Climate Change [IPCC], 2012). A more nuanced understanding of how climatic factors affect migration choices will help shape

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adaptation policies that in turn help ensure that whatever strategies households (HHs) do use – including migration – *increase resilience to climate change* (see Black et al., 2008; Warner et al., 2009; Warner, 2010).

Moreover, such academic work on environmentally induced human mobility does not determine whether the latter indicates 'successful adaptation' or a 'failure to adapt' *in situ* (Barnett & Webber, 2010; Jäger et al., 2009; McLeman & Smit, 2006; Oliver-Smith, 2009).

To fill these research gaps, the 'Where the Rain Falls' (Rainfalls) research undertook eight case studies using the same methodology. The research addressed the question 'under what circumstances do HHs use migration as a risk management strategy when facing rainfall variability and food insecurity?'[1] The results of the Rainfalls study presented in this special issue of *Climate and Development* indicate for the first time in a comparative set of case studies how changes in rainfall variability, food, and livelihood security interact to shape risk management decisions that may or may not result in migration at the HH level, and what role other social, economic, and political factors play in these dynamics.

Evidence from these country cases illustrates a dynamic range of interactions between the variables which shape risk management decisions including migration (seasonal, temporary, permanent, or none) of HHs with different characteristics (e.g. wealth, land ownership, access to livelihood diversification options, gender, age, and education). The research shows how those characteristics facilitate or hinder the ability of HHs to manage rainfall-related risks to livelihoods and food security by using different forms of migration. The findings reveal that most HHs use migration to manage the risks of changing rainfall variability to livelihoods and food security. However, *the degree to which migration improves the adaptive capacity of those HHs lies in the sensitivity of migrant-sending HHs to climatic factors, and the risk management options and strategies those HHs can access when facing climatic stressors that affect HH food production and consumption*.

The Rainfalls research expands insights into how human mobility may develop in the context of a changing climate where rainfall patterns are expected to shift notably in timing (seasonality), quality (extreme events, intensity of rainfall), and distribution (geographically) in the coming decades. The question is not whether environmental drivers are the sole factors causing mobility, but instead how multiple factors interact to shape migration choices. A more nuanced understanding of how climatic factors affect migration choices will help shape adaptation investments and policies. The latter could help ensure that whatever strategies HHs use – including migration – contribute to increased resilience to climate change (Warner et al., 2012).

From the outcomes of the eight case studies, this article introduces a typology that distinguishes between four types of HHs in a broad spectrum between resilient and vulnerable HHs. Within these HHs, the article addresses a classification of 'content' and 'erosive' migration that is caused by the original situation of the HHs but at the same time contributes to and feeds into the development of the HH conditions. Hence, with this typology, the article shows that not only migration is a process but also the conditions and circumstances of the HHs – and accordingly – the communities.

Moreover, this special issue of *Climate and Development* presents the Rainfalls Agent-Based Migration Model (RABMM) and its application to the Tanzanian case study (RABMM-T) (Smith, 2014). Developed using the Rainfalls survey data, the model has been designed to represent the level of vulnerability of HHs to rainfall variability-induced changes in livelihood and food security, and their subsequent impact on the migration of HH members. On the basis of the livelihood and food security systems modelled, each HH determines its resilience each month using attributes such as income, food production, family size, and the migration of HH members. Changes in rainfall over time affect these attributes and therefore adjust each HH's degree of resilience and their propensity towards migration.

2. Conceptual framework, methods, and site selection for the Rainfalls research

2.1 *Conceptual framework*

The conceptual framework for the research is given in Figure 1. It highlights the three main research variables (rainfall variability, food security, and migration) and their interactions. Research findings are based primarily on fieldwork-generated qualitative and quantitative data. Where secondary data have been used, this is indicated by coloured boxes at the edge of the research area boxes. The arrows in the framework represent feedback loops that change initial conditions as HHs dynamically manage rainfall risks to food production and consumption.

The research framework employed in the case studies presented in this special issue examines the interrelationships and pathways affecting HH risk management and migration decisions related to rainfall, food, and livelihood. In this framework, rainfall variability can cause droughts, floods, dry spells, and heavy rainfall events. This rainfall variability in turn influences the livelihood security of the studied HHs through changes in livestock and crop production. Land ownership and land holding also impact livelihood security of HHs. The third variable deals with HH strategies to manage risks to livelihood – and food security. As the figure illustrates, factors such as the degree to which HH economy and food consumption depend on rainfall, the more sensitive it may be to changes in rainfall variability. Other factors such as the availability of a range of coping strategies further affect how HHs use migration to manage climatic risks. Some risk management strategies, including

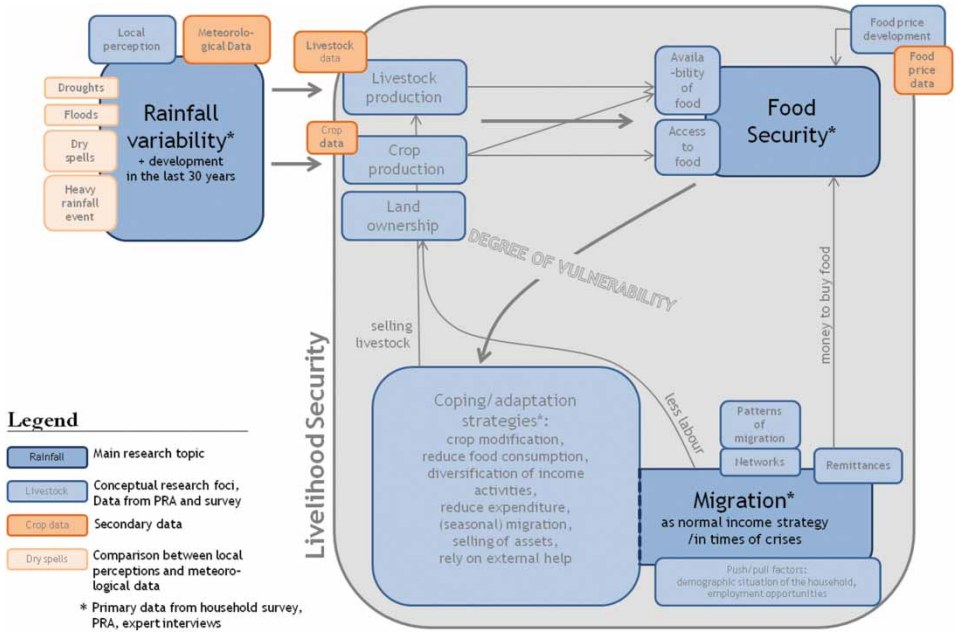

Figure 1. Research foci, methods, and data sources.
Source: Rademacher-Schulz and Rossow, 2012 in Warner et al. (2012, p. 37).

migration, affect the resilience or vulnerability of the HHs to climatic stressors like rainfall changes. If successful, migration can reduce food insecurity by increasing the available resources to buy food in the cases where migrants can send food or cash remittances to HH members. In this case, migration can be called 'content'. If migration as a risk management strategy is unsuccessful – in this case 'erosive' migration, it can exacerbate food insecurity (no remittances or food sent, reduced labour supply in HH for food production). HH characteristics themselves influence the migration outcome (discussed in Section 3).

2.2 *Data collection methods and modelling*

In conducting field research in the eight case study countries, the following three complementary methods were applied (available at Rademacher-Schulz et al., 2012):

- *Participatory research approach* (PRA, $n = 2000$ respondents) including transect walks (providing a cross-sectional representation of the different agro-ecological zones and their comparison against certain parameters of interest to the study); wealth ranking (investigating the perceptions of wealth differences and inequalities in the communities); focus group discussions (bringing various groups of the communities together in open discussions); mobility maps (exploring the movement pattern of the individuals, groups, and communities); seasonality calendars (reflecting the perceptions of the local people regarding seasonal variations in the research site); livelihood risk rankings (identifying local people's perceptions of the risks they face and how they rank the magnitude of each risk); Venn diagrams (showing the importance and accessibility of crucial institutions and individuals influencing the local communities); and impact diagrams (identifying the impacts of certain activities, interventions or events on the communities, and the interrelations among all these factors).
- *A HH survey* ($n = 1300$) was carried out to obtain quantifiable indicators and trends that reflect how different factors affect HHs in terms of rainfall variability, livelihood/food security, and migration, and to run a statistical analysis that complements the qualitative outcomes. Researchers administered the HH survey and participatory research expert interviews mainly with government representatives, civil society actors, and scientists/academics who possess particular knowledge and information about specific topic areas related to the project's research (migration, rainfall variability, livelihoods/food insecurity, national and local development plans, climate change adaptation, vulnerability, etc.). Each case surveyed between 130 and 206 HHs representing (at least 10% of the local (district) population in six of the eight cases).
- *Semi-structured expert interviews* with various stakeholders were run, where the researchers asked the questions relevant to the main three variables of the study. It was important to receive information and points of view from policy-makers, academics, non-governmental organization representatives, and

meteorological experts, in order to have as many as possible insights into national and local issues that are of great importance for the research.

The qualitative and quantitative data also served to develop and apply the agent-based model (ABM), which tested migration outcomes in four plausible future scenarios of rainfall. The RABMM was designed to represent the level of vulnerability of HHs to rainfall variability-induced changes in livelihood and food security, and their subsequent impact on the migration of HH members. The ABM was employed in the case of Tanzania as an illustration, but will be applied to other case studies. Modelling, based on the survey data, has shown that migration from vulnerable HHs in Tanzania is sensitive to changes in rainfall patterns, especially under extreme drying (Scenario 4). By contrast, extreme wetting (Scenario 3) results in the lowest numbers of migrants from vulnerable HHs.

2.3 *Site selection*

The study employed general criteria for country and research site selection; the researchers were interested in having a regional balance by covering three regions, namely South and Southeast Asia, Sub-Saharan Africa, and Latin America. This research was carried out in districts in eight countries, namely Guatemala (Western Highlands – Cabricán Municipality), Peru (Central Andes – Huancayo Province), Ghana (Northern Ghana – Upper West Region – Nadowli District), Tanzania (Northern Tanzania Kilimanjaro Region – Same District), Bangladesh (Northern Bangladesh – Kurigram District), India (Central India – Chhattisgarh – Janjgir District), Thailand (Northern Thailand – Lamphun Province), and Vietnam (Mekong Delta – Dong Thap Province). Table 1 lists the research sites and main findings in each site.

The eight countries selected are highly exposed to climatic stressors, varying by ecosystem type, and elevation. These characteristics served for research addressing livelihoods of people relying on ecosystems on a daily basis across the research countries. Specific site selection criteria included the importance of rainfall in livelihood and food production systems (mono- and bimodal systems, dependence on rain-fed agriculture), and occurrence of rainfall-related events with reported changes in variability in recent years, significant levels of poverty and food insecurity, and recorded history of migration in study areas. Moreover, the sensitivity of livelihoods to changing rainfall patterns, the relatively high levels of poverty, and food insecurity as well as the recorded history of migration and its linkages to all the above-mentioned variables were important selection criteria.

3. Findings: rainfall perceptions, rainfall impacts on livelihood, food, and migration decisions

This section summarizes the most important research outcomes. It first gives a general idea about the three main variables of the study, namely rainfall variability, livelihood and food security, and migration. It illustrates common and diverging factors across the eight researched districts in tables drawn from original data from each case. The tables in this section draw on this data from each case study, which can be found in the respective case study reports (available at www.ehs.unu.edu and www.wheretherainfalls.org).

3.1 *Changes in rainfall variability*

Rural people in the eight research locations perceive climatic changes happening today in the form of rainfall variability. These perceptions are consistent in sign (e.g.

Table 1. Research sites, their geographical location, and specific findings related to migration.

Research site	Findings
Northern Thailand (Lamphun Province)	Diverse livelihoods and access to assets and services make migration a matter of choice in Lamphun Province
Peru Central Andes (Huancayo Province)	Livelihood options and migration strategies in Huancayo Province vary by elevation and proximity to urban centres
Vietnam Mekong Delta (Dong Thap Province)	Landless, low-skilled poor of Hung Thanh Commune have few options, despite a rising economic tide
Central India (Janjgir District, Chhattisgarh)	Poor HHs in Janjgir-Champa still must rely on seasonal migration for food security, despite irrigation, industrialization, and safety net
Northern Bangladesh (Kurigram District)	Migration is a key coping strategy for poor HHs in Kurigram, but one with high social costs
Guatemala Western Highlands (Cabrican Municipality)	Little livelihood diversification and limited migration opportunities leave people of Cabrican with few good options to adapt *in situ* or migrate
Northern Ghana (Nadowli District, Upper West Region)	High dependence on rain-fed agriculture in Nadowli district contributes to continued reliance on seasonal migration as a coping strategy
Northern Tanzania (Same District, Kilimanjaro region)	Migration is a common coping strategy for smallholder farmers and livestock keepers struggling for food security in Same district

Source: Warner et al. (2012).

'more' or 'less') with an analysis of local meteorological data over the last three decades (see Afifi, Liwenga, & Kwezi, 2014; Milan and Ho, 2014; Murali and Afifi, 2012; Rademacher-Schulz, Schraven, & Mahama, 2014). These perceptions of changing rainfall patterns shape HH risk management decisions. Table 2 draws from case study data (questionnaire and PRA). Local people – largely dependent on rainfall for their main source of food and income – reported changes in timing, quality, quantity, and overall predictability of rainfall in recent years against past experience. The most common changes reported relate to delayed onset and shorter rainy seasons; reduced number of rainy days per year; increased frequency of heavy rainfall events; and more frequent prolonged dry spells during rainy seasons.

3.2 *Livelihood and food security related to rainfall variability*

It is important to mention that the indicator for food security in the HH survey of the Rainfalls research was the *food production* in the HHs (subsistence) and the *food availability* in the markets. The same concept was applied when talking to the communities in the PRA sessions and the experts in the formal interviews. The primarily agriculture-based HHs in the research sites reported that rainfall variability negatively affects food production and food consumption. Table 3 draws from original data from each case study and illustrates the central pattern observed: less predictable rainfall patterns affect the ability of HHs to feed themselves and earn livelihoods. Unexpected rainfall affects HH income through investment decisions about

Table 2. Perceptions of changes in rainfall variability.

Perceptions of changes in rainfall variability		Reference in respective case study report (at www.ehs.unu.edu and www.wheretherainfalls.org)
Guatemala	Sixty-seven percent of HHs surveyed reported more dry spells, 53% more floods, and 91% reported more heavy rainfall than in earlier times (20 or more years in the past)	Table 9, p. 35; Table 10, p. 37
Peru	Majority of survey respondents identified new patterns of rainfall: more drought and dry spells, more heavy rains, and somewhat increased floods. Impact of changing rainfall on food production severe for 53% of HHs	Table 8, p. 45
Ghana	Most respondents (87%) indicated that dry spells were more frequent and lasted longer during the rainy season, that there was more floodings (87%), and that there were more extreme events (65%) than in the past	Table 5, p. 57; Table 6, p. 58
Tanzania	Of survey respondents, 68% perceive shorter rainy seasons, 84% perceive longer dry spells. The Tanzania Meteorological Agency reported that over the same time period, they have observed varying dates for the onset of rain, reduced length of growing seasons, and early cessation of rain, and increased length of dry spells even in the growing seasons	Table 4, pp. 50–51
India	Of survey respondents, one-third reported increased droughts and dry spells (perception in spite of increased availability of irrigation); half reported increasing extreme weather events, and almost two-thirds report fewer rainy days than in the past	Table 10, p. 56; Table 11, p. 57
Bangladesh	Of HH surveyed, 79% reported less flooding, 19% reported more drought and dry spells, 65% reported more out-of-the ordinary and extreme rainfall; and 43% reported more heavy rain than 30 years ago. The majority of respondents recall having six seasons; while 80% of survey respondents indicated that today only three to four seasons were observed	Figure 8, p. 61; Figure 9, p. 62
Thailand	Of respondees, 87% stated that over the last 10–20 years, heavy rainfall events occurred more often. In total, 73.3% of respondents perceive more rainfall, 48.5% perceive the rainy season is longer, and half of respondents perceive that flooding occurs more often. Local meteorological data verified these perceptions. Fifty-one percent of HHs considered the impact of rainfall-related environmental stress on their livelihoods to be significant	Table 6, p. 37
Vietnam	Respondents perceive that the total amount of rain and the length of the rainy season have increased, in line with meteorological data for the area. People also note an increase in occurrence of heavy rainfall events	Table 3, p. 44; Table 4, p. 45

Source: *Where the rain falls case study reports and global policy report* (2012).

Table 3. Reported links between rainfall changes and livelihoods.

Link between rainfall and livelihoods		Reference in respective case study report (at www.ehs.unu.edu and www.wheretherainfalls.org
Guatemala	Rainfall affects food production and the economies of 68% of HHs, respectively; In relation to changes in rainfall patterns, HHs reported concerns about the long-term viability of their farming systems and food availability	Table 17, p. 54
Peru	Two-thirds of HHs sustain crop damage and lower crop yields. Forty-two per cent experience substantial negative impacts on HH income from rainfall variability. Rainfall changes affect the ability of HHs to feed themselves and earn livelihoods, with over 80% of HHs responding to survey experienced decreases in harvest, livestock, and own food consumption in the past 5–10 years	Table 10, p. 51
Ghana	Rainfall variability changes affect food production 'a lot' in 91.1% of HHs surveyed, and negatively impact 89.2% of surveyed HH economies. In total, 92.4% of HHs reported lower crop yields affecting HH income when unexpected rain patterns occur, 37.3% reported increasing food prices	Table 8, p. 64; Tables 9 and 10, p. 65
Tanzania	Changes in rainfalls variability translate directly into impacts on food security. Unexpected rainfall patterns affect food production of 87% of HHs, and 82.4% of respondents 'HH income 'a lot'. Unexpected drought (timing, intensity) identified as the major hazard to HH livelihoods	Table 12, p. 76; Table 13, p. 77
India	Seventy-three per cent of survey respondents noted that changing rainfall affects food production negatively. Top risks to livelihoods related to rainfall changes: less rain and delayed rain, not enough food due to inadequate or unexpected rainfall (in spite of irrigation)	Table 20, p. 84; Tables 12–15, pp. 62–65
Bangladesh	In total, 58.7% of HH surveyed say rainfall variability affects food production; 88.7% reported lower HH income related to changes in rainfall variability; 64% reported increased food prices related to unexpected rainfall; 68.7% reported reduced HH food consumption when rainfall changed unexpectedly	Table 16, p. 97
Thailand	Three-fourth of HHs suffer from lower income due to declining crop yields and deceasing income from agriculture as a result of the exposure to environmental stress	Table 20, p. 66
Vietnam	In total, 89.5% of HHs economies negatively affected by changing rainfall patterns via food production (crops destroyed, lower crop yields, property damage, less demand for labour)	Does changing rainfall affect your food production (Table 14 a–f), p. 68

Source: *Where the rain falls case study reports and global policy report* (2012).

seed varieties, when and what to plant, and expected crop yields. Adverse rainfall conditions are perceived to be increasing, and are associated with lower crop yields (used for HH income and consumption). HHs across all case studies frequently identified rainfall-related factors as among the top five risks they are concerned about. As the articles in this special issue show, HHs seek to offset these risks through livelihood diversification, changing food consumption patterns and eating less, migrating, etc. PRA sessions revealed that some HHs consider leaving agricultural livelihoods because of perceived increased rainfall variability (but the most climate-sensitive HHs often lack the skills and opportunities to find alternative livelihoods).

Levels of food insecurity varied significantly across the eight sites depending on factors such as: the total amount and seasonality of rainfall; the degree of agricultural intensification; the extent of livelihoods diversification; and the access of poor HHs to social safety net and other support services. Access to land of sufficient quality to support HH food consumption and income needs was an important issue in the research areas. Landlessness and land scarcity were manifest in median values of 15.5% and 37.7% of HHs surveyed, respectively, with these HHs in each site manifesting distinct characteristics relevant to their mobility decisions (discussed below). The average land holding for HHs across all sites was 1.5 hectares of productive land (excluding grazing land for livestock).

3.3 *HH migration experience managing rainfall stress on HH income and consumption*

Migration – seasonal, temporary, and permanent – plays an important part in many families' struggles to deal with rainfall variability and food and livelihood insecurity. Migration associated with rainfall is often motivated by attempts of HH dependent on rain-fed agriculture to stabilize HH income and food consumption. Migration –

seasonal, temporary, and permanent – plays an important part in many families' struggle to deal with rainfall variability and food and livelihood insecurity, and was reported to have increased in recent decades in a number of the research sites. However, landless, low-skilled and poor HHs (most sensitive to rainfall variability many) frequently noted that migration is often the last option for them when they are unable to access stable agriculture-based incomes and food consumption *in situ*.

Rainfall was observed to have a more direct relationship with HH migration decisions in research sites where the dependence on rain-fed agriculture, often with a single harvest per year, was high and local livelihood diversification options were low. Across many of the case studies, rainfall-related risks such as crop production decline, rainy season shifts, longer drought periods causing unreliable harvest, and increased drought frequency were among the top reasons for attempting migration.

Migration was found to have increased in recent decades in a number of the research sites. Migration related to rainfall variability and stress on livelihoods and food production systems was found to be almost entirely within national borders. It was predominantly *male*, but with growing participation by women in a number of countries. Seasonal, temporary, or permanent migration patterns were observed. Migration was undertaken largely by *individual* HH members (with India as the exception where entire nuclear families moved together). Migration in the studies is largely driven by *livelihood-related needs* (HH income) in most countries, but with a growing number of migrants seeking improved skill sets (e.g. through education) in countries such as Thailand, Vietnam and Peru. The research across the studies shows a mix of *rural–rural* and *rural–urban*, with more productive agricultural areas (Ghana, Bangladesh, and Tanzania), nearby urban centres (Peru and India), mining areas (Ghana), and industrial estates (Thailand and Vietnam) as the most common destinations (see Afifi et al., 2014; Etzold, Ahmed, Hasan, & Neelormi, 2014; Milan & Ho, 2014; Murali & Afifi, 2014; Rademacher-Schulz et al., 2014; Sakdapolrak, Promburom, & Reif, 2014; Van der Geest, Thao, & Khoa, 2014) (Table 4).

Migration experiences varied across the research sites in terms of migration as a response to rainfall variability; in the cases of Thailand and Peru, livelihood options are more diverse and people rather migrate voluntarily to improve their already relatively good livelihood. In Vietnam, HHs that suffer from poverty and do not benefit from the economic boom are often left behind (trapped populations). Similarly, the poor Indian HHs in India do not benefit from the power plants (as they do lack the necessary skills to be employed there) and do not receive only water from the canals. Therefore, they rely on seasonal migration to secure their livelihoods. Migration in Bangladesh is a typical coping strategy that becomes expensive for the people left behind. In Guatemala, there are very limited migration opportunities (lack of financial means caused by poor livelihood diversification options as well as strict border controls for migrants to the USA).

Table 5 provides numbers reflecting demographics and types of migration in the HHs sampled in the respective case studies.

Male migration (97%) is predominant in Bangladesh, where at the same time it is mainly married men (89%) who migrate, which has its social implications on the wives who are left behind. The highest rates of female migrants are in Thailand (39%, where as compared with the past more migration among women is occurring) followed by India (38%). Since in the case of India, people of the research site rather migrate in families, which has negative implications on the child education; the rate of female migrants is relatively high. In the cases of Guatemala, Bangladesh, and India, migration is rather motivated by securing the livelihood (97%, 90% and 88%, respectively). Seasonal migration has the highest rate in Bangladesh (80%) in contrast to Guatemala (only 17%), partially due increasingly constrained migration (policy-related). Permanent migration is not detected in the case studies, except for Thailand (28%).

4. Analysis of current HH migration decisions: HH characteristics and sensitivity to rainfall variability and food/livelihood security

The HH profiles described in this section were derived through analysis of the findings. Rainfalls research provides a bridge between an early, exploratory phase of research on environmental change and human mobility and a next generation of research that can utilize a growing information base to more effectively build and test hypotheses about the relationships between variables.

HH sensitivity to rainfall variability affects food and livelihood security outcomes and migration choices and patterns. HHs with more diverse assets and access to a variety of adaptation, livelihood diversification, or risk management options – through social networks, community or government support programmes, and education – can use migration in ways that enhance resilience. Those HHs that have the least access to such options – few or no livelihood diversification opportunities, no land, little education – use (usually) internal migration during the hunger season as a survival strategy in an overall setting of erosive coping measures which leave or trap such HHs at the margins of decent existence.

HH characteristics in districts surveyed. Before exploring, the factors that affect whether migration helps or hinders HH risk management of rainfall-related risks, Table 6 summarizes the HHs surveyed in districts in eight countries. The last column of the table shows the means for each respective variable for all HHs in the study. Of the HHs surveyed, a median value of 13.3% was headed

Table 4. Reported links between rainfalls changes, livelihoods, and migration.

Rainfall, livelihoods and migration		Reference in respective case study report (at www.ehs.unu.edu and www.wheretherainfalls.org
Guatemala	Ninety-seven per cent of migration aspirations associated with hopes to secure stable HH consumption and income generated by rain-fed agriculture; of migration that does occur 77% are male; migration opportunities (seasonal in Guatemala and long-term to the USA) are decreasing due changing labour markets and difficulties in reaching destinations	Table 15, p. 49; Table 16, p. 52
Peru	HH use migration to lower their dependence on agriculture-based livelihoods and expanded employment opportunities in non-farming activities in urban areas	Table 15, p. 59; Table 16, p. 60
Ghana	The 10 most important factors in HH migration decisions centre exclusively on agriculture and livestock rearing directly related to food security and climate/rainfall variability impacts on rain-fed agriculture. Most important triggers of migration among HHs are crop production decline, rainy season shifts, unemployment, longer drought periods causing unreliable harvest, and increased drought frequency. Migration helps bridge income gaps but not improving overall well-being (HH member left behind)	p. 101; Table 19, pp. 102–103
Tanzania	Identified linkages between unpredictable and changing weather patterns and the decision to migrate; top three factors affecting HH migration decisions are: (1) increased drought frequency, (2) longer drought periods, and (3) water shortage. Out-migration from Same District is a mix of rural–rural and rural–urban migration	Table 23, pp. 94–95
India	Migration is one of the most important strategies employed by the residents of the research villages to cope with rainfall variations/climatic changes and food insecurity. Migration often the last resort for resource-poor and landless HHs, especially when they are unable to access or benefit from livelihood options *in situ*. Migration does not increase resilience or provide better opportunities. Group migration (in families) sustains social ties but increases negative effect on schooling, education, and skill building	p. 90
Bangladesh	Migration is a major risk management/'coping strategy' to address unfavourable economic and unexpected environmental conditions, including the local implications of rainfall variability. Longer dry spells and frequent droughts are a 'very important' migration reason for 39% and 36% of HHs, respectively. Landless, low-skilled and poor HHs (depending on rain-fed agriculture for both their livelihoods and food security) are the most sensitive to rainfall variability. Also often trapped due to lack of resources	Table 20, pp. 110–111
Thailand	Diversified on- and off-farm (less sensitive to rainfall variability) income-generation activities, access to financial resources through community funds, and assistance from the local government reduce vulnerability to rainfall-related stress and food insecurity. Adaptation *in situ* and migration is an opportunity to capture better opportunities	Table 21, pp. 68–69
Vietnam	Migration as a risk management strategy (short run only), if HHs face difficulties attaining livelihood security locally. However, impact on longer-term resilience can be very negative: For landless and low-skilled HHs, migration can help fill HH income gaps if successful, but can also interrupt skill building and education. Strategy used to deal with food shortage, table 8; reasons for migrating (Table 15, pp. 73–75)	p. 54, shows migration as a risk management strategy to deal with food shortage; Table 15 reasons to migration (pp. 73–75)

Source: *Where the rain falls case study reports and global policy report* (2012).

Table 5. Demographics and types of migration in the research areas.[a]

Indicators	Lamphun Thailand	Huancayo Peru	Chhattisgarh India	Dong Thap Vietnam	Kurigram Bangladesh	Nadowli Ghana	Same Tanzania	Cabricán Guatemala	
Total number of HHs	206	150	180	150	150	158	180	136	Total = 1310
HH with migration experience (%)	67	63	42	60	43	77	49	19	Mean = 59.13
Migrant demographic information									
Total number of migrants	224	160	212	168	89	257	204	35	Total = 1349
Male (%)	61	64	62	63	97	69	68	77	Mean = 70.06
Female (%)	39	36	38	37	3	31	32	23	Mean = 29.94
Average age of migrants	23.18	24.43	21.1	27.6	37	22.68	24.95	22.8	Mean = 25.47
Education level of migrants (average years of schooling)	8.48	8.88	6.1	7.6	3.5	4.06	5.7	4.83	Mean = 6.14
Marital status of migrants									
Single (%)	43	33	19	58	11	40	45	20	Mean = 33.68
Married (%)	50	46	70	39	89	53	47	46	Mean = 54.85
Other (%)	7	21	11	3	0	7	8	34	Mean = 11.47
Purpose and temporal aspects of migration choices									
Migration motivated by need to earn livelihood (%)	76	76	88	70	90	83	40	97	Mean = 77.37
Migration motivated to improve skills, education (%)	18	14	2	18	10	9	20	3	Mean = 11.74
Other (%)	6	10	10	13	0	8	41	0	Mean = 10.89
Type of migration									
Seasonal (%)	66	67	66	36	80	58	50	17	Mean = 54.85
Temporal (%)	6	33	28	64	20	37	43	80	Mean = 38.91
Permanent (%)	28	0	6	0	0	5	7	3	Mean = 6.24
Migration status									
Current (%)	42	46	58	50	84	68	47	NA	Mean = 56.25
Returned (%)	60	53	42	50	16	32	53	NA	Mean = 43.77

Source: Warner et al., 2012; HH surveys in eight case studies.

[a]In the HH survey, sometimes respondents did not give a clear answer, which made the interviewer drop the respective question. In other cases, respondents gave two answers where the question required only one answer. Therefore, in some exceptional cases in this table (particularly the cases of Thailand, Peru, and India), adding up percentages gives a sum of slightly less or more than 100%. Seasonal migration is defined as yearly recurring migration over periods of less than six months per year. Temporary migration is defined as a move from the HH of origin during at least six months per year to a place within the country or abroad with the purpose of working, studying, or family reunification, over a distance that forces the concerned person to settle at the destination and stay overnights. Current migration means that a person is currently away for the purpose of migration. Returned migration is defined as the return of a once-migrated HH member who has not migrated again in more than one year.

Table 6. HHs surveyed in eight case study research sites.[a]

	Lamphun Thailand	Huancayo Peru	Chhattisgarh India	Dong Thap Vietnam	Kurigram, Bangladesh	Nadowli Ghana	Same Tanzania	Cabricán Guatemala	
HHs interviewed (*n*)	206	150	180	150	150	158	180	136	Total = 1310
Approximate % of local population	31.7	29.9	12.8	8.6	2.3	27.2	11.9	18.5	Mean = 17.8
Female-headed HHs interviewed (%)	14.6	20.6	7.7	6.6	2.7	12	23	15	Mean = 12.8
Female interviewees (%)	14.6	75.3	18.3	44.7	19	20	58.1	63	Mean = 39.1
Average age of the interviewees	49.62	42.14	43.58	44.4	45	47.75	47.39	37.04	Mean = 44.7
HH size (average)	4.31	5.03	6.64	4.3	5.1	7.03	6.08	6.79	Mean = 5.6
HH dependency ratio	0.49	0.88	0.70	0.46	0.80	0.93	1.29	1.10	
Average years of schooling of HH-head	4.16	7.56	5.93	5.2	3.3	2.78	5.16	3.12	Mean = 4.7
Average years of schooling of HH-members aged 14+	5.82	8.42	7.48	6.7	4.6	4.02	6.06	3.57	Mean = 5.9
Poor (1.25–2.5 US$/cap/day) (%)	78	82	55	68.6	66	na	na	61.6	Mean = 51.4
HHs facing food shortages in last year (%)	29.1	82.6	43.9	43	75.3	52.5	84	52.9	Mean = 52.9
Landless HHs (%)	2.4	43.3	24.4	31	36	6	6.7	2.9	Mean = 19.1
Land scarce HH – small land holding (%)	44.6	39.3	36.1	26	48	3.8	24.8	65	Mean = 35.9
Medium land holdings (%)	22.3	8.6	12.8	36.6	13	33	49	24	Mean = 24.8
Above average land holdings (%)	30.6	8.8	26.1	6.6	3	43.6	19.3	6	Mean = 17.9
Average land holding size (ha)	2.856	0.54	1.18	2.4	0.5	7.02	1.815	0.54	Mean = 2.1 ha
HHs with migrants (%)	67	63.3	41.7	60	43.3	76.6	53.9	23.5	Mean = 57
Migrants seeking livelihood diversification (%)	76.00	75.6	87.7	69.6	90	82.8	78.4	97.1	Mean = 80.6

Source: Warner et al., 2012.

[a]Definition of dependency ratio: ratio of HH members typically not in the labour force (the dependent part – age ranges 0–14 and >64) and those typically in the labour force (the productive part – age range 15–64). It is used to measure the pressure on productive HH members. Definition of land scarce varies by country: Thailand ≤ 10 Rai or 1.6 ha; Peru 0.1–5.0 ha; India ≤ 1 acres; Vietnam 0.1–1.0 ha; Ghana 0.1–1.0 ha; Bangladesh 0.1–0.7 ha; Tanzania 0.01–1.75 acres; and Guatemala <0.44 ha. Definition of medium-sized farm varies by country: Thailand 10.01–20 Rai; India 1.01–2 acres; Ghana <5 ha; Tanzania 1.76–4 acres; and Guatemala >0.44 and <1 ha. Definition of above average-sized farm varies by country: India ≥ 2 acres; Ghana >5.01 ha; Tanzania ≥ 4.01 acres; and Guatemala >1 ha.

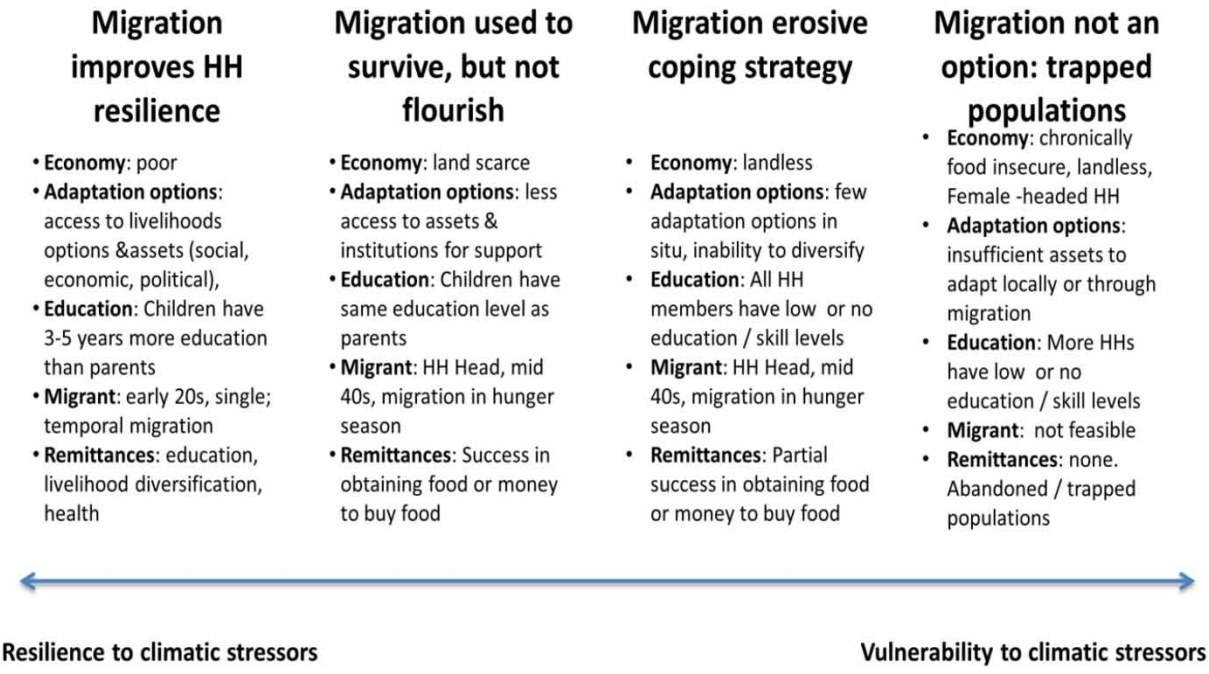

Figure 2. HH profiles affect whether migration is adaptive or erosive vis-à-vis rainfall, food, and livelihood insecurity. Source: Warner et al., 2012.

by females. The average HH dependency ratio is the highest in the research site of Tanzania (1.29) followed by Guatemala (1.10). This means that in Tanzania, on average, every active HH member corresponds to 1.29 inactive (dependent) HH members. The two other extremes are the cases of Vietnam (0.49) and Thailand (0.46); for example, in the research site of Thailand, on average, every active HH member corresponds to only 0.46 inactive (dependent) HH members.

The eight articles in this special issue aim to build understanding about how HHs use migration to manage risk or to survive when faced with changing rainfall patterns that affect food and livelihood security. Observations in the field based on the HH survey and PRA sessions across the eight case studies showed that HH responses to rainfall variability may be grouped into four HH migration profiles (found in each of the case studies). These four HH groupings help explain the role of migration in HH attempts to manage rainfall-related risks and bring insights to the debate about whether migration is a 'positive' form of adaptation to climate change, or whether it is an erosive and undesirable action indicating constraints or limits to adaptive capacity *in situ*. Figure 2 shows these four HH profiles, which are discussed below.

4.1 *HHs that use migration to improve their resilience (content migration)*

Across all case studies, some HHs use migration as one successful risk management or livelihood strategy among a wider range of options. The profile of such HHs was low income or poor, but with adequate access to a variety of livelihood options and assets (social, political, and financial) to enable the HH to be less sensitive to rainfall stressors. Children in these HHs typically had 3–5 years more education than parents, with migrants usually in their early 20s, single, aspiring to better livelihood opportunities, and able to send remittances back home. Migration, first and foremost, is an accessible option for those HHs to enhance livelihood security and resilience for the entire HH, including members left behind. Second, migration is an active, positive choice associated with capturing an opportunity that benefits the HH. For instance, in these HHs, migrant remittances facilitate investments in education, health, and assets that enhance the welfare of the HH in ways that make it less susceptible to rainfall stressors.

For example, Promburom and Sakdapolrak (2012) show that 51% of HHs in Lamphun Province, Thailand, considered the impact of rainfall-related environmental stress on their livelihoods to be significant. Three quarters of HHs suffer from lower income due to declining crop yields and deceasing income from agriculture as a result of the exposure to environmental stress. However, diversified on- and off-farm (less sensitive to rainfall variability) income-generation activities, access to financial resources through community funds, and assistance from the local government reduce HH vulnerability to rainfall-related stress and food insecurity. In Lamphun, diverse livelihoods and access to assets and services make migration a matter of choice.

This pattern was found to some degree in the research in Peru. In their research on Huancayo Provine, Peru, Milan and Ho (2013) find that livelihood options and migration strategies vary by elevation and proximity to urban centres. The impact of changing rainfall on food production is severe for 53% of HHs and two-thirds of surveyed HHs reported crop damage and lower crop yields from changing rainfall patterns. Rainfall changes affect the ability of HHs to feed themselves and earn livelihoods and 42% experience substantial negative impacts on HH income. Migration facilitates lowered dependence on agriculture-based livelihoods and expanded employment opportunities in non-farming activities in nearby urban areas.

For the next two groups, impacts of migration on HHs facing rainfall stressors depend on the degree of 'success' migrating members have in securing food or resources to obtain food.

4.2 *HHs that use migration to survive, but not flourish (content migration at the risk of becoming erosive)*

For this group, migration is a way to avoid the worst consequences of rainfall variability and food insecurity, but few or inadequate livelihood diversification or *in situ* adaptation options available mean that HHs may be 'just getting by'. These families are usually land-poor, and while they may have access to llivelihood diversification strategies, these options are often insufficient to ensure food security for the HH. Migrants are usually heads of HH in their mid-40s. Children in these HHs have – within a four-month average – the same level of education and skill sets as their parents. These families have less access to social institutions and less access than the previous group to other forms of livelihood diversification or measures to cope with rainfall-related stressors on livelihoods and food security.

While migration for these HHs is somewhat accessible – they have the assets necessary to migrate – the migration choice is more risky than for resilient HHs. The HHs in this group can easily slide from 'resilient' to 'vulnerable', if migration proves to be erosive or if rainfall stressors overwhelm the capacity of these HHs to cope. For these HHs, migration may perpetuate cycles of debt (migration is an investment) and periodic hunger (if migration is erosive). Migration may not be the first choice if more viable *in situ* options were available or accessible. Migration for such HHs is often seasonal or temporary to obtain food directly, or to obtain resources to access food. Migration, therefore, serves as a stop-gap measure, allowing temporary relief from rainfall variability and the impacts of crop failure or decline on the HH economy, but it does not transform HHs or release them from the poverty cycle.

This pattern of migration related to managing the risks of changing rainfall patterns on livelihood and food security is illustrated in the articles on Bangladesh, Vietnam, and India: Ahmed, Hassan, Etzold, and Neelorm (2012) show that in Kurigram District, Bangladesh, migration is a major 'coping strategy' to address unfavourable economic and unexpected environmental conditions, including the local implications of rainfall variability: 89% of HHs were affected economically by prevailing weather patterns and rainfall variability. Longer dry spells and frequent droughts are a 'very important' migration reason for 39% and 36% of HHs, respectively. In the district surveyed, both of these climatic variations have severe impacts on local agricultural production and thus on people's livelihoods. Landless, low-skilled and poor HHs (depending on rain-fed agriculture for both their livelihoods and food security) are the most sensitive to rainfall variability and utilize rural–rural migration to manage climatic risks. Although migration allows HHs to survive the impacts of rainfall variability on HH consumption and economy, there are negative social consequences associated with this risk management choice.

Nguyen, Nguyen, and van der Geest (2012) did research in the Thap Muoi District in Vietnam (in the Mekong Delta). They find that of the HHs surveyed, the majority noted the adverse effects of heavy rainfall, shifting seasonality of rainfall and a higher frequency of rainy days on crop yields and non-farm income sources: 89.5% of these HHs reported negative effects of changing rainfall patterns on HH economy. Migration in Thap Muoi District is a short-term risk management strategy (short run only), if HHs face difficulties attaining livelihood security locally. However, the impacts on longer-term resilience can be very negative. For landless and low-skilled HHs, rural–rural migration can help fill HH income gaps if it is content, but can also interrupt skill building and education.

Murali and Afifi (2014) demonstrate in the Jangir District in Chhattisgarh State in India that migration is one of the most important strategies employed by the residents of the research villages to cope with rainfall variations/climatic changes and food insecurity. Therefore, migration is often the last resort for resource-poor and landless HHs, especially when they are unable to access or benefit from livelihood options *in situ*. The authors find that migration does not increase resilience or provide better long-term opportunities. Family migration keeps HHs intact but amplifies negative longer-term effects on livelihood diversification, for example by interrupting the schooling of children, and HH skill building.

4.3 *HHs that use migration as a last resort and 'erosive' coping strategy*

Another profile of HHs included those for whom migration is an erosive coping strategy (i.e. one that makes them more

vulnerable or prevents them from escaping poverty). These HHs are similar to the previous group; these HHs are landless or land scarce, poor, and have few or no options to diversify livelihoods away from crop and livestock production. Children from these HHs have the same (low) level of education as their parents. Migrants from these HHs compete for unskilled employment in the agricultural sector (and sometimes in urban settings). The migrant profile of such HHs in the Rainfalls research was head of HH, mid-40s, married with dependents. These HHs are also 'just getting by', and do not have access to or are unable to capture *in situ* adaptation or livelihood diversification options. Typical coping measures when faced with rainfall stressors on livelihoods and food availability include reducing food consumption, the quality of food consumed, selling assets, or seeking help from others in the village. As these HHs may already have limited mobility, focus group discussions indicated that entire villages may face similar challenges and be in a poor position to help each other in times of need (co-variation of risks).

Migration for this type of HH can be seasonal (less than six months), temporary (more than six months), or permanent, with the nearest places with more favourable livelihood opportunities as areas of destination. When such migrants leave during the hunger season – where there is no harvest and people run out of food reserves – to find food or resources to access food, HH members left behind can be more vulnerable to a variety of environmental as well as social stressors. Migration is a last resort to avoid the worst consequences of food insecurity and may require actions – such as risky loans to pay for migration– that leave the HH deeper in poverty. For these HHs, repeated environmental shocks and stressors – and repeated migration –erode livelihoods, food security, and asset bases enough to make migration inaccessible. This pattern can be seen in small numbers in all the cases but is more pronounced in countries that generally face larger challenges with poverty and food insecurity and low livelihood diversification options for climate-sensitive sectors.

Rademacher-Schulz et al. (2013) find in the Nadowli district in Ghana that migration at new points of time (e.g. during the main food production periods) is mainly due to livelihood and food insecurity linked to climatic and environmental factors affecting rain-fed agriculture. They find that the most important triggers of migration among HHs are crop production decline, rainy season shifts, unemployment, longer drought periods causing unreliable harvest, and increased drought frequency. HHs use migration to link bridging income gaps but are often unable to improve overall well-being for those HH members left behind. In Nadowli, female-headed HHs are more vulnerable to shifting rainfall variability, face a higher degree of food insecurity, have fewer HH members of working age, possess less land, and engage slightly less in migration than male-headed HHs (Rademacher-Schulz & Mahama, 2012).

The research by Liwenga, Kwezi, and Afifi (2012) in the Same District in Tanzania shows that changes in rainfall variability translate directly into impacts on food security. Surveyed HHs identified drought as the major hazard to HH livelihoods. In Same, rainfall changes affect the food production of more than 80% of HHs 'a lot' and there are strong linkages between unpredictable and changing weather patterns and the decision to migrate. The top three factors affecting HH migration decisions in Same are: (1) increased drought frequency, (2) longer drought periods, and (3) water shortage. While the majority of migrants are male and young, women now represent one-third of the total and out-migration from Same District is a mix of rural–rural and rural–urban migration.

4.4 *HHs that cannot use migration and are struggling to survive in their areas of origin (trapped populations)*

The final profile of HHs includes those that have been described as 'trapped populations' in the literature: HHs that do not possess the assets necessary to migrate, even to cope with food insecurity, or who cannot access migration options. These are often landless or land scarce HHs in very poor areas. Characteristics of these HHs (or individual members within the HH) include: female-headed HHs who may have multiple burdens of needing to care for agricultural land and care for young children or elderly, HHs where – often – a main breadwinner has already left the HH in search of other livelihood options, HHs with few able-bodied workers in relation to dependents such as children, elderly, or disabled persons. These HHs face acute food production and consumption shortfalls when rainfall varies, and they report having too little to eat at multiple times in a given year. These HHs tend to have few or no diversification options, and limited migration options. For trapped HHs or populations, repeated environmental shocks and stressors can continue to erode their asset base and increase their food and livelihood insecurity. In Guatemala, remote, food-insecure communities face a situation where they have few good options – high sensitivity to rainfall, few local options to diversify risks or livelihoods, and migration options that are too expensive (to a major city or international), too risky, or to places with similar challenges (see Milan & Ruano, 2014).

Examples of such HHs were found in all research areas, but the research in Guatemala provided more examples of communities with few good options to either stay or leave. Milan and Ruano (2013) shares results from Cabricán, Guatemala, showing that 97% of migration is motivated by attempts to secure stable HH consumption and income generated by rain-fed agriculture. Rainfall affects food production of 68% of HHs surveyed. Migration opportunities (seasonal in Guatemala and long-term to the USA) are decreasing due to decreased demand for labour

and difficulties in reaching destinations. HHs reported concerns about the long-term viability of their farming systems and food availability, but were also not in a position to use migration to ameliorate the risks changes in rainfall patterns pose for HH economy and HH consumption. Some very vulnerable HHs in Bangladesh, especially women-headed HHs, were also found to have characteristics of 'trapped populations' unable to improve their situation *in situ* or via migration to improve livelihood and food security (Ahmed et al., 2012).

5. The ABM and the case of Tanzania

Results from RABMM-T by Smith (2014) suggest that the rate of migration from non-resilient HHs is highly sensitive to changes in rainfall patterns, especially under an extreme drying scenario where the rate modelled is almost 50% greater by 2047 than under a base scenario (replicating past rainfall). By contrast, the modelled rate of migration from resilient HHs is far less sensitive to changes in rainfall with the greatest deviation away from the base scenario being −15% by 2047. Under an extreme drying scenario, the rate of migration from non-resilient HHs is therefore modelled to increase considerably while the rate from resilient HHs decreases by a lesser degree.

By presenting model outputs that distinguish between resilient and non-resilient HHs and that are normalized against a historical base scenario, the rates of migration presented by Smith indicate the proportional change in modelled migration resulting from each rainfall scenario. In this way, the considerable impact of an extreme drying scenario upon those HHs with already depleted adaptation resources is revealed and their status as the most vulnerable highlighted. However, if the results of RABMM-T were presented in terms of total migrants, the larger number of resilient HHs, for whom the rate of migration is seen to marginally decrease under extreme drying, would conceal the increased migration activity of those few most vulnerable HHs. These findings further reinforce earlier statements within the literature that the migration decision is highly complex and case specific and that the application of standardized meta-actor rules of behaviour to such heterogeneous agents does not adequately represent the complex and non-linear processes at play (Kniveton, Smith, & Black, 2012). On this basis, the use of an agent-based modelling approach such as RABMM-T provides the opportunity for unexpected and potentially insightful outcomes to emerge.

6. Outlook and conclusions

6.1 *Summary*

The results presented in this article indicate the circumstances under which resilient and vulnerable HHs use migration as a risk management strategy when faced with rainfall variability and related livelihood and food insecurity. Rural people in the eight research locations perceive climatic changes happening today in the form of rainfall variability, and these perceptions shape HH risk management decisions. The most common changes reported relate to the timing, quality, quantity, and overall predictability of rainfall. These perceived changes correlate with an analysis of local meteorological data over the last several decades. The largely agriculture-based HHs in the research sites report that rainfall variability is already negatively affecting production and contributing to food and livelihood insecurity.

The relationship between rainfall variability and migration was manifest via livelihood and food security of HHs. Rainfall was observed to have a direct relationship to food production and consumption, influencing HH migration decisions in research sites where the dependence on rain-fed agriculture was high and local livelihood diversification options were low.

Climatic factors affect migration via impacts on HH economy (food production) and HH food security (food consumption). In most districts surveyed, respondents were poor and often land scarce, and most used migration in one form or another. The findings suggest that the answer to how climatic stressors affect migration decisions and the degree to which migration improves the adaptive capacity of those HHs lie in the vulnerability of the HH and its sensitivity to climatic factors. The data reveal for the first time in a comparable global study distinct HH profiles of 'resilience' – those HHs in which migration is one of a variety of adaptation measures that progressively reduce the climate-sensitivity of those HHs – and 'vulnerability' – those HHs in which migration is part of a spectrum of erosive coping strategies and in which sensitivity to climatic stressors is maintained or exacerbated. In contrast, migration can also undermine climate-resilient development efforts for 'vulnerable' HHs which have the least access to such options – few or no livelihood diversification opportunities, no land, little education – use migration as a survival strategy in an overall setting of erosive coping measures which leave or trap such HHs at the margins of decent existence.

The research results presented here showed that 'resilient' and 'vulnerable' HHs use migration in different ways when faced with climatic stressors, with implications for how we understand the role of migration in adaptation to climate change: Resilient HHs employ migration as one of a number of risk management strategies that reduce the climatic sensitivity of the HH over time. Resilient HHs have diverse assets and access to a variety of adaptation measures – livelihood diversification, or risk management options through social networks, community or government support programmes, and education. They use migration to further diversify livelihoods, build skill

sets, and enhance resilience. In contrast, vulnerable HHs have fewer and less effective risk management strategies. They use migration as part of 'climate survival strategies' which ultimately increase HH sensitivity to climatic risks like changes in rainfall variability. Those HHs with least access to adaptation options use internal migration during the hunger season, which reduces HH labour to tend and harvest crops, maintains land tensure, and interrupts HH investments in education as a survival strategy in an overall setting of erosive coping measures which leave or trap HHs at the margins of decent existence. An adaptation gap could grow for those already vulnerable HHs engaging in migration and other erosive coping strategies because they cannot access sufficient adaptation options. It is important to note, however, that it is not always possible to draw a clear cut between 'vulnerable' and 'resilient' HHs or between 'erosive' and 'content' migration, as the process is dynamic and HHs and migrants can move between the various circumstances, respectively. Furthermore, among the eight case studies of the research, there was no case study where all the HHs gave a model of 'resilience' or 'vulnerability', but a mixture and an overlap between all these indicators were present in all the case studies to various extents.

6.2 *Outlook*

The 2007 IPCC fourth Assessment Report predicts that the average global temperature rise could reach 6.4°C by 2100. Even after mitigation actions have been taken and adaptation choices have been made, climate impacts are likely to outstrip the options available to vulnerable countries, communities, and HHs. The consequences of greater variability of rainfall conditions – less predictable seasons, more erratic rainfall, unseasonable events, or the loss of transitional seasons – have significant repercussions for food security, livelihoods of climate-dependent people, and the migration decisions of vulnerable HHs. Pressure on rainfall-dependent livelihoods is likely to grow as a driver of long-term mobility in the coming decades if vulnerable HHs are not assisted in building more climate-resilient livelihoods *in situ*.

Understanding how HHs manage impacts of changing rainfall patterns on livelihoods and food security today is of paramount importance for adaptation planning, development, and transition to a more climate-resilient future. People in vulnerable communities worldwide are already experiencing impacts associated with extreme weather events and slow-onset climate change. They report changing rainfall patterns, shifting growing seasons, and increasingly severe weather events (IPCC, 2012). Climate change threatens to decrease agricultural productivity, increase food insecurity, and challenge the livelihoods and survival of poor people, particularly smallholder farmers, livestock keepers, and the landless in least developed countries.

In this context of potentially significantly changing weather patterns including rainfall patterns, research must further identify those characteristics that make HHs and communities more resilient to climatic stressors, and those that lead to erosive coping that undermines development efforts. The Rainfalls research presented in this special issue of Climate and Development help shed light on the role migration plays in HH risk management strategies vis-à-vis rainfall changes, food, and livelihood security. This research is a step contributing to more differentiated knowledge of adaptation for certain HH profiles. As adaptation knowledge and possible actions to address climatic risks improve, interventions can become more targeted towards the particular risk management needs of vulnerable communities – and help ensure that migration can be one of a variety of adaptation choices which help reduce sensitivity to climate stressors. In terms of research sites and methodologies, future research should continue using a mixed-methods approach but expand the scale of the research sites, so that more credible generalizations can be done within one case study rather than increasing the number of case studies and keeping the small-scale analysis and geographic coverage/scope in each case study.

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Notes

1. This article is the introduction to a set of eight comparable case studies and provides an overview of the key issues, results, and implications of migration as a risk management strategy vis-à-vis rainfall-related food and livelihood security. More in-depth, information can be obtained in other articles in the special issue that covers eight case studies of the project in addition to an article that applies a computational ABM on Tanzania.

References

Afifi, T., & Jäger, J. (eds.). (2010). *Environment, forced migration and social vulnerability.* Heidelberg: Springer.

Afifi, T., Liwenga, E., & Kwezi, L. (2014). Rainfall induced crop failure, food insecurity and outmigration in Same-Kilimanjaro, Tanzania. *Climate and Development*, 6(1).

Ahmed, A.U., Hassan, S.R., Etzold, B., & Neelorm, S. (2012). *"Where the Rain Falls Project". Case study: Bangladesh. Results from Kurigram District, Rangpur Division* (Report No. 2). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Barnett, J., & Webber, M. (2010). *Accommodating migration to promote adaptation to climate change*. Policy Research Working Paper 5270. April 2010. Background to the 2010 World Development Report. doi: 10.1596/1813-9450-5270.

Betts, A. (2010). The refugee regime complex. *Refugee Survey Quarterly*, *29*(1), 12–37.

Black, R., Bennett, S.R.G., Thomas, S.M., & Beddington, J.R. (2011). Climate change: Migration as adaptation. *Nature*, *478*(7370), 447–449.

Black, R., Knieveton, D., Skeldon, R., Coppard, D., Murata, A., & Schmidt-Verkerk, K. (2008). *Demographics and climate change. Future trends and their policyiImplications for migration*. Brighton: Development Research Centre on Migration, Globalisation and Poverty, University of Sussex.

De Sherbinin, A., Warner, K., Erhart, C., & Adamo, S. (2011). Climate change and migration. *Scientific American*, Jan 2011, 50–58.

El-Hinnawy, E. (1985). *Environmental refugees*. Nairobi: United Nations Environment Programme.

Etzold, B., Ahmed, A., Hasan, S., & Neelormi, S. (2014). Clouds gather in the sky, but no rain falls. Vulnerability to rainfall variability and food insecurity in Northern Bangladesh and its effects on migration. *Climate and Development*, 6(1).

Foresight. (2011). *Migration and global environmental change – future challenges and opportunities*. London: Government Office for Science.

Ho, R., & Milan, A. (2012). *"Where the Rain Falls" project. Case study: Peru. Results from Huancayo Province, Junín Region* (Report No. 5). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Hugo, G. (2008). *Migration, development and environment*. Geneva: International Organization for Migration.

Intergovernmental Panel on Climate Change. (2012). Managing the risk of extreme events and disasters to advance climate change adaptation. In C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, & P.M. Midgley (Eds.), *A special report of working groups I and II of the intergovernmental panel on climate change* (p. 582). Cambridge: Cambridge University Press.

IPCC AR4 WG1. (2007). Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., & Miller, H.L. (Eds.). *Climate change 2007: The physical science basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 978-0-521-88009-1 (pb: 978-0-521-70596-7).

Jäger, J., Frühmann, J., Günberger, S., & Vag, A. (2009). *Environmental change and forced migration scenarios project synthesis report*. Deliverable D.3.4 for the European Commission.

Kniveton, D.R., Smith, C.D., & Black, R. (2012). Emerging migration flows in a changing climate in dryland Africa. *Nature Climate Change*, *2*(6), 444–447. doi: 10.1038/nclimate1447.

Liwenga, E.T., Kwezi, L., & Afifi, T. (2012). *"Where the Rain Falls" project. case study: Tanzania. Results from Same District, Kilimanjaro Region* (Report No. 6). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

McLeman, R., & Smit, B. (2006). Migration as an adaptation to climate change. *Climatic Change*, *76*(1–2). 31–53.

Milan, A., & Ho, R. (2014). Livelihood and migration patterns at different altitudes in the Central Highlands of Peru. *Climate and Development*, 6(1).

Milan, A., & Ruano, S. (2014). Rainfall variability, food insecurity, migration and trapped populations in Cabricán, Guatemala. *Climate and Development*, 6(1).

Murali, J., & Afifi, T. (2012). *"Where the Rain Falls" Project. case study: India. results from Janjgir-Champa District, Chhattisgarh* (Report No. 4). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Murali, J., & Afifi, T. (2014). Rainfall variability, food security and human mobility in the Janjgir-Champa district of Chhattisgarh State, India. *Climate and Development*, 6(1).

Myers, N. (1993). Environmental refugees in a globally warmed world. *Bioscience*, *43*, 752–761.

Myers, N. (1997). Environmental refugees. *Population and Environment*, *19*(2), 167–82.

Myers, N. (2002). Environmental refugees: A growing phenomenon of the 21st century. *Philosophical Transactions: Biological Sciences*, *357*(1420), 609–613.

Myers, N. (2005). *Environmental refugees: An emergent security issue*. 13th Economic Forum, Prague, 23–27 May.

Nguyen, V.K., Nguyen, C.T., & van der Geest, K. (2012). *"Where the Rain Falls" project. Case study: Viet Nam. Result from Dong Thap Province, Thap Muoi District* (Report No. 8). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Oliver-Smith, A. (2009). *Nature, society, and population displacement: toward an understanding of environmental migration and social vulnerability.* InterSecTions 'Interdisciplinary Security ConnecTions' Publication Series of UNU-EHS No. 8, Bonn.

Piguet, E. (2010). Climate and migration: A synthesis. In T. Afifi & J. Jäger (Eds.), *Environment, forced migration and social vulnerability* (pp. 73–86). Bonn: Springer.

Promburom, P., & Sakdapolrak, P. (2012). *"Where the Rain Falls Project". Case study: Thailand. results from Thung Hua Chang District, Northern Thailand* (Report No. 7). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Rademacher-Schulz, C., & Mahama, E.S. (2012). *"Where the Rain Falls Project". Case study: Ghana. results from Nadowli District, Upper West Region* (Report No. 3). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Rademacher-Schulz, C., Schraven, B., & Mahama, E.S. (2014). Time matters – shifting seasonal migration in Northern Ghana in response to rainfall variability and food insecurity. *Climate and Development*, 6(1).

Rademacher-Schulz, C., Afifi, T., Warner, K., Rosenfeld, T., Milan, A., Etzold, B., & Sakdapolrak, P. (2012). Rainfall variability, food security and human mobility. An approach for generating empirical evidence (Intersections No. 10). Bonn: United Nations University Institute for Environment Human Security (UNU-EHS).

Sakdapolrak, P., Promburom, P., & Reif, A. (2014). Why successful in-situ adaptation with environmental stress does not prevent people from migrating? Empirical evidence from Northern Thailand. *Climate and Development*.

Smith, C. (2014). Modeling migration futures: Development and testing of the rainfalls agent-based migration model-Tanzania. *Climate and Development*, 6(1).

Stark, O., & Levhari, D. (1982). On migration and risk in LDCs. In *Economic development and cultural change*, Vol. 31. (Reprinted from *Migration and Economic Growth*, by Mathias Czaika & Carlos Vargas-Silva (Eds.), 2012, Cheltenham: Elgar).

Van der Geest, K., Thao, N.C. & Khoa, N.V. (2014). A wealth group-differentiated analysis of climate impacts and migration in the Upper Mekong Delta, Vietnam. *Climate and Development*, 6(1).

Warner, K. (2010). Global environmental change and migration: Governance challenges. Global environmental change, special issue focusing on resilience and governance. *Global Environmental Change*, *20*, 402–413. doi: 10.1016/j.gloenvcha.2009.12.001.

Warner, K., Afifi, T., Henry, K., Rawe, T., Smith, C., de Sherbinin, A. (2012). *"Where the Rain Falls": Climate change, food and livelihood security, and migration. Global policy report of the Where the Rain Falls Project*. Bonn: UNU and CARE.

Warner, K., Erhart, C., de Sherbinin, A., Adamo, S., & Chai-Onn, T. (2009). *In search of shelter: Mapping the effects of climate change on human migration and displacement, CARE/CIESIN/UNHCR/UNU-EHS/World Bank*. Genève: United Nations University, Institute for Environment and Human Security.