Migration as adaptation strategy to cope with climate change

A study of farmers' migration in rural India

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Abstract

Purpose – This study aims to evaluate the link between climate/weather change and farmer migration in Bihar, India. The influence of cognitive conditions and climate-related stress on farmer migration decisions and the socioeconomic characteristics of migrating and non-migrating farm households are analysed. The focus is the role of migration in access to climate and agricultural extension services and the contribution of migration to enhanced farmer coping capacity.

Design/methodology/approach – A primary survey was conducted of farm households in seven districts of Bihar, India. Farmer perceptions of climate change were analysed using the mental map technique. The role of socioeconomic characteristics in farm household migration was evaluated using binary logistic regression, and the influence of migration on access to climate and agricultural extension services and the adaptive capacity of migrating households was investigated using descriptive statistics.

Findings – Climate-induced livelihood risk factors are one of the major drivers of farmer's migration. The farmers' perception on climate change influences migration along with the socioeconomic characteristics. There is a significant difference between migrating and non-migrating farm households in the utilization of instructions, knowledge and technology based climate and agriculture extension services. Benefits from receipt of remittance, knowledge and social networks from the host region enhances migrating households' adaptive capacity.

Originality/value – This study provides micro-evidence of the contribution of migration to farmer adaptive capacity and access to climate and agricultural extension services, which will benefit analyses of climate-induced migration in other developing countries with higher agricultural dependence. In addition, valuable insights are delivered on policy requirements to reduce farmer vulnerability to climate change.

Keywords Adaptation strategies, Climate change, Migration, Agriculture, Extension services, Socioeconomic conditions

Paper type Research paper

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1. Introduction

Human displacement in response to environmental shocks is not a new phenomenon. Hippocrates and Aristotle believed that the characteristics of the natural environment determined the human habitability of a region and, in turn, the characteristics of its inhabitants (Livingstone, 2000). Large disparities in income and living standards are major reasons for increased migration from rural to urban areas in developing countries such as India. Economists including Fei and Ranis (1964), Harris and Todaro (1970), Stark (1984), Lucas (1997) have provided theoretical support for this hypothesis of internal migration. Fei and Ranis (1964) broadly explained that rapid internal migration is a desirable process by which surplus labour at $MP_L = 0$[1] is withdrawn from traditional agricultural occupations to provide cheap manpower to the modern industrial state, where $MP_L > 0$[2]. A country will remain in a middle income trap if it fails to make the transition from labour-intensive to capital-intensive production (Kohli *et al.*, 2011).

Agriculture has predominantly become a climate-sensitive sector in which surplus labour ($MP_L = 0$) has increased and emerged as a major contributing factor to internal migration to non-climate-sensitive sectors (where $MP_L > 0$). The Harris and Todaro (1970) model of economic development explains some drivers of rural urban migration. The basic postulate of this model is that migration is based on the expected income differential between rural and urban areas rather than the wage differential alone. Lucas (1997) subsequently supported this model but added that the understanding of the factors determining the urban component other than the wage differential remains poor. De Haas (2010) also noted that:

> [. . .] whether migration occurs crucially depends on the skills and knowledge of migrants and conditions in the specific economic sectors where they are likely to find employment both at the origin and destination.

New Economics of Labour Migration (NELM) models conceptually differ from other models by incorporating rural risk as a factor determining migration decisions. According to this approach, the migration decision is based on important human groups such as families and households rather than the individual alone (Mincer, 1978; Stark and Levhari, 1982; Stark and Bloom, 1985; Stark and Lucas, 1988). This model also views migration as a family strategy aimed at maximizing expected earnings and reducing the risk of consumption failure by diversifying income sources across sectors or agro-zones.

Human migration is not only a response to poverty and social deprivation but also an adaptive response to changing climate (Scheffran *et al.*, 2012). Extreme weather events, sea level rise and environmental degradation are major consequences of climate change. These changes are major causes of short- or long-term migration due to loss of climate-sensitive occupations and low adaptive capacity in South Asia, including India (Bhatta and Aggarwal, 2016; Kumar and Viswanathan, 2012; Deshingkar and Akter, 2009, Deshingkar and Start, 2003). Most developing countries face resource constraints in meeting the demands of high populations and thus have low adaptive capacity (Ahmed *et al.*, 2012). The adaptive capacity of a household is based on several factors, including financial resources, access to information, social resources, human capital and infrastructure (Barnett and Webber 2009). Households may reduce expenditures on non-essential goods, use formal and informal credit or draw on public assistance (Gray and Mueller, 2012). Alternatively, or in conjunction, families may send a member elsewhere to access alternative income sources for remittance to the origin household (McLeman and Smit, 2006). In the absence of group-based mitigation activities and spatial coping strategies, migration can be an important adaptation strategy for households to adapt to climate shocks. Due to uncertainty related to climate-sensitive occupations, households engage in livelihood diversification, a major coping strategy for various economic and environmental challenges (Bhatta *et al.*, 2015b). Remittances are the most obvious factor enhancing the capacity of households to adapt to stress (Banerjee *et al.*, 2011). The increase in income from diversified livelihood sources allows farmers to enhance their adaptive capacity to cope with climate risk (Cunguara *et al.*, 2011; Tripathi, 2017, Patnaik and Das, 2017).

Adaptation is a major policy option to avoid the dire consequences of climate change, and migration is one potential adaptation strategy (Nordas and Gleditsch, 2007; Laczko and Aghazarm, 2009; Tacoli, 2009; Scheffran *et al.*, 2012). As the most climate-centric economic activity, agriculture faces the greatest risk and uncertainties associated with loss of livelihood. Stojanov *et al.* (2016a, 2016b) found that at the national level, individuals first recognize change in climatic aberrations and choose to migrate as a coping strategy. Farmers are the main performers and actors at the farm level, and therefore farmer perceptions of climate change and the socioeconomic characteristics of farm households are the main factors driving farmer migration. Although perception of climate change is a prerequisite for the individual adaptation response, socioeconomic conditions determine the vulnerability of farm households to climate-induced economic tragedy and social deprivation. Farmers opt to migrate in search of alternative livelihoods under the risk of crop failure or low crop yield due to the impact of unpredictable climate consequences. In addition to generating a certain expected income, migration provides opportunities to acquire knowledge on new techniques and farming practices to enhance agricultural income. Moreover, remittances from the host region reduce credit constraints on the adoption of adaptation strategies (Patnaik and Narayanan, 2015), thus scaling up the adaptive capacity and resilience of the home region.

Given this theoretical background, there is a need to study the migration-climate nexus in a more context-specific manner by integrating multiple socioeconomic, political, cultural and developmental factors. Furthermore, there is a need to reveal how household characteristics influence the migration decision to develop more informed regional policies (Upadhyay *et al.*, 2015). This study develops an understanding of the role of migration as an adaptation strategy to cope with climate change and attempts to reframe the debate as "migration is not always the result of an individual failure to adapt effectively". The study assesses whether farmers in the study area perceive changes in climate/weather and accordingly identifies different cognitive conditions inducing the decisions of farmer to migrate for the Kharif or Rabi season. Furthermore, the socioeconomic conditions of migrating and non-migrating farm households are evaluated. The focus of this study is to evaluate the role of migration in access to climate and agricultural extension services and further assess the contribution of migration in enhancing farmer coping capacity.

The remainder of the paper is organized as follows. Section 2 briefly reviews the literature on different causes of migration, including climate-induced migration. Section 3 discusses the study area, and Section 4 describes the methodology and survey design. Section 5 presents the results and discussion of farmers' perceptions of climate change and their migration decisions, the role of socioeconomic characteristics in migration as an adaptation strategy, the role of migration in the choice of extension services, migration as an adaptation strategy and the adaptation strategies adopted by migrating and non-migrating farmers. Finally, Section 6 discusses the conclusions and policy implications of the study.

2. Literature review

Climate change is a stress factor underlying migration in climate-vulnerable regions (Warner and Afifi (2014); Adger *et al.*, 2002, 2015; Curtis and Schneider, 2011; Gray and

Bilsborrow, 2013; Henry *et al.*, 2004; Hunter *et al.*, 2013; Mueller *et al.*, 2014; Stal, 2011). Migration provides individuals with an opportunity to make non-marginal adjustments in adapting to climate change (Klaiber, 2014), and the potential impacts of climate change on migration have long been a subject of intense interest in the policy and academic arenas (Warner, 2010; Renaud *et al.*, 2007; Stern, 2007; Conisbee and Simms, 2003).

A baseline assumption prevalent in the literature is that individuals migrate to other locations because they failed to adapt effectively (Warner, 2010; Renaud *et al.*, 2007; Conisbee and Simms, 2003; Adamo, 2010). Environmental factors indirectly affect individual migration decisions by impacting economic activity, e.g. loss of agricultural productivity and increased expenditure due to increasing food prices (Porter *et al.*, 2014). Credit sources may be insufficient for the adoption of modern technologies for climate change mitigation and adaptation (Lybbert and Sumner, 2012). In most South Asian countries, the probability of migrating under adverse conditions is higher among households with poor socioeconomic profiles (Etzold *et al.*, 2014; Bhatta *et al.*, 2015a; Bhatta *et al.*, 2015b). Migration-related decisions are based on vulnerability to economic, political, social and demographic factors (Stojanov, 2004; Stojanov *et al.*, 2016a, 2016b; Yi Sun *et al.*, 2017). Families may relocate individual members to earn income to sustain the expenditures of the family, acquire knowledge and increase capabilities to confront future shocks and stresses (de Haan *et al.*, 2002).

2.1 Reasons for migration

NELM (Taylor, 1999) describes migration as a potential source of capital transfer to help traditional communities move towards modern knowledge and education. For instance, agricultural extension is an important engine of knowledge innovation and development in developing countries (Rivera and Sulaiman, 2009). Extension services are comprehensive institutional arrangements that help farmers organize themselves and links farmers to markets (Swanson, 2006). Transfer of resources to the home region, including knowledge, remittance and migrant return, can contribute to increased awareness of the value of technical and institution sources of climate information and extension services. Remittance income directly affects the resource base, economic well-being and resilience of the home community (Adger *et al.*, 2002). Individual migrants scale up community capabilities to acquire sustainable livelihoods and development. In developing countries, remittance income is increasing substantially due to high rates of migration. These links between host and home communities are required to strengthen the resilience of the home community (Conway and Cohen, 1998), increase its economic well-being (Adger *et al.*, 2002) and provide access to resources that enrich its human, social and cultural capital (Woodruff and Zenteno, 2007, Massey *et al.*, 1993; Taylor, 1999). Social networks in the host region have also identified as a major factor for migration by providing support in terms of accommodation and employment opportunities (Ravuvu, 1992).

2.2 Migration due to climate change

A broad spectrum of the literature supports links between climate change and prehistoric human settlement and migration (Huntley, 1999; Tyson *et al.*, 2002). In response to the loss of climate- sensitive occupations and the non-availability of climatic-insensitive occupations, communities diversify their livelihoods by intensifying agricultural and non-farm activities (McDowell and Haan, 1997). Tschakert and Tutu (2010) further emphasized the importance of migration in coping with climate change; in particular, in South Asia, a large number of landless and marginal farmers have migrated to cope with climate variability (Bhatta and Agarwal, 2016). The impact of climate change on human migration dynamics is particularly notable in rural areas due to a lack of adaptive capacity (Boyd and Ibarrarán, 2009; Kates, 2000). Perception of climate change is an important precondition for individual adaptation responses, including farm-level adaptation (Bryan *et al.*, 2009; Hassan and Nhemachena, 2008; Gbetibouo, 2009). At the micro-level, climate-driven migration decisions of farm households initially depend on their perception of climate change/variability, the associated risks and uncertainties of crop failure and loss of livelihood and the need for alternate income sources. A farmer's decision to migrate follows a cognitive process involving recollection of past incidents of climate extremes and current understanding of the climate based on intuition and perceptions of risks associated with climate change (Grothmann and Patt, 2005; Adger *et al.*, 2009; Marx *et al.*, 2007). However, given the significant differences between personal experience and external sources of information due to climate uncertainty, farmers may place greater weight on recent climatic events (Hansen *et al.*, 2004). Wider gaps between climate variations anticipated by farmers and actual climate forecasts may also lead to indecisiveness (Roncoli *et al.*, 2002; Below *et al.*, 2010). Changes in agricultural systems do not involve linear updating of a farmer's decision making, and therefore the manner in which farmers revise their anticipations of climate variation crucially determine adaptation decisions (Bryan *et al.*, 2009; Gbetibouo, 2009).

Despite the plethora of literature on climate change, adaptation and migration, gaps remain in identifying the prevailing heterogeneous influences in the home region that drive migration and how migration further enhances the migrating member's ability to acquire knowledge on farm management and extension benefits. Studies of climate-induced migration patterns among different heterogeneous groups are very limited (Bhatta *et al.*, 2015b). Therefore, it is pertinent to understand migration as the major source of household resilience under the scenario of climate change.

3. Study area

This study was conducted in three sub agro-climatic zones of the Middle Ganga Plain in the state of Bihar, India. The river Ganga divides the state into North Bihar (area of 53,300 km^2) and South Bihar (area of 40,900 km^2). North Bihar (Zones I and II) is highly flood prone, whereas South Bihar (Zone III) is drought prone (Agricultural profile of the state, BAMETI, 2017). Annual precipitation in the state varies between 990 and 1,200 mm, with major precipitation during the months of July to September. The state experiences the summer season between the months of April and June and the winter season from December to February. The hottest month is May, with a maximum temperature of 45°C, and the coldest month is January, when the temperature falls below 10°C (IMD, 2009). These sub agro-climatic zones have experienced the brunt of changing temporal and spatial patterns of rainfall and temperature. The state has two major cropping seasons, Kharif and Rabi[3]. The population pressure is quite high in the state, with a population density of 1,102/km^2, in contrast to the national average of 382/km^2 (Census of India, 2011). Consistent with the high population density, resource constraints are enormous in Bihar: 42.6 per cent of the population is below the poverty line, in contrast to the national average of 26.10 per cent (Department of Agriculture, Govt. of Bihar). Approximately 89 per cent of the population resides in rural areas where agriculture and animal husbandry are the main sources of livelihood.

Internal migration is a major issue in the Indian economy due to the history of unequal growth among states. The availability of migration data in India is limited to two sources: census data collected by the Registrar General of India and survey data (employment-unemployment surveys or special migration surveys) collected by the National Sample Survey Organization (NSSO). Bihar is a major contributor to internal migration due to high rates of temporary and seasonal migration (Keshri and Bhagat, 2013). The major reason for migration is the unavailability of non-farm employment opportunities and other attributes of higher living standards. According to the 2011 census, Bihar has the second highest rural population, 11.1 per cent, after Uttar Pradesh, which has a rural population of 18.6 per cent. Bihar also ranks at the top of migrant-sending states in India.

The Economic Survey of India (2016-17), which uses the new Cohort-based Migration Metric (CMM)[4], reports that annual average inter-state labour mobility averaged 5-6 million people between 2001 and 2011 and accounted for 60 million inter-state migrants and 80 million inter-district migrants. The first-ever estimates of railway passenger traffic data for the period 2011-2016 reveal work-related migration of approximately nine million people, nearly double the figures in the 2011 Census (Economic Survey, GOI 2017). Based on the relationship between CMM scores and per capita the survey reveals that the rate of net out-migration in less developed state such as Bihar and Uttar Pradesh is high.

Different data sources have classified Bihar as one of the highest contributors to out-migration in India. The combination of natural, economic, and social circumstances forces family members to migrate. The NSSO 64th round also highlighted Bihar as a major migrant-sending state and identified work/employment and education as the major reasons for male migration and marriage as the major reason for female migration. Domestic remittances from the host region to meet household consumption expenditures are a major driver of internal migration in Bihar. Tumbe (2011) found that the dependence on domestic remittances is much higher in Bihar than the average for India and has grown since the 1990s.

4. Methodology

4.1 Sample selection

This study was conducted in Bihar state of India during the first half of 2015. The state of Bihar is divided into three sub-agro-climatic zones of middle Ganga plain on the basis of different hydrological, climatic, soils and agricultural attributes. The 7 districts were randomly selected out of 38 districts from the three sub-agro-climatic zones. The 72 villages from these 7 districts were selected randomly which were closer to the district headquarter and farm household have easier access to inputs, institutional farm aid and management and vice versa. The district headquarters have villages within the periphery of 10-70 kilometres (subject to size of the districts) with their institutional support and market access. From these 72 villages, 735 farm households were selected randomly. Finally, the data from 700 farm households was found complete in all aspects for the purpose of statistical analysis. This study included all land size groups, such as marginal, medium, small and large. The preliminary information on the farm household was collected from the office of Head of the village.

4.2 Questionnaire design

The self-administered structured questionnaire was discussed with the farm household to ensure consistency and collect data. If a household declined to respond, the next farm household in the same land size category was approached. The selected households were engaged in farming either on their own farms (i.e. land ownership) or others' farms (i.e. rented land). Therefore, all households qualified for consideration as farmers or farm households because they were the main on-farm actors and decision-makers. The questionnaire was designed to capture the farmers' local perceptions and observations of climate change and experiences with climate variability and extreme events over the past two decades. In addition, a mental map technique was adopted in which the famers were asked about their local perceptions of changes in climate based on their past and current experiences and observations of changes/variations in climate variables. Ethnographic studies have confirmed that individuals can correctly identify climate change over a decade or longer based on personal experience (Marin, 2010; West *et al.*, 2003; West *et al.*, 2008). For example, a recent study in Burkina Faso found that farmers successfully recognized a decrease in rainfall that occurred over a 30-year period (West *et al.*, 2008). Furthermore, the farmers were enquired about their socioeconomic conditions, their choices and access to information about climate and new agricultural techniques (climate and agricultural extension services) and, accordingly, their choices of adaptation strategies among 11 different adaptation alternatives[5] for the Kharif and Rabi seasons separately[6]. The adaptation options attempted to capture capital-intensive, labour-intensive and knowledge-intensive techniques to facilitate the assessment of whether migration contributes to the adoption of adaptation strategies.

4.3 Data analysis

A binary logistic regression model was used to assess the role of socioeconomic characteristics. The study was based mainly on the assumption that the migration decisions of farmers are family strategies and therefore either the farmer or at least one member of the household will migrate to nearby zones or more distant cities. Furthermore, the study principally used behavioural attributes of migrating and non-migrating farmers and did not include psychological factors other than perceptions of climate stress as drivers of farmer migration. Descriptive statistics were used to reveal differences in adaptation behaviour, choice of agriculture and climate extension services and pattern of adoption of different adaptation strategies between migrating and non-migrating farmers or farm households.

5. Results and discussion

5.1 Perceptions of climate change and migration

A farmer's experiences and perceptions of climate variability and climate extremes determine the nature of migration, i.e. temporary or permanent. For instance, farmers who are more vulnerable to climate extremes and experience continuous changes in climate patterns are more likely to permanently migrate due to continuous loss of assets (e.g. land), wealth and livelihood, whereas farmers affected by seasonal climate variations and provisional changes in climate may decide to make temporary income arrangements to fulfil livelihood requirements. Temperature and precipitation were considered as climate variables in this study. The farmers' perceptions of climate change were evaluated based on their responses (i.e. yes or no) to the question "Have you observed any long-term changes in mean temperature and rainfall levels over the last 20 years?". Of the surveyed farmers, approximately 91 and 86 per cent reported observing changes in temperature and rainfall patterns, respectively, over the past 20 years.

The decision to migrate was analysed for two cropping seasons, Kharif and Rabi, because climate conditions for ideal crop productivity and thus farm expenditures and management practices differ by farming season. Based on the farmers' responses on the perception of changes in temperature and precipitation and their choices to migrate due to crop sensitivity, four cognitive conditions of the farmers' decision were considered:

(1) perceive changes in climate and migrate;
(2) perceive changes in climate but do not migrate;
(3) do not perceive changes in climate and therefore do not migrate; and
(4) do not perceive changes in climate yet choose to migrate.

Table I presents the farmers' decisions to migrate as driven by their perceptions of climate change/variability. Of the 700 farm households surveyed, based on the sensitivity of planted crops to temperature changes, approximately 62 and 38 per cent opted to migrate and not migrate, respectively, in Kharif; in Rabi, approximately 64 per cent opted to migrate and 36 per cent chose not to migrate. Furthermore, based on the sensitivity of planted crops to changes in rainfall conditions, 60 and 40 per cent opted to migrate or not migrate, respectively, in Kharif; in Rabi, approximately 67 per cent opted to migrate, and 33 per cent chose not to migrate. In both seasons, the percentage of respondents opting to migrate due to perceived changes was much higher than the percentage choosing to migrate despite not perceiving climate change. However, a high percentage (30-35 per cent) of respondent perceived climate change but did not migrate. The characteristics of the farm households can explain these differences in choice.

The majority of the surveyed farmers considered migration a profitable coping strategy. Perceiving climate change and migration was the dominant cognitive condition for both Kharif and Rabi in the study area. This condition is mainly driven by the rural risk factors associated with climate changes/variations in the home region. The decision to migrate is part of a household coping strategy rather than an individual decision. Farmers under the second cognitive condition, i.e. migrating despite not perceiving climate change, mainly aim to diversify and maximize their income sources. A few farmers chose not to migrate despite perceiving climate changes (the third cognitive condition), mainly because of uncertainties in the host region (e.g. guarantee of employment, costs associated with migration) and unfavourable socioeconomic conditions in the home region (e.g. household size, education, land size). The fourth cognitive condition implies that farmers are not aware of any changes in climate conditions and are either satisfied with their economic conditions in the home region, do not find migration a profitable option or lack the skill and knowledge to migrate.

5.2 Role of socioeconomic characteristics in migration as an adaptation

An understanding of the socioeconomic characteristics of farmers is important to recognize the main factors driving migration. The migration decisions of farmers are family strategies that are mainly undertaken to overcome the risk of loss of income and of social deprivation and ensure consumption smoothening. To assess the role of socioeconomic conditions in farmer migration as an adaptation, a binary logistic regression model was used with the migration decision of farmers ("1" for migration and "0" for non-migration) as a single categorical predictor. Socioeconomic variables such as age and education level of the farm household head; proportion of males in the household to total household size; proportions of other family members, i.e. proportion of females and children younger than 10 years of age;

Table I. Perceptions of climate change/variability as drivers of farmers' decisions to migrate

	Kharif season		Rabi season	
Conditions	Temperature	Precipitation	Temperature	Precipitation
Migrated total	62	60	64	67
Not migrated total	38	40	36	33
Perceive and migrated	57	52	59	58
Did not perceive but migrated	5	8	5	9
Perceive and not migrated	34	34	33	29
Did not perceive and not migrated	3	6	3	4

Notes: The numbers are in percentages and they may not add up to 100 due to rounding off
Source: Own calculation

size of land; land ownership pattern (own farm land or rent); and livestock were considered as independent variables.

As shown in Table II, age and education of the farm household head, male proportion, proportion of other family members, farm size and land ownership were significant factors in Rabi. The results for Kharif were similar, except farm size. Age of the farm household head was positively significant for both seasons. Farmer age is a measure of farm experience, which determines a farmer's perception, willingness to adapt and adaptation decisions. Older farmers feel a greater sense of responsibility for ensuring sustained livelihood sources for their families and therefore either migrate themselves or encourage other household members to migrate, not only to reduce dependency but also to ensure remittances to the home region. As noted earlier, the dependence on domestic remittances has increased in Bihar since the 1990s (Tumbe, 2011). Education level positively affected the migration of farmers or household heads by increasing their capability to acquire and synthesize information on climate conditions and respond; farmers with more education are also more aware about available opportunities in the host region. Furthermore, the intra-household spill-over effect of education encourages other household members to move out of the home region as well. In the study area, a higher proportion of males in the household positively influenced the intent to migrate, as more male members ensure more earning hands and more efficient exploitation of social networks in the host region. The proportion of women and children younger than 10 years of age signifies dependency; therefore, a higher proportion positively influenced migration decisions because of the need for income to meet higher consumption requirements. Land ownership pattern was negatively significant for both seasons, implying that farmers who do not possess their own land are more likely to migrate as a result of lower net income (net agricultural income after paying land rent) that is insufficient to meet consumption requirements and other household expenditures in the home region. Farm size was negatively significant in Rabi. The larger the land size, the greater the requirement for family labour for farm management; consequently, farm households may not intend to migrate. However, farm size was not significant for Kharif.

5.3 Role of migration in extension services

The present scenario of climate change and its related risks demands regular access to new knowledge through adequate and well-timed extension services. Agricultural extension services and credit facility are the two institutional arrangements that most enable adaptation. Agricultural extension facilitates the delivery of information on seasonal climate variations and new technologies to help farmers perceive climate changes quickly and modify their agronomic practices accordingly. Migration is a major source of awareness via

Variables	Migration in Rabi season	Migration in Kharif season
Age (Head of the HH)	0.0493628 (4.00)**	0.079568 (5.73)**
Education (Head of the HH)	0.1590579 (5.09)**	0.1506099 (4.45)**
Farm size	−0.678732 (−2.07)*	0.0442645 (1.39)
Ownership patterns	−0.678732 (−2.62)*	−0.7613176 (−2.72)*
Male proportion to HH size	5.847889 (5.20)**	7.232698 (5.85)**
Other proportion to HH size	1.202599 (8.54)**	1.759723 (10.30)**
Livestock	−0.016438 (−0.20)	0.009304 (0.11)

Notes: * $p < 0.05$; ** $p < 0.01$
Source: Own calculation

Table II. Results of binary logistic regression model income and knowledge transfer from the host region to the home region for efficient utilization of extension services. Through social networks, returning migrants help local communities advance the use of technology in agricultural activity and increase awareness of institutional arrangements that can enhance agricultural returns.

In the study area, farmers obtain climate-related information such as expected seasonal rainfall and temperature levels, timing of monsoon onset and predicted climate extremes such as flood and drought from climate extension sources. Agricultural extension services provide information on farm mechanization, new crop varieties, drought-tolerant crop varieties, availability of quality seeds, plant protection, soil health and market information. Climate extension sources include information from the meteorological department, local government sources, mobile (e.g. internet, telephone help lines), radio and television. Agricultural extension sources are identified as information from field officers, television, mobile, radio and television. Differences in the adoption of agriculture extension sources between migrating and non-migrating farm households during the different cropping seasons were assessed (Figures 1 and 2).

Migrating farm households made greater use of both climate and agricultural extension services than non-migrating households in both seasons (Figures 1 and 2). Among migrating farmers, 70-77 per cent still used radio, which is the oldest source of

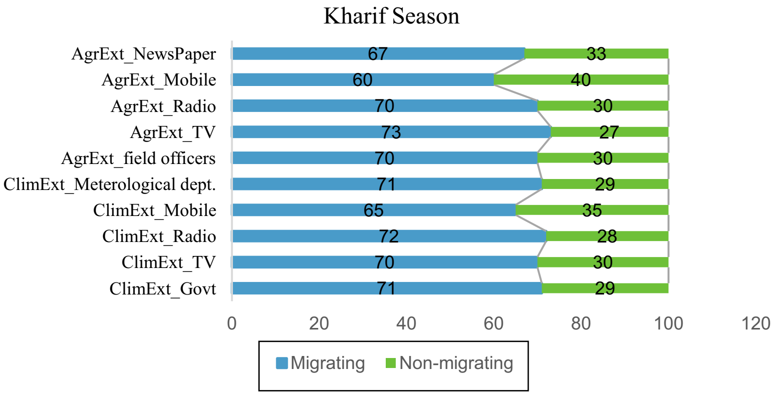

Figure 1.
Choice of extension services by migrating and non-migrating households in Kharif

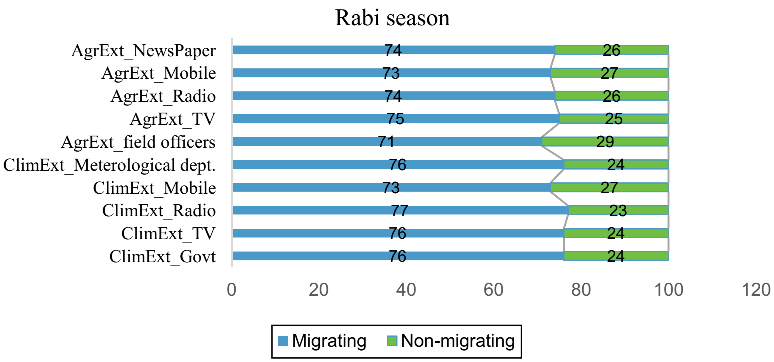

Figure 2.
Choice of extension services by migrating and non-migrating farm households in Rabi

information on climate and agriculture; approximately 60-73 per cent used mobile; and 67-74 per cent used newspapers. Furthermore, approximately 71-76 per cent of migrating farmers found climate information provided by the meteorological department and field officers useful. Migrating households are better informed about the use of sources such as mobile and television in agricultural management based on experiences gained from their social networks and experiences in the host region (Scheffran *et al.*, 2012). The utilization of other extension sources, such as newspapers, depends upon the education level of the farmers. Because mobile is a knowledge-based technology, migrating farmers are more efficient in utilizing these resources for agricultural management. Also, remittances from the host region improve economic well-being, which enables the purchase and utilization of televisions, mobile phones, newspapers, computers and radios in the home region. The non-migrating farmer's need for information can also be met by sharing information, knowledge, technology and skills in the migrating communities, thus improving "social learning" and the adaptive capacity of the home region.

5.4 Migration as an adaptation strategy or source of adaptation strategy

This section examines how migration enhances a farmer's adaptive capacity and enables the adoption of other adaptation strategies. In all, 11 different adaptation strategies (including migration) were identified as the most suitable farm management practice, farm technology and farm financial management alternatives: planting different crop varieties, changing land under cultivation, increasing/decreasing irrigation, adopting soil conservation techniques, adopting water conservation techniques, crop insurance, migration, switching from farm to non-farm activities, leasing land, planting horticulture and planting vegetables. Farmers expressed their choices of adaptation strategies in accordance with their perceptions of changes/variations in temperature and rainfall and their own farming practices separately for Kharif and Rabi. Although these strategies may be profit-driven instead of climate-driven, their choices of strategies were assumed to be driven by climatic factors as reported by farmers themselves (Maddison, 2006; Nhemachena and Hassan, 2007).

To examine the farmers' choices of adaptation strategies, the adaptation level was developed based on the number of adaptation strategies adopted (Bhatta *et al.*, 2016). The number of adaptation strategies reported by the farmers ranged from a minimum of 0 (no adaptation considered) to 11 (maximum number of adaptation strategies used by any farmer). The average number of adaptation strategies adopted by farmers in Kharif for perceived changes in temperature and rainfall was approximately four for both. In Rabi, the average was approximately five for both perceived changes in temperature and rainfall. Based on these averages, four adaptation scores were identified: no adaptation (0), low adaptation level (1-3 adaptation strategies), medium adaptation level (4-6 adaptation strategies) and high adaptation level (7-11 adaptation strategies). The farmers reported their choices of adaptation strategies separately for perceptions of temperature and rainfall and for Rabi and Kharif. Therefore, the choices of adaptation strategies were not mutually exclusive as farmers could decide to make several changes at the farm level simultaneously (e.g. farmers may change crop varieties, irrigation and insurance simultaneously due to flood risks or shortage of rainfall in Kharif).

Adaptive capacity is the property of a system to adjust its characteristics or behaviour to expand its coping range under existing climate variability or future climate conditions (Brooks and Adger, 2005). Accordingly, this study assumes that farmers with a higher adaptation level (coping range) have higher adaptive capacity. Adaptive capacity also demonstrates individual capacity to moderate the impacts of climate change at the farm level as finely determined by the skill, education and personal ability of the farmer (Tarleton and Ramsey, 2008). Table III presents the results for the importance of migration in enhancing a farmer's adaptation level (adaptive capacity) by cropping season in the study area. Among the 700 farmers surveyed, 138 (20 per cent) and 136 (19 per cent) did not adapt to changes in temperature and rainfall, respectively, in Kharif; in Rabi, 74 (11 per cent) farmers did not adapt to changes in both.

Among the surveyed households, 60-62 per cent and 64-67 per cent adapted migration as an adaptation strategy in Kharif and Rabi, respectively. More farm households chose to migrate in Rabi than in Kharif, which is more labour-intensive and requires numerous farming activities. Due to the lack of adequate work for all members of the household in Rabi, some chose to migrate. According to Viswanathan and Kumar (2015), out-migration from one state to another in India is more sensitive to changes in rice yield (a Kharif crop) than wheat yield (a Rabi crop). This discrepancy with the results of the present study is mainly attributable to differences in scale and the type of data used to assess migration. Viswanathan and Kumar (2015) focused on state-level migration in India using actual weather, crop yield and per-capita net state domestic product. By contrast, the present study is a micro-level evaluation of migration as an adaptation strategy and mainly uses uncertain and unpredictable behavioural attributes of farmers. In Kharif, for changes in temperature and rainfall, 204 (29 per cent) respondents had a low level of adaptation, 279 (40 per cent) farmers had a medium adaptation level, and only 81 (12 per cent) had a high level of adaptation. Similarly, for Rabi, for changes in temperature, 171 (24 per cent) respondents had a low level of adaptation, 306 (44 per cent) had a medium adaptation level, and only 149 (21 per cent) had a high level of adaptation; for rainfall changes, 174 (25 per cent) had a low level of adaptation level, 305 (44 per cent) had a medium adaptation level, and only 147 (21 per cent) had a high level of adaptation. Thus, in the study area, a medium level of adaptation was most prevalent, and farmers mostly adopted four to six different adaptation strategies in a season in response to changes in temperature or rainfall.

In Kharif, among the 700 surveyed farmers, 437 (62 per cent) and 418 (60 per cent) opted for migration due to changes in temperature and rainfall, respectively. In Rabi, 450 (64 per cent) farmers and 471 (67 per cent) farmers chose to migrate due to changes in temperature and precipitation, respectively. The importance of migration in enhancing a farmer's adaptation level (adaptive capacity) by cropping season in the study area was examined by evaluating the proportion of migrating farmers to total adapting households at each level of

Table III. Importance of migration in enhancing a farmer's adaptation level (adaptive capacity) by cropping season in the study area

Household (HH) adaptation (in terms of no. of adaptation strategies)	Adaptation level No (0)	Low (1-3)	Medium (4-6)	High (7-11)	Total
Kharif season					
Total No. HH (Temp)	138 (20)	171 (24)	300 (43)	91 (13)	700 (100)
Migrating HH (Temp)	0	116 (57)	248 (89)	73 (90)	437 (62)
Total No. of HH (Rain)	136 (19)	204 (29)	279 (40)	81 (12)	700 (100)
Migrating HH (Rain)	0	116 (57)	238 (85)	64 (79)	418 (60)
Rabi season					
Total No. HH (Temp)	74 (11)	171 (24)	306 (44)	149 (21)	700 (100)
Migrating HH (Temp)	0	78 (46)	240 (78)	132 (89)	450 (64)
Total No. of HH (Rain)	74 (11)	174 (25)	305 (44)	147 (21)	700 (100)
Migrating HH (Rain)	0	88 (51)	253 (83)	130 (88)	471 (67)

Source: Author's own calculation, Figures in parenthesis are shows percentages of total adaptation. In Kharif, approximately 79-90 per cent of farm households with a high level of adaptation and approximately 85-89 per cent of farm households with a medium adaptation level were migrating households. Similarly, in Rabi, approximately 89 per cent of farmers with a high adaptation level and 78-83 per cent of farmers with a medium adaptation level were migrating households. These results indicate that migrating households have a higher adaptation capacity as they are able to adopt more adaptation strategies due to support from host regions in the form of remittances, knowledge, resources and networks.

5.5 Adaptation strategies adopted by migrating farm households by season in the study area

To assess the importance of migration in the adoption of other available adaptation strategies in the study area, the adaptation strategies adopted by migrating and non-migrating farm households were analysed separately for observed changes in temperature and rainfall and for Kharif and Rabi (Figure 3).

For both Kharif and Rabi, the responses for changes in temperature and rainfall were similar: migrating households reported choosing more adaptation strategies than non-

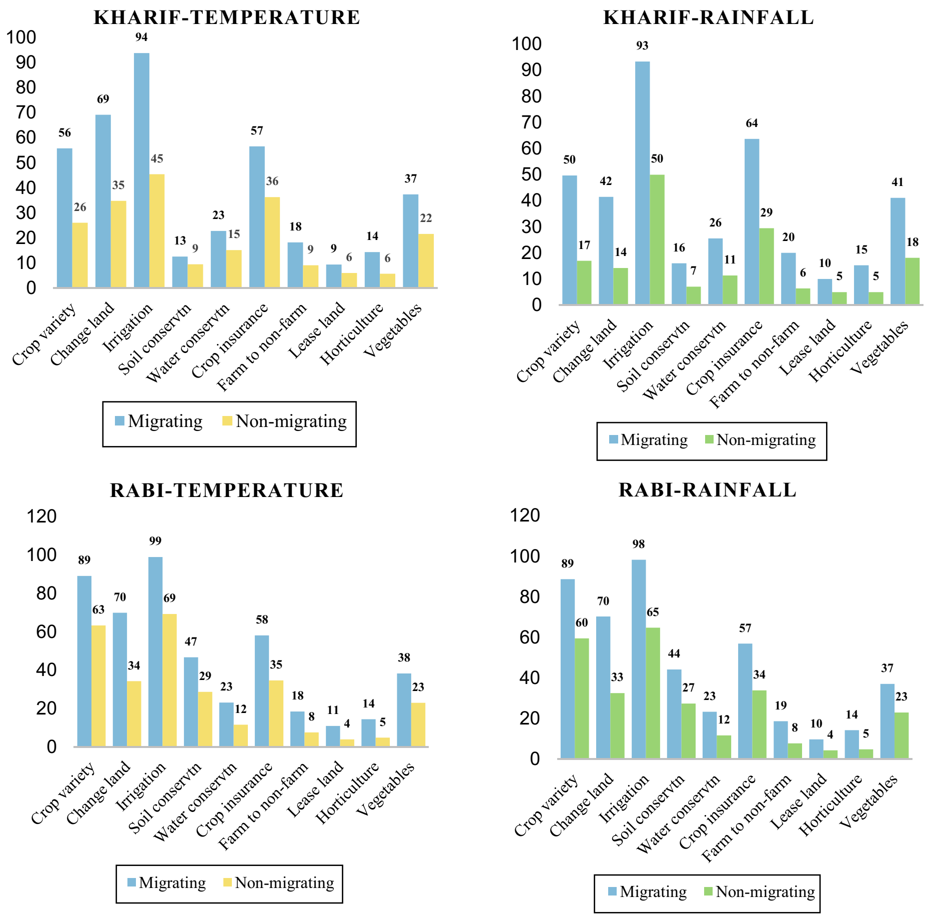

Figure 3.
Adaptation strategies of migrant and non-migrant households in Kharif and Rabi

migrating households. In Kharif, for temperature and precipitation, 94 per cent of migrating farm households chose irrigation, 42-69 per cent opted to change land under cultivation, 50-56 per cent changed crop variety, 57-64 per cent opted for crop insurance, 23-26 per cent chose water conservation, 13-16 per cent chose soil conservation and 37-41 per cent planted vegetables. Similarly, in Rabi, 99 per cent chose irrigation, 70 per cent opted to change land under cultivation, 89 per cent changed crop variety, 58 per cent opted for crop insurance, 23 per cent chose water conservation, 44-47 per cent chose soil conservation and approximately 38 per cent planted vegetables. Compared with migrant farm households, the proportion of non-migrating farmers that chose these strategies was remarkably low.

For instance, in Kharif, only 45-50 per cent of non-migrating farmers chose irrigation, 29-36 per cent chose insurance and 7-9 per cent opted for soil conservation. Similar responses were recorded for Rabi; only 65-69 per cent chose irrigation, approximately 34 per cent chose to change land under cultivation, and 12 per cent opted for water conservation. The most common adaptation strategies chosen by migrating and non-migrating farm households for all four scenarios were changing crop variety, changing land under cultivation, irrigation, crop insurance, soil and water conservation and planting vegetables. These adaptation strategies are knowledge-, capital- and resource-intensive in nature, and therefore migrating farm households has a comparative advantage over non-migrating farm households. Migrating farm households benefitted from the remittances and knowledge they gained from the host region. Migrant farmers gained knowledge about crop varieties, new methods of irrigation and soil and water conservation techniques from the migrant network in the host region. Migrating farmers were more informed about new government initiatives for crop insurance schemes and new credit facilities and thus were able to utilize these facilities. In addition, remittances from the host region helped migrating farmers buy seeds for new crop varieties and adopt advanced farm mechanization techniques. The results indicate that remittances, knowledge and social networks from the host region directly enhance the economic conditions of migrating households and, to some extent, non-migrating households, further enhancing their ability to adapt in the home region. Thus, at the micro-level, farmer migration can be beneficial for improving adaptation, resilience and livelihood sustainability in the home region.

6. Conclusions

Climate-induced migration has typically been considered a livelihood or survival strategy under adverse and extreme climate conditions. Although farmers clearly often resort to migration either to diversify income sources or smooth consumption, migration has a much wider role to play as an adaptation strategy. The present study evaluated the influence of climate change perception on farmer migration. In addition, the contribution of migration in enhancing the adaptive capacity of farmers by scaling up their financial capabilities and knowledge of modern agricultural technology was analysed. Furthermore, the influence of migration on accessing climate and agricultural extension services was explored, and differences in adaptation strategies for the two different seasons of Kharif and Rabi were characterized to identify improved cultivation practices that are more tolerant towards climate change. This study finds that climate-induced livelihood risk is the major driver of farmer migration for both seasons. Migration is also related to economic incentives in the form of increased employment opportunities and to the value of the crop at home. For example, in Kharif, farm households choose to migrate less due to the cultivation of high-value crops and labour intensive such as rice that require more labour for farm management. By contrast, due to a lack of adequate work in Rabi, some family members may opt to migrate. With respect to socioeconomic conditions, the age of the head of household, proportion of male members in the household and the dependency ratio enhance the sense of responsibility towards sustaining household livelihood sources and therefore positively influence farmer migration. Educated farmers are more inclined to migrate as they are acquainted with benefits and opportunities available elsewhere. Furthermore, land size has a negative influence on farmer migration. Ownership is also an important factor in migration. A large farm size and ownership of the land increase agricultural income, which can aid consumption smoothening and other needs. By comparison, marginal and small-holding farmers and farmers operating on rented land have a higher sense of insecurity and therefore higher pressure to migrate.

Compared with non-migrating households, migrating farm households admit better utilization of instruction-, knowledge- and technology-based climate and agriculture extension services such as information from meteorological divisions, agricultural field officers, mobile, newspapers and television. Migrating farm households mostly have a higher adaptation level and are more capable of adopting knowledge-, capital- and resource-intensive adaptation strategies due to the receipt of remittances from migrating household members. Non-migrating households receive positive externalities due to spillover. Overall, the analysis indicates that migrating households have a comparative advantage over non-migrating households in terms of adaptive capacity. To further understand migration as an adaptation strategy, net revenue differences between migrating and non-migrating households should be explored.

In terms of policy perspectives, the focus should be on developing the nexus between risk reduction, development and capacity building in rural areas. The government should strive towards creating non-climate-sensitive livelihood options to diversify farm household income and enhance adaptive capacity. In addition, capacity building and training on knowledge-intensive adaptation strategies are needed in rural areas. Policies must be developed that nurture and strengthen social networks through community participation to enhance group-based adaptation approaches.

Notes

1. A marginal product of labour (MP_L) equal to zero indicates that the last added unit of labour has zero productivity and that the marginal product is not equal to a subsistence level of wages. Lewis defined this level as "disguised unemployment".
2. A marginal product of labour (MP_L) greater than zero indicates that the last added unit of labour has positive productivity and that the marginal product is at least greater than the subsistence level of wages.
3. The cropping season in Bihar is classified into two main seasons based on weather attributes: Kharif and Rabi. The Kharif cropping season is from July to October during the southwest monsoon, and the Rabi cropping season is from October to March (winter). The crops grown between March and June are summer crops.
4. CMM (t) = 100 × [Population in 20-29 age cohort in Census(t) – Population in 10-19 age cohort in Census(t-10) – Cohort Mortality]/[Population in 10-19 age cohort in Census(t-10), Cohort mortality 10 x Age-specific (10-19) mortality rate per year × Population in 10-19 age cohort in Census(t-10)]. Data Source: Population data from the 1991, 2001 and 2011 Census and age-specific mortality data (State level) for the 10-19 age group for the years 1996 and 2006 from Sample Registration System statistics.
5. Changing crop varieties (planting different crops, drought-resistant varieties, high-yield verities, water sensitive crops, short duration varieties); changing land under cultivation (land rotation or altering the area under cultivation); increasing irrigation (increase/decrease the intensity of

irrigation to overcome shortage or excess of rainfall. Using tube well, water pump, etc.); adopting soil conservation strategies (for maintaining soil fertility-like zero-tilling, etc.); adopting water conservation strategies (rain water harvesting, building tanks or water reservoirs); crop insurance (insure crops to overcome crop losses due to climatic disturbances); migration (migrating to urban area to diversify their livelihood options); switching from farm to non-farm activities (changing land from farm to non-farm activities mainly in non-climate sensitive activities); leasing land for other purposes (leasing land for other non-farm activities; planting horticulture crops along with major crops (planting fruits like- mango, litchi, banana, guava etc. and nuts, seeds, herbs, sprouts, mushrooms, flowers, seaweeds and non-food crops such as grass and ornamental trees and plants); planting vegetables (Planting vegetables like potato, brinjal/eggplant, cauliflower, cabbage, tomatoes, chili, etc.)

6. Considering the high rate of temporary and seasonal migration in Bihar (Keshri and Bhagat, 2013), migration was considered as an option in both Rabi and Kharif separately. In this sense, work, business, and education are broadly considered as reasons for migration. Marriage and place of birth are not considered as reasons for migration because these reasons are based on social considerations (Viswanathan and Kumar, 2015).

References

Adamo, S.B. (2010), "Environmental migration and cities in the context of global environmental change", *Current Opinion in Environmental Sustainability*, Vol. 2 No. 3, pp. 161-165.

Adger, W.N., Arnell, N.W., Black, R., Dercon, S., Geddes, A. and Thomas, D.S. (2015), "Focus on environmental risks and migration: causes and consequences", *Environmental Research Letters*, Vol. 10 No. 6, p. 060201.

Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D.R., Naess, L.O., Wolf, J. and Wreford, A. (2009), "Are there social limits to adaptation to climate change?", *Climatic Change*, Vol. 93 No. 3, pp. 335-354.

Adger, W.N., Kelly, P.M., Winkels, A., Huy, L.Q. and Locke, C. (2002), "Migration, remittances, livelihood trajectories, and social resilience", *AMBIO: A Journal of the Human Environment*, Vol. 31 No. 4, pp. 358-366.

Afifi, T. (2011), "Economic or environmental migration? The push factors in Niger", *International Migration*, Vol. 49 No. s1, pp. e95-e124.

Ahmed, A.U., Hassan, S.R., Etzold, B. and Neelormi, S. (2012), *Where the Rain Falls, Case Study: Bangladesh*, United Nations University and Institute for Environment and Human Security (UNU-EHS), Bonn.

BAMETI (2017), *Agricultural Profile of the State*, BAMETI, Bihar.

Banerjee, S., Gerlitz, J.I. and Hoermann, B. (2011), "Labour migration as a response strategy to water hazards in the Hindu Kush-Himalayas. Kathmandu, Nepal", *ICIMOD*.

Barnett, J. and Webber, M. (2009), "Accommodating migration to promote adaptation to climate change", *The Commission on Climate Change and Development*, available at: www.ccdcommission.org (accessed on 5).

Below, T., Artner, A., Siebert, R. and Sieber, S. (2010), "Micro-level practices to adapt to climate change for African small-scale farmers", A Review of Selected Literature, Environ. Prod. Technol. Division, p. 953.

Bhatta, G.D. and Aggarwal, P.K. (2016), "Coping with weather adversity and adaptation to climatic variability: a cross-country study of smallholder farmers in South Asia", *Climate and Development*, Vol. 8 No. 2, pp. 145-157.

Bhatta, G.D., Aggarwal, P.K., Kristjanson, P. and Shrivastava, A.K. (2016), "Climatic and non-climatic factors influencing changing agricultural practices across different rainfall regimes in South Asia", *Current Science*, Vol. 110 No. 7, p. 1272.

Bhatta, G.D., Aggarwal, P.K., Poudel, S. and Belgrave, D.A. (2015a), "Climate-induced migration in South Asia: migration decisions and the gender dimensions of adverse climatic events", *Journal of Rural and Community Development*, Vol. 10 No. 4.

Bhatta, G.D., Aggarwal, P.K., Shrivastava, A.K. and Sproule, L. (2015b), "Is rainfall gradient a factor of livelihood diversification? Empirical evidence from around climatic hotspots in Indo-Gangetic plains", *Environment, Development and Sustainability*, Vol. 18 No. 6, pp. 1657-1678.

Boyd, R. and Ibarrarán, M.E. (2009), "Extreme climate events and adaptation: an exploratory analysis of drought in Mexico", *Environment and Development Economics*, Vol. 14 No. 3, pp. 371-395.

Brooks, N. and Adger, W.N. (2005), "Assessing and enhancing adaptive capacity", Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures, pp. 165-181.

Bryan, E., Deressa, T.T., Gbetibouo, G.A. and Ringler, C. (2009), "Adaptation to climate change in Ethiopia and South Africa: options and constraints", *Environmental Science & Policy*, Vol. 12 No. 4, pp. 413-426.

Census of India (2011), *Government of India*, New Delhi.

Climate of Bihar (2009), *Indian Metrological Department*, Pune.

Conisbee, M. and Simms, A. (2003), *Environmental Refugees: The Case for Recognition*, New Economics Foundation, London, pp. 17-18.

Conway, D. and Cohen, J.H. (1998), "Consequences of migration and remittances for Mexican transnational communities", *Economic Geography*, Vol. 74 No. 1, pp. 26-44.

Cunguara, B., Langyintuo, A. and Darnhofer, I. (2011), "The role of nonfarm income in coping with the effects of drought in southern Mozambique", *Agricultural Economics*, Vol. 42 No. 6, pp. 701-713.

Curtis, K.J. and Schneider, A. (2011), "Understanding the demographic implications of climate change: estimates of localized population predictions under future scenarios of sea-level rise", *Population and Environment*, Vol. 33 No. 1, pp. 28-54.

De Haan, A., Brock, K. and Coulibaly, N. (2002), "Migration, livelihoods and institutions: contrasting patterns of migration in Mali", *Journal of Development Studies*, Vol. 38 No. 5, pp. 37-58.

De Haas, H. (2010), "Migration and development: a theoretical perspective1", *The International Migration Review*, Vol. 44 No. 1, pp. 227-264.

Deshingkar, P. and Akter, S. (2009), *Migration and Human Development in India*, Research Paper 2009/13, Human Development Reports, UNDP.

Deshingkar, P. and Start, D. (2003), *Seasonal Migration for Livelihoods in India: Coping, Accumulation and Exclusion*, Overseas Development Institute, London.

Etzold, B., Ahmed, A.U., Hassan, S.R. and 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*, Vol. 6 No. 1, pp. 18-27.

Fei, J.C.H. and Ranis, G. (1964), *Development of the Labor: Surplus Economy*, ed., Irwin.

Gbetibouo, G.A. (2009), "Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo basin, South Africa", *International Food Policy Research Institute*, Vol. 849.

Gray, C. and Bilsborrow, R. (2013), "Environmental influences on human migration in rural Ecuador", *Demography*, Vol. 50 No. 4, pp. 1217-1241.

Gray, C. and Mueller, V. (2012), "Drought and population mobility in rural Ethiopia", *World Development*, Vol. 40 No. 1, pp. 134-145.

Grothmann, T. and Patt, A. (2005), "Adaptive capacity and human cognition: the process of individual adaptation to climate change", *Global Environmental Change*, Vol. 15 No. 3, pp. 199-213.

Hansen, J.W., Marx, S.M. and Weber, E.U. (2004), "The role of climate perceptions, expectations, and forecasts in farmer decision making: the argentine pampas and South Florida", *Final Report of an IRI Seed Grant Project*.

Harris, J.R. and Todaro, M.P. (1970), "Migration, unemployment and development: a two-sector analysis", *The American Economic Review*, Vol. 60 No. 1, pp. 126-142.

Hassan, R. and Nhemachena, C. (2008), "Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis", *African Journal of Agricultural and Resource Economics*, Vol. 2 No. 1, pp. 83-104.

Henry, S., Schoumaker, B. and Beauchemin, C. (2004), "The impact of rainfall on the first out-migration: a multi-level event-history analysis in Burkina Faso", *Population and Environment*, Vol. 25 No. 5, pp. 423-460.

Hunter, L.M., Murray, S. and Riosmena, F. (2013), "Rainfall patterns and US migration from rural Mexico", *International Migration Review*, Vol. 47 No. 4, pp. 874-909.

Huntley, B. (1999), "Climatic change and reconstruction", *Journal of Quaternary Science*, Vol. 14 No. 6, pp. 513-520.

Kates, R.W. (2000), "Cautionary tales: adaptation and the global poor", *Societal Adaptation to Climate Variability and Change*, Springer, Netherlands, pp. 5-17.

Keshri, K. and Bhagat, R.B. (2013), "Socioeconomic determinants of temporary labour migration in India: a regional analysis", *Asian Population Studies*, Vol. 9 No. 2, pp. 175-195.

Klaiber, H.A. (2014), "Migration and household adaptation to climate: a review of empirical research", *Energy Economics*, Vol. 46, pp. 539-547.

Kohli, H.S., Sharma, A. and Sood, A. (Eds) (2011), *Asia 2050: Realizing the Asian Century*, SAGE Publications India.

Kumar, K.K. and Viswanathan, B. (2012), *Weather Variability and Agriculture: Implications for Long and Short-Term Migration in India*, Centre for Development Economics Department of Economics, Delhi School of Economics.

Laczko, F. and Aghazarm, C. (Eds) (2009), *Migration, Environment and Climate Change: Assessing the Evidence*, International Organization for Migration, Geneva, pp. 7-40.

Livingstone, D.N. (2000), "Environmental determination", in Johnston, R.J., Gregory, D., Pratt, G. and Watts, M. (Eds), *The Dictionary of Human Geography*, 4th ed., Blackwell, Oxford, pp. 212-215.

Lucas, R.E. (1997), "Internal migration in developing countries", *Handbook of Population and Family Economics*, Vol. 1, pp. 721-798.

Lybbert, T.J. and Sumner, D.A. (2012), "Agricultural technologies for climate change in developing countries: policy options for innovation and technology diffusion", *Food Policy*, Vol. 37 No. 1, pp. 114-123.

Maddison, D. (2006), "The perception of and adaptation to climate change in Africa", *CEEPA. Discussion Paper No. 10*, Centre for Environmental Economics and Policy in Africa. University of Pretoria, Pretoria.

Marin, A. (2010), "Riders under storms: contributions of nomadic herders' observations to analysing climate change in Mongolia", *Global Environmental Change*, Vol. 20 No. 1, pp. 162-176.

Marx, S.M., Weber, E.U., Orlove, B.S., Leiserowitz, A., Krantz, D.H., Roncoli, C. and Phillips, J. (2007), "Communication and mental processes: experiential and analytic processing of uncertain climate information", *Global Environmental Change*, Vol. 17 No. 1, pp. 47-58.

Massey, D.S., Arango, J., Hugo, G., Kouaouci, A., Pellegrino, A. and Taylor, J.E. (1993), "Theories of international migration: a review and appraisal", *Population and Development Review*, Vol. 19 No. 3, pp. 431-466.

McDowell, C. and Haan, A.D. (1997), "Migration and sustainable livelihoods: a critical review of the literature", Working Paper-Institute of Development Studies, University of Sussex.

McLeman, R. and Smit, B. (2006), "Migration as an adaptation to climate change", *Climatic Change*, Vol. 76 Nos 1/2, pp. 31-53.

Mincer, J. (1978), "Family migration decisions", *Journal of Political Economy*, Vol. 86 No. 5, pp. 749-773.

Mueller, V., Gray, C. and Kosec, K. (2014), "Heat stress increases long-term human migration in rural Pakistan", *Nature Climate Change*, Vol. 4 No. 3, pp. 182-185.

Nhemachena, C. and Hassan, R. (2007), "Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa", *IFPRI Discussion Paper No. 00714*, International Food Policy Research Institute, Washington, DC.

Nordas, R. and Gleditsch, N.P. (2007), "Climate change and conflict", *Political Geography*, Vol. 26 No. 6, pp. 627-638.

Patnaik, U. and Das, P.K. (2017), "Do development interventions confer adaptive capacity? Insights from rural India", *World Development (Article in Press)*, Vol. 97, pp. 298-312.

Patnaik, U. and Narayanan, K. (2015), "How effective are coping mechanisms in securing livelihoods against climatic aberrations?: Evidences from rural India", *International Journal of Climate Change Strategies and Management*, Vol. 7 No. 3, pp. 359-374.

Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., Iqbal, M.M., Lobell, D.B. and Travasso, M.I. (2014), *Chapter 7: Food Security and Food Production Systems*, Cambridge University Press.

Ravuvu, A. (1992), "Security and confidence as basic factor in pacific islander's migration", *The Journal of the Polynesian Society*, Vol. 101 No. 4, pp. 329-341.

Renaud, F.G., Bogardi, J.J., Dun, O. and Warner, K. (2007), *Control, Adapt or Flee: How to Face Environmental Migration*?, UNU-EHS.

Rivera, W.M. and Sulaiman, V.R. (2009), "Extension: object of reform, engine for innovation", *Outlook on Agriculture*, Vol. 38 No. 3, pp. 267-273.

Roncoli, C., Ingram, K. and Kirshen, P. (2002), "Reading the rains: local knowledge and rainfall forecasting in Burkina Faso", *Society &Natural Resources*, Vol. 15 No. 5, pp. 409-427.

Scheffran, J., Marmer, E. and Sow, P. (2012), "Migration as a contribution to resilience and innovation in climate adaptation: social networks and co-development in Northwest Africa", *Applied Geography*, Vol. 33, pp. 119-127.

Stal, M. (2011), "Flooding and relocation: the Zambezi river valley in Mozambique", *International Migration*, Vol. 49 No. s1, pp. e125-e145.

Stark, O. (1984), "Rural-to-urban migration in LDCs: a relative deprivation approach", *Economic Development and Cultural Change*, Vol. 32 No. 3, pp. 475-486.

Stark, O. and Bloom, D.E. (1985), "The new economics of labor migration", *The American Economic Review*, Vol. 75 No. 2, pp. 173-178.

Stark, O. and Levhari, D. (1982), "On migration and risk in LDCs", *Economic Development and Cultural Change*, Vol. 31 No. 1, pp. 191-196.

Stark, O. and Lucas, R.E. (1988), "Migration, remittances, and the family", *Economic Development and Cultural Change*, Vol. 36 No. 3, pp. 465-481.

Stern, N.H. (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University press.

Stojanov, R. (2004), "Environmental migration: how can it be estimated and predicted?", *Geographica*, Vol. 38, pp. 77-84.

Stojanov, R., Kelman, I., Ullah, A.K.M., Duží, B., Procházka, D. and Blahůtová, K.K. (2016a), "Local expert perceptions of migration as a climate change adaptation in Bangladesh", *Sustainability*, Vol. 8 No. 12, p. 1223.

Stojanov, R., Duží, B., Kelman, I., Němec, D. and Procházka, D. (2016b), "Local perceptions of climate change impacts and migration patterns in Malé, Maldives", *The Geographical Journal*, doi: 10.1111/geoj.12177.

Swanson, B.E. (2006), "Extension strategies for poverty alleviation: Lessons from china and India", *Journal of Agricultural Education and Extension*, Vol. 12 No. 4, pp. 285-299.

Tacoli, C. (2009), "Crisis or adaptation? Migration and climate change in a context of high mobility", *Environment and Urbanization*, Vol. 21 No. 2, pp. 513-525.

Tarleton, M. and Ramsey, D. (2008), "Farm-level adaptation to multiple risks: climate change and other concerns", *Journal of Rural and Community Development*, Vol. 3 No. 2.

Taylor, E.J. (1999), "The new economics of labour migration and the role of remittances in the migration process", *International Migration (Geneva, Switzerland)*, Vol. 37 No. 1, pp. 63-88.

The Economic Survey of India (2016-17), *Ministry of Finance*, Government of India.

Tripathi, A. (2017), "Socioeconomic backwardness and vulnerability to climate change: evidence from Uttar Pradesh state in India", *Journal of Environmental Planning and Management*, Vol. 60 No. 2, pp. 328-350.

Tschakert, P. and Tutu, R. (2010), "Solastalgia: environmentally induced distress and migration among Africa's poor due to climate change", *Environment, Forced Migration and Social Vulnerability*, Springer Berlin Heidelberg, pp. 57-69.

Tumbe, C. (2011), "Remittances in India: facts & issues", *Indian Journal of Labour Economics*, Vol. 54 No. 3, pp. 479-501.

Tyson, P.D., Lee-Thorp, J., Holmgren, K. and Thackeray, J.F. (2002), "Changing gradients of climate change in southern Africa during the past millennium: implications for population movements", *Climatic Change*, Vol. 52 No. 1, pp. 129-135.

Upadhyay, H., Kelman, I., Lingaraj, G.J., Mishra, A., Shreve, C. and Stojanov, R. (2015), "Conceptualizing and contextualizing research and policy for links between climate change and migration", *International Journal of Climate Change Strategies and Management*, Vol. 7 No. 3, pp. 394-417.

Viswanathan, B. and Kumar, K.K. (2015), "Weather, agriculture and rural migration: evidence from state and district level migration in India", *Environment and Development Economics*, Vol. 20 No. 4, pp. 469-492.

Warner, K. (2010), "Global environmental change and migration: governance challenges", *Global Environmental Change*, Vol. 20 No. 3, pp. 402-413.

Warner, K. and Afifi, T. (2014), "Where the rain falls: evidence from 8 countries on how vulnerable households use migration to manage the risk of rainfall variability and food insecurity", *Climate and Development*, Vol. 6 No. 1, pp. 1-17.

West, C.T., Roncoli, C. and Ouattar, F. (2008), "Local perceptions and regional climate trends on central plateau of Burkina Faso", *Land Degradation & Development*, Vol. 19 No. 3, pp. 289-304.

West, C.T., Vásquez-Léon, M. and Finan, T.J. (2003), 12.3 Testing Farmers' perceptions of Climate Variability: A Case Study From The Sulphur Springs Valley, AZ.

Woodruff, C. and Zenteno, R. (2007), "Migration networks and microenterprises in Mexico", *Journal of Development Economics*, Vol. 82 No. 2, pp. 509-528.

Yi, S., Chengjin, X., Hailing, Z. and Zheng, W. (2017), "Migration in response to climate change and its impact in china", *International Journal of Climate Change Strategies and Management*, Vol. 9 No. 3.

Further reading

Bedford, R., Ho, E. and Lidgard, J. (2000), *International Migration in New Zealand: Context, Components and Policy Issues*, University of Waikato, Population Studies Centre.

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