Rao, Sandeep K. and Veena, A, (2018) Migration estimation in India : a monsoon migration model. Journal of Rural Development, 37 (1). pp. 51-70. ISSN 0970-3357 , 10.25175/jrd/2018/v37/i1/122691

Migration Estimation in India: A Monsoon Migration Model

Mr. Sandeep K. Rao, Adjunct Faculty, PES University, PES-IUP, Bengaluru

Dr. Veena A, Professor, PES University, Bengaluru

Migration Estimation in India: A Monsoon Migration Model

Abstract

Rural-Urban and Rural-Rural migration has become one of the most common phenomenon of population demographic changes. Several factors which contribute towards the improvement of the livelihood and opportunities to the migrated labourers have been studied. More than 69 per cent of the 1.21 billion people live in rural India (2011 Census) and agriculture is their main source of income. Agriculture contributes to 18 per cent to the GDP of India. Due to the lack of adequate public irrigation facilities most of these farmers are dependent heavily on monsoon as the main source of water for agriculture. Since a large percentage of these farmers are into subsistence farming, they lack the capital required to set up their own irrigation facilities. When the monsoon fails, or when there is excess rain, there is loss of crop and hence rural-to-urban migration results.

There are many factors influencing rural to rural and rural to urban migration. One such important factor is agricultural distress. Agriculture being predominantly dependent on monsoon in India, there is an immediate need in accessing the relationship among agriculture, migration and rainfall. This paper analyses the role of quantum of rainfall in determining the rate of migration with empirical evidence from India and proposes a model to estimate the migration rate based on the quantum of rainfall.

Keywords: Migration, Push-Pull factor, Rainfall, Agricultural yield and income.

Introduction

Migration involves movement from one area to other, within or across the national administrative boundaries for a specific short term period or for the purpose of permanent change in residence. Migration can also be classified based on geographic boundaries like inter-state migration, intra-state migration, inter-country or inter-continental migration. Moving across the national boundaries occur as part of either immigration or as refugees. This has greater significance and factors influencing cross border migration are diverse like natural disasters, wars, search of new jobs and better living standards or opportunities.

In the coming decades, there can be disruptions in the human population and also the migration due to changing climatic conditions. These climate-induced movements can have influences on origin, destination and the path of migration. Rural-Urban migration spikes in India can occur due to adverse economic conditions of the cultivators as a direct consequence of rainfall shortages. (Bart, François Gemenne et.al, 2012). Large number of people are migrating due to the hostile inhabitable conditions as a result of climate change (IOM, 2009).

Climate induced International migration has been studied with reference to the impact of the sea level rise resulting in inundation of coastal regions. Arguments and questions were raised on the institutional arrangements to handle such migrations both within the domestic boundaries and across international borders (Byravan and Rajan, 2009). Studies have established the association between low rainfall and international migration (Hunter et.al., 2013). Thirty per cent urban growth in India is due to rural-urban migration (Mitra & Muryama, 2008), while two thirds of the urban growth is due to migration around the world (Gugler, 1988).

In India, nearly 20 per cent of the total internal migrants in the year 2007-08 was rural-to-urban migration (64th round of NSS Survey). The gross decadal intra state migration of male and female in Karnataka state was 11.54 percent of its total urban population. The Bangalore Urban Agglomeration was 13.4 percent, 16.4 percent in Delhi and 15.1 percent in Greater Mumbai (2001 Census). Bihar and Uttar Pradesh are the largest migrant origin states in India. Mumbai, Delhi and Kolkata are the largest migrant destination cities in India. Drought prone rural regions of Andhra Pradesh, Maharashtra, and Karnataka have seen significant seasonal migration in search of employment with better wages. 32.76 percent of total migration in Karnataka, that is around 610,032 people migrated from rural to urban areas under all categories (2011 Census).

This paper focuses on Indian migration with respect to monsoon. In India, around 30 per cent of the population migrate internally as per the Census of India, 2001, and around 28.5 per cent of the population as per the NSSO 2007–08.

Literature Review

Climate change has become a major global concern in the recent decade. Several organisations and world forums have debated on the impact of the changing climatic conditions on health, farming, drought, natural calamities and others. One of the major emerging concern is the impact of change in climate on the agricultural output. Studies have shown that there is a significant impact of change in climate on agriculture (Kumar and Parikh, 2001; Mall et.al., 2006; World Bank, 2008). The empirical evidence shows that the crop yields, especially those of cereals like wheat and rice, have a significant drop with changing climatic conditions. This has also triggered migration of people from agricultural sector. Thus there has been a lot of focus on the linkages among weather variability, migration and urban-rural wage differentials (McLeman and Smit, 2006; Perch-Nielsen et al., 2008; Bardsley and Hugo, 2010; Feng et al.,2010, Dallman and Millock, 2012; and Nawrotzki et.al., 2012). The impact of agricultural production on the rural to urban migration of farmers have also been studied (Wang, Rada et.al, 2014).

India has a large population which is dependent on the agriculture for their livelihood. Most of these agricultural lands are rain fed due to the lack of irrigation infrastructure or inadequate capital investments by farmers due to their low income status. Developing countries like India, is more sensitive to rural-urban migration during extreme climatic and weather conditions which affect the agricultural output. (McLeman and Hunter 2010). Short term migration is influenced by weather variability, through the twenty-year total rainfall deviation and mean of maximum temperature (Kavi Kumar and Brinda, 2012). There have been studies that indicate the migration under climate change occurs either in the intra-national and/or intra-regional levels (Massey et al., 2010).

Other factors which affect the migration linked to agriculture, like the income status of the farmer, has been studied. It is observed that farmers in the upper echelons of the socioeconomic spectrum show lower sensitivity to climate induced migration as they have their own businesses, capital and other assets which can provide them for longer periods. However, this is not true in case of lower income status farmers (landless labourers), whose income is solely based on the agricultural output. Adverse climate variations induce economic hardships to these farmers inducing rural to rural or rural to urban migration. The cyclical migration for short durations may continue to grow due to droughts. (Deshingkar and Start, 2003). Datt and Ravallion (1998), provide further evidence of the productivity connection to migration through the estimation of effects on yield growth on poverty, relative food prices and real wages in rural India between 1958-94. They showed that poverty reduction is possible through both higher productivity and higher real wages.

Inhabitants of rural areas who are dependent highly on agriculture or natural resources for subsistence are affected by lower rainfall and more intense weather patterns (McLeman and Hunter 2010). Climatic change patterns can be direct and results in immediate displacement due to property damage as seen with events like storms, floods, earthquakes. They can also be slower onset events like droughts which can lead to crop failure and depletion of productivity and yield. (de Sherbinin, Warner, and Ehrhart 2011; Sanchez Cohen et al. 2012). Thus the lower yield leads to lower household income. Complications can further compound where there is no adequate crop insurance to cover the crop failure (Gine, Townsend, and Vickery 2008; Hertel and Rosch 2010). More generally the families which are dependent on the natural resources face difficulties with reduction in yields due to climate variability.

Models of Migration have been part of the literature which tries to establish the several relationships among various factors influencing migration. Some important models are the Ravenstein Law of migration (Ravenstein, 1885), Lee's push pull Model (Lee, 1966), Gravity model, Alonso's General theory of movement (Vries et.al, 2000), Intervening opportunity model. Several models have been developed and proposed which provides model framework for migration linking it to environmental conditions (Perch-Nielsen et al., 2008; Black et al, 2011). In their framework Black et.al., (2011) categorized economic factors, political factors, demographic factors, social and environmental factors as the major drivers of migration. An agent based model was developed to study the internal migration in Bangladesh. This model predicts that the internal migrants over the next forty years may be in the range of three to ten million depending on the extremity of the climatic changes (Hassani-Mahmooei and Parris, 2012). Various econometric studies have established linkages of migration to weather variability through agriculture channel. (Feng et.al., 2010; Barbieri et.al., 2010; Dillon et.al., 2011; and Marchiori et.al., 2012).

Warner, K., Afifi et.al, (2012), used the Rainfalls Agent-Based Migration Model (RABMM) to access the impact on migration as a result of rainfall induced vulnerability towards food security and livelihood. Their research showed rainfall as being a significant driver of migration. Their empirical study in Tanzania revealed the contrast among the contended and vulnerable household towards migration due to future rainfall patterns. While the vulnerable families were more sensitive to mobility, the contended households were less sensitive. Their case studies and modelling results indicate that the variability of the rainfall influences the labour market and productivity. They also showed that the rainfall variability impacts the vulnerability of the households based on their income and family size.

Rationale for developing the Monsoon Migration Model

Several studies have been conducted on analysing the push and pull factors responsible for migration. These factors included job opportunities, wages, better standard of living, children welfare. The paper (Veena & Sandeep, 2017), discussed about the various push pull factors responsible for the intra state migration, identified through a survey among migrant settlements in Bengaluru. These factors included low wages in non-agricultural sector, agricultural unemployment, lack of employment opportunities among others. In that paper, drought, agricultural unemployment and low agricultural income were identified as important agrarian factors. An association among these variables was established through the Cronbach's Alpha value as 0.509. It was particularly identified that draught was one of the important factors influencing the migration decision of the farmer families.

Monsoon-Migration Model (Veena & Sandeep, 2017) proposed a linear relationship between the migration and the deficit rainfall. The model is given as below

$$\mathbf{M_{pt} = \alpha_t + \beta(R_{dt}) + u} \quad \text{---- (equation 1)}$$

R_{dt} is the rainfall deficit for t^{th} year

M_{pt} = Number of families migrated in the year "t" × Number of family members migrated

So, M_{pt} = Total Migration population in t^{th} year.

$M_{pt} = f(R_{dt}, O)$; where O is other factors.

β = Slope of the Model regressor R_{dt}

u = disturbance in the true model, which explains the deviations not caused by deficit rainfall.

The above model was designed using rainfall as a factor influencing migration among cultivators. However, other factors like yield, income of the household, agricultural employment, agricultural allied businesses activities can also have an influence in migration decisions.

Theoretical Framework: The Monsoon Migration Model

This paper is an extension of the Monsoon-Migration Model (Veena & Sandeep, 2017). The proposed model considers certain new factors along with rainfall as independent variables. It continues to allow disturbance term which represents factors that are not part of the model. The quantum of rainfall can be further categorised based on its influence on the agricultural output. Every geographic region can be classified based on the topography and the weather conditions which are ideal for the crops grown in that region. Thus different varieties of crops are grown based on the precipitation conditions in those areas. Paddy, banana, sugarcane requires higher rainfall when compared to millet, sorghum, onions, peanuts, beans that requires lower quantum of rain. Based on the geography, the major crop cultivated is dependent on how much 'Normal range' of rainfall that geographic area should have for a good yield.

The 'Normal range' of rainfall, represented by π hereon, is defined as the quantum of rain necessary per rainfall × frequency of such rainfalls, which will lead to the optimum agricultural output, ie, yield. The minimum output of production required by a farmer is that which can cover at least the variable cost of cultivation. The optimum agricultural output is the production maximising condition. Thus over the Normal range continuum a specific quantity of rain $\pi_{optimum}$

shall maximize the agricultural yield (y_{max}). In this model, it is assumed that $\pi_{optimum} = \pi$ and over the entire normal range of rainfall there will be optimum yield.

The Optimum yield, will be utility maximizing condition (U_{max}) to the cultivator. A cultivator shall continue to plough the land as long as this utility maximizing state is satiated under certain time duration condition addressed below. Under these conditions of optimum yield and U_{max} there is no migration.

The U_{max} is not just a static condition but it is required to remain at this level over a 'minimum time period', t_{min} condition. This time period is the minimum period in which the rainfall need to be in the normal range. Within a certain standard deviation σ_t around the t_{min}: the utility function slope will remain positive. The Standard deviation of time accounts for the period in which the rainfall is not normal, and the cultivator seeks other temporary employment means for subsistence.

Beyond this time range ($t_{min} \pm \sigma_t$), the utility of the cultivator will start diminishing and the utility function slope becomes negative if the rainfall continues to be in the 'Not Normal' range. Conversely this means a sub-optimal level of production. For the proposed model, the actual yield will be lesser than optimum yield, i.e., sub-optimum yield $y_{sub} < y_{max}$. Thus, as per the proposition earlier, when the yield is y_{sub} the rainfall should $\neq \pi$. This y_{sub} rainfall is called 'Not Normal range'.

The Not Normal range of rainfall can be either excess to π, i.e, π_e or can be a deficit to π, i.e, π_d which is R_{dt} in the equation (1). Both excess and deficit rainfall will result in crop loss. Thus from the above propositions, both π_e and π_d results in $y_{sub.}$ and the utility will start diminishing. Also for the new model the R_{dt} shall be redefined as the $\pi_{d.}$ Both π_e and π_d are the push factors for migration.

The income of the cultivator and the yield are related to each other (Schneider and Gugerty, 2011). The increase in agricultural production leads to the increase in farmer's income, which in turn increases the demand for goods and services of nonfarm products and services produced in the rural areas (Mellor, 1999). Higher agricultural output is also responsible for increased employment though forward and backward linkages of non-agricultural sectors of both rural and urban areas (Hanmer and Naschold 2000). This will result in reduced poverty, decelerating migration to urban areas and reducing the food prices. Empirical studies support the proposition that the poverty reduction is related to the increased agricultural productivity (Mellor, 1999).

The y_{max} occurs in the normal range of rainfall (π). This facilitates the recovery of the minimum variable cost of cultivation and profits. Higher the yield, higher is the income of the cultivator. This in-turn increases the utility and results in lower migration.

Migration Velocity M_v, is the rate at which the migration changes with respect to time. Note that the time dimension in this model is having a specific definition, and it is the period when the Utility is diminishing due to the π_e or π_d. Thus the migration velocity is the first derivative of the Monsoon Migration function with respect to time beyond the $t_{min.}$

$$M_v = \frac{d(\text{Mpt})}{dt}, \text{ where } M_V = 0 \text{ if } t = t_{min}$$

Insert here

Figure 1: Migration as a function of Rainfall

This indicates that there will be no change in migration up to t_{min}. The Quantum of rain will be 'Normal Range' during this period. In the figure (1), the normal range of rainfall is shown by N. The utility will also be U_{max} up to the t_{min}. Beyond N, the rainfall is excess (π_e). The Level Zero of the Rainfall axis indicates the minimum rainfall of the Normal Range. If the rain fall is below this, then there will be deficit rainfall (π_d). During the t_{min} there may be a minimum migration which could be caused due to other exogenous factors not included in the model. This is indicated by the intercept of Migration axis of the Monsoon Migration function in the figure (1), which is 'a'. Beyond $t_{min\pm}\sigma_t$ Migration Acceleration M_A will set in. M_A is the rate of change of Migration Velocity with respect to time.

$$M_A = \frac{d2(\mathrm{Mpt})}{dt2} = \frac{d(\mathrm{Mv})}{dt}$$

It is observed in the Figure (1), that the migration function graph slope becomes steeper beyond the t_{min}. As the time dimension increases the slope become steeper, and there is greater migration velocity. The Migration velocity also changes continuously at an accelerated rate. This indicates that the Migration Function is non-linear model. Only π with a t_{min} will decelerate the migration.

Inset here

Figure 2: Migration based on diminishing utility due to reduction in Yield.

The Figure (2) has 3 graphs, graph (1), (2) and (3). The Graph (1) shows the relationship between the rainfall range and the production yield. The Graph (2) shows the relationship between the income and yield, and the graph (3) shows the relationship between the satiation (utility) and the Migration.

The graph (1) in figure (2) indicates the relationship between the yield and the rainfall. It is like the Laffer Curve. As shown, when the rainfall is in the Normal range π ($R_1 - R_2$ on y axis), the yield is maximum (y_{max}) shown as XY on the x axis. If the rainfall enters the $\pi_{e,}$ that is rain fall is more than OR_2 then the yield reduces to y_{sub} and this is shown by the OX on the x axis. Similarly, if the rainfall enters the $\pi_{d,}$ that is rain fall is below OR_1 then the yield reduces to y_{sub} and this is shown by the OX on the x axis. Y is the maximum yield that can be produced at the most optimal rainfall condition.

The graph (2) in figure (2) shows the production yield on the x axis and shows the changes in the income level at each production level on the y axis. This graph also establishes the relationship between the rainfall and the income of the cultivators. OI is the income level at which the minimum variable cost of production is recovered and any income below this is a result of the $y_{sub.}$ The optimum yield level generates income higher than the OI level.

The graph (3) in figure (2) shows Utility on the x axis and the quantum of migration on the y axis. At y_{max} (higher yield) from graph (2), the satiation of the cultivator is maximum, i.e, $U_{max.}$ (as shown in graph 3). This will result in Low migration rates. The slope of the Utility curve is also flat in this range showing that the migration velocity and acceleration is very low. When the y_{sub} occurs the utility diminishes and we can see that the utility curve starts to rise, indicating that the migration is steadily increasing. At very low y_{sub} levels the migration acceleration is very high and the total migrated population increases exponentially.

From the discussion on figure (2), it can be established that the $M_{pt,}$ the total migrated population, is a function of the rainfall. Thus Monsoon Migration Model should, include time constraint t_{min}, π_e and π_d elements. The excess or deficit rainfall is the quantitative aspect of the rainfall defined based on the geographic cropping requirement. When migration from a specific location is being quantified, it is required to record the actual rainfall in that geographic location and then check whether the rainfall is 'Normal' or 'Not Normal' for that geographic cropping condition.

The monsoon migration model can be modelled as two equations below,

$$M_{pt} = \beta_1 + \beta_2(R) + u \quad \text{---- (equation 2)}$$

$$M_{pt} = \beta'_1 + \beta_2(R) + u \quad \text{---- (equation 3)}$$

In the above equations (2) and (3) M_{pt}= Number of families migrated in the year "t" × Number of family members migrated. This means M_{pt} = Total Migration population in t^{th} year. R = Actual quantum of rain. While 'u' is the disturbance in the true model, which explains the deviations caused by factors other than quantum of rainfall.

Equation 2 shows the total Migration under 'Normal' rain fall conditions and equation (3) shows the migration under 'Not Normal' rainfall conditions.

Further let $\delta = \beta'_1 - \beta_1$

The equation (2) and (3) are combined as $M_{pt} = \beta_1 + \delta + \beta_2(R) + u$ **----** (equation 4)

A dummy variable 'NOT' and a slope dummy variable 'NOTR' which is the product of 'NOT' and 'R' with ɣ as the coefficient is introduced in the equation (4). The dummy variable NOT can take values of 1 or 0, where 1 indicates 'Not Normal' rainfall and 0 indicates 'Normal' rainfall. The model considers the reference as 'Normal' rainfall. The equation (4) can be restated as below

$$M_{pt} = \beta_1 + \delta\,(NOT) + \beta_2(R) + \gamma\,(NOTR) + u \quad \text{---- (equation 5)}$$

$$M_{pt} = \beta_1 + \delta\,(NOT) + (\beta_2 + \gamma\,NOT)\,R + u \quad \text{---- (equation 6)}$$

Based on the theoretical framework of the Monsoon Migration model proposed, the equation (6) can be simplified by stating that the migration percentage with respect to the population of the area ($\%M_{pt}$) is a function of the absolute deviation in the rainfall in percentage (%ADR).

That is ($\%M_{pt}$)= *f* (%ADR).

Where, Percentage Migration ($\%M_{pt}$) = (Actual Migration / Population of the Region) ×100

Percentage Absolute Deviation (%ADR) = (Actual rainfall - Normal rainfall)/Normal rainfall ×100

The following model is proposed.

$$\ln(\%M_{pt}) = \beta_1 + \beta_2 (\%ADR) + u \quad \text{---- (equation 6.a)}$$

Hypothesis for the study

H_0: There is no significant relationship between Percentage Migration ($\%M_{pt}$) and Percentage Absolute Deviation (%ADR)

H_a: There is a significant relationship between Percentage Migration ($\%M_{pt}$) and Percentage Absolute Deviation (%ADR)

Methodology

For the purpose of the empirical study, cross sectional data of the total migration from 28 states and 7 union territories (UT) of India, as per the 2001 Census is considered (detailed enumerated migration data of 2011 census is not yet published by the Government of India). For the same year, 2001, the rainfall statistics (Actual and Normal rainfall) for 36 rainfall zones/regions of India has been considered (provided by National data centre of India Meteorological department). The rainfall statistics from the rainfall zones were aggregated for each states and union territories. In certain cases, the aggregation was done for more than one state and union territory. Table 1 provides the data of the Actual Rainfall (a), Normal rainfall (b), percentage of Absolute deviation in rainfall (c), Population of the Zone (e) for different states and union territories in India.

Insert here
Table 1. State wise Rainfall and Migration

In Table 1. for each rainfall zones (column a), the percentage deviation of actual rain (column c) from the normal rain (column b) is calculated and the absolute value of the same has been shown in column d. Similarly, the percentage of migration (column g) with respect to the population (column e) and actual migration (column f taken from the 2001 Census) has been shown. The Census data for migration includes migrants for various purposes like education, work, marriage and others. For the purpose of this study migration population is calculated by considering only those who have migrated for the purpose of business or work/employment.

The proposed model considers states which are agriculturally sound. Analysis was carried out by using rainfall statistics of 15 Indian states. Some states are not considered based on certain criteria. Firstly, states (Arunachal Pradesh, Himachal Pradesh etc.) with low agricultural contribution to state GDP are not considered. Some states like Jammu & Kashmir and Rajasthan are not considered even though their agricultural contribution to the state GDP is high, because the type of crop they grow (apples in J&K and mustard in Rajasthan), are rain independent. Urban States like Goa and Delhi are not considered, as their contribution to agriculture is very minimal. Among the seven eastern sister states, only Assam and Meghalaya are considered (Agricultural statistics at a Glance).

Result of analysis

The equation (6.a) is tested empirically by fitting the regression using the data from Table 2.

Insert here
Table 2: State wise percentage of Absolute deviation of rainfall and percentage of migration (log)

The variables %ADR and ln(%Mpt) are taken as PERADEV and LNPERMIG respectively and the LNPERMIG is regressed on PERADEV. The SPSS output for the Regression is as follows

Insert here **Table 3 : Model Summary**

Insert here **Table 4 : ANOVA[b]** **Table 5 : Coefficients[a]**

It is observed that the R^2 from table 3, is 0.678 which indicates a good fit of the model, that is 67.8% of the dependent variable is predicted by the selected independent variables. The slope coefficient of PERADEV from table 5 is 0.037 with a t-statistic of 2.913 which is significant. Thus the null hypothesis H_0 is rejected at 5% level of significance.

The equation (6.a) for this data can be written as follows,

$$\ln(\%M_{pt}) = -2.015 + 0.037\ (\%ADR). \quad \text{---- (equation 6.b)}$$

Insert here Figure 3: Regression Fit for Rainfall and Migration

Based on the regression output, the estimated "percentage of migration" against "the percentage of absolute deviation in rainfall" is shown in figure 4.

Insert here
Figure 4: Change in the Migration with Rainfall deviation

Equation 6(b) it follows that,

$$\%\Delta(\%M_{pt}) \approx (100\times0.037)\ \Delta\ (\%ADR) \quad \text{-------- (equation 6c)}$$

Thus from equation (6c), it can be stated that one unit change in %ADR results in 3.7 percent change in $\%M_{pt}$

Enhancements to the Monsoon model in equation (6)

Based on the empirical study and continuing with the equation (6) restated below, the model can be further enhanced to include the dummy variables for absolute deviation in rainfall and the income variable.

$$M_{pt} = \beta_1 + \delta\ (NOT) + (\beta_2 + \gamma\ NOT)\ R + u \qquad \text{---- (equation 6)}$$

The 'Not Normal' rainfall condition can be either π_e or π_d and are introduced as dummy variables with coefficients δ_e and δ_d respectively representing the change in migration due to the excess or deficit rainfall. The π_e or π_d can take values of either 1 or 0.

If $\pi_e = 1$, indicates excess rainfall and π_d must be zero.

If $\pi_d = 1$, indicates deficit rainfall and π_e must be zero.

If both π_e and $\pi_d = 0$, indicates 'Normal' rainfall. Under any circumstances, it is not plausible for both π_e and π_d to be equal to one.

Thus the equation (6) can be restated as below considering $\delta_e + \delta_d = \beta'_1 - \beta_1$

$$\mathbf{M_{pt} = \beta_1 + \delta_e (\pi_e) + \delta_d (\pi_d) + \beta_2(R) + \gamma_e (\pi_e R) + \gamma_d (\pi_d R) + u} \qquad \text{---- (equation 7)}$$

From equation (7) the following equations results and can be used to quantify migration under different rainfall conditions

Normal rainfall condition migration equation is $M_{pt} = \beta_1 + \beta_2(R) + u$

Excess rainfall condition migration equation is $M_{pt} = \beta_1 + \delta_e \pi_e + (\beta_2 + \gamma_e \pi_e) R + u$

Deficit rainfall condition migration equation is $M_{pt} = \beta_1 + \delta_d \pi_d + (\beta_2 + \gamma_d \pi_d) R + u$

The income status of the cultivator is also important for the migration (Deshingkar and Start, 2003). Middle income class and poor households with landholdings are more vulnerable to the rainfall variations. A range of factors like limited alternative skills and small asset base can act adversely in case of crop failure (Warner, Henry et.al, 2012). The very high income and low income category of cultivators' migrations are inelastic to 'Not Normal' rainfall range. The middle income category cultivators' migration is highly elastic to the 'Not Normal' rainfall.

Thus the migration model can also be defined based on income alone. Considering the need to include a qualitative data of the income category of the cultivator, farmers household can be classified into low income, middle income and high income category. The income is represented as Y. As the middle income class migration is highly elastic to 'Not Normal' rainfall, middle income category is considered as the base reference category for the model. H represents high income category and L represents low income category and are taken as dummy variables in the model. These dummy variables will have a value of 1 or 0, if the cultivator 'belongs to' or 'does not belong to' the income category respectively. λ_H and λ_L are considered to be the slope coefficients of H and L dummy variables respectively. The slope dummy variable of income categories will be YH and YL. ξ_H and ξ_L are the incremental marginal change associated with the high income and low income.

Thus the migration equation can be stated as a function of income alone as follows,

$$M_{pt} = \beta_3 + \lambda_H (H) + \lambda_L (L) + \beta_4(Y) + \xi_H (HY) + \xi_L (LY) + u \quad \text{---- (equation 8)}$$

Combining Equations (7) and (8), and taking $\beta_m = \beta_1 + \beta_3$ the Income Monsoon Migration Model is stated as below

$$M_{pt} = \beta_m + \delta_e(\pi_e) + \delta_d(\pi_d) + \beta_2(R) + \gamma_e(\pi_e R) + \gamma_d(\pi_d R) + \lambda_H(H) + \lambda_L(L) + \beta_4(Y) + \xi_H(HY) + \xi_L(LY) + u$$

---- (equation 9)

The Income Monsoon Migration model as proposed in equation (9) thus considers deficit and excess rainfall to measure the migration. The proposed model is linear in parameter. The model also considers the influence of income of the farmer household on migration. When H=0, the model quantifies migration among low income category farmers. When L=0, migration among the high income category cultivator can be estimated. For migration among the middle income category cultivators, both H and L values are taken as 0.

Empirical study for the Income-Monsoon Migration Model

The empirical study for the Income monsoon migration model (equation 9) has not been conducted because of the lack of availability of the relevant data. The model requires data specific to the migrant population statistics from each rainfall zone, which also include their income before they migrated. The rainfall data in India is being captured with respect to the rainfall zones. However, this data need to be captured for specific cropping zones and the migration data captured by the Census must also match the data for these cropping zones in order to empirically test the model. With the data currently available, fitting the model in the equation 9 is not possible.

Conclusion

A majority of employment generation in country like India is through the agriculture and allied industries. Agriculture being predominantly dependent on the monsoon rains is vulnerable to extreme climatic conditions. Farmers in rural areas mostly depend on agriculture for income. When the income generated through this primary occupation is not sufficient, they are forced to migrate to other areas, usually the urban locations. This intra-state and inter-state migration puts a lot of pressure on the civic amenities in the urban destinations. Inadequate infrastructure and public utility services puts a lot of stress on the existing facilities, thus reducing the welfare of the society as a whole. Other adverse effects on wages in destination has also been widely studied and documented. Therefore, a good estimation of the migration can provide sufficient data to the local government to plan the infrastructure to support the incoming population and formulate policy regulations necessary to increase the welfare of the society.

The monsoon migration model proposed and empirically tested in this paper will be able to estimate the migration quantum from a specific geographic location based on the quantum of rainfall. Further, this paper has also proposed the income-monsoon migration model which has an additional variable, the income of the migrants from the specific location, for the estimation of quantum of migration based on the migrant income. This model can be empirically tested provided that the government of India collect enumeration data of the migrants specific to the cropping zones with their income. This will enable to provide suggestions and insights to the government for policy making.

References

Agricultural statistics at a Glance, Directorate of agriculture and statistics, http://eands.dacnet.nic.in/Advance_Estimate-2010.htm-

Barbieri, A.F., E. Domingues, B. L. Queiroz, R.M. Ruiz, J.I. Rigotti, J.A.M. Carvalho, and M.F. Resende (2010). Climate Change and Population Migration in Brazil's Northeast: Scenarios for 2025-2050. Population and Environment, 31: 344-370.

Bardsley, DK; Hugo, GJ (2010). Migration and climate change: examining thresholds of change to guide effective adaptation decision-making. Population and Environment 32(2-3): 238-262

Bart W. Édes, François Gemenne, Jonathan Hill and Diana Reckien (2012). Addressing Climate Change and Migration in Asia and the Pacific. Asian Development Bank.

Black, R., D. Kniveton and K. Schmidt-Verkerk, (2011). Migration and Climate Change: Towards an Integrated Assessment of Sensitivity. Environment and Planning A, volume 43.

Byravan, S. and Rajan S.C (2009). Warming up to immigrants: An option for US climate policy. Economic and Political Weekly, 44, 19-23.

Dallman, I; Millock, K (2012). Climate variability and internal migration: a test on Indian inter-state migration. Paper Presented at the ENMRDTE Pre-conference on Migration and Environment, 17 October, 2012, Clermont-Ferrand, France

Datt G and M Ravallion (1998). Farm Productivity and rural poverty in India. Journal of Development Studies 34:4, 62-85

de Sherbinin, A., Warner, K., and Ehrhart, C. (2011). Casualties of climate change. Scientific American, 304(1), 64-71.

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

Dillon, A., V. Mueller, and S. Salau (2011). Migratory Responses to Agricultural Risks in Northern Nigeria. American Journal of Agricultural Economics, 93: 1048-1061.

Feng, S., Krueger, A. B., and Oppenheimer, M. (2010). Linkages among climate change, crop yields and Mexico–US cross-border migration. Proceedings of the National Academy of Science, 107(32), 14257-14262.

Fernando Riosmena, Raphael J. Nawrotzki, Hunter Lori M, (2013). Rainfall Trends, Variability and U.S. Migration from Rural Mexico: Evidence from the 2010 Mexican Census Institute of Behavioral Science. Working paper

Gine, X., Townsend, R., and Vickery, J. (2008). Patterns of rainfall insurance participation in rural India. The World Bank Economic Review, 22(3), 539-566.

Gugler, J. (1988). Over Urbanization Reconsidered in J. Gugler (ed). The Urbanisation of the Third World. Oxford: Oxford University Press.

Hanmer, L., & Naschold, F. (2000). Attaining the International Development Targets: Will Growth Be Enough? Development Policy Review, 18(1), 11-36. doi: 10.1111/1467-7679.00098

Hassani-Mahmooei, B. and B.W. Parris (2012). Climate Change and Internal Migration Patterns in Bangladesh: An Agent-based Model. Environment and Development Economics, doi:10.1017/S1355770X12000290.

Hertel, T. W., and Rosch, S. D. (2010). Climate Change, Agriculture, and Poverty. [Article]. Applied Economic Perspectives and Policy, 32(3), 355-385.

International Organization for Migration (IOM), (2009). Migration, Environment and Climate Change: Assessing the evidence.

Kavi Kumar K. S. and Brinda Viswanathan, (2012). Weather variability and agriculture: implications for long and short-term migration in India. Center for Development Economics, Delhi school of Economics, Working paper No. 220

Kumar, KS Kavi; Parikh, J (2001). Socio-economic impacts of climate change on Indian agriculture. International Review of Environmental Strategies 2(2): 277-293

Lee ES, (1966). A Theory of Migration. Demography, 3(1), 47-57

Mall, RK; Singh, R; Gupta, A; Srinivasan, G; Rathore, LS (2006). Impact of climate change on Indian agriculture: a review, Climatic Change 78: 445-478

Marchiori, L., J-F. Maystadt, and I. Schumacher (2012). The Impact of Weather Anomalies on Migration in sub-Saharan Africa. Journal of Environmental Economics and Management, 63:355-374.

Massey, D. S., Axinn, W. G., and Ghimire, D. J. (2010). Environmental change and out-migration: evidence from Nepal. Population and Environment, 32(2-3), 109-136.27

McLeman, R., and Hunter, L. M. (2010). Migration in the Context of Vulnerability and Adaptation to Climate Change: Insights from Analogues. Wiley Interdisciplinary Reviews: Climate Change, 1(3), 450-461.

McLeman, R; Smit, B (2006). Migration as an adaptation to climate change. Climatic Change 76(1-2): 31-53

Mellor, J. (1999). Faster, More Equitable Growth – The Relation Between Growth in Agriculture and Poverty Reduction Agricultural Policy Development Project (Research Report No. 4). Washington, D.C.: United States Agency for International.

Mitra Arup and Murayama Mayumi (2008). Rural to Urban Migration: A District Level Analysis for India. IDE Discussion Paper, No 137

Nawrotzki, RJ; Riosmena, F; Hunter, LM (2012). Do Rainfall Deficits Predict U.S.-Bound Migration from Rural Mexico? Evidence from the Mexican Census. Population Research Policy Review, doi: 10.1007/S11113-012-9251-8

Perch-Nielsen, S., Bättig, M., and Imboden, D. (2008). Exploring the link between climate change and migration. Climatic Change, 91(3-4), 375-393.

Perch-Nielsen, S; Battig, M; Imboden, D (2008). Exploring the link between climate change and migration. Climatic Change 91(3-4): 375-393

Ravenstein EG (1885). The Law of Migration. Journal of the Statistical Society of London, 48(2), 167-235

Sanchez Cohen, I., Oswald Spring, U., Diaz Padilla, G., Cerano Paredes, J., Inzunza Ibarra, M. A., Lopez Lopez, R., and Villanueva Diaz, J. (2012). Forced migration, climate change, mitigation and adaptation policies in Mexico: Some functional relationships. International Migration, 1-20, doi: 10.1111/j.1468-2435.2012.00743.x.

Schneider Kate and Gugerty Mary Kay (2011). Agricultural Productivity and Poverty Reduction: Linkages and Pathways, The Evans School Review, Vol. 1, Num. 1

Veena A and K Rao, Sandeep. (2017), Analysis of Socio Economic Conditions and Migration Patterns of Migrant Settlements in Bengaluru, Shinoda, Inoue and Suda (eds), Social Transformation and Cultural Change in South Asia: From the Perspectives of the Socio-Economic Periphery, ISBN 978-4-904626-27-6, (pp. 141-164), Tokyo: The Institute of Oriental Studies, Daito Bunka University.

Vries J, Nijkamp P, Rietveld P (2000). Alonso's General Theory of Movement. Tinbergen Institute Discussion Paper (TI 2000-062/3)

Wang Chenggang, Rada Nicholas, Qin Lijian & Pan Suwen, (2014). Impacts of Migration on Household Production Choices: Evidence from China. The Journal of Development Studies, 2014 Vol. 50, No. 3, 413–425

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: CARE France and UNU-EHS.

World Bank (2008). Climate change impacts in drought and flood affected areas: case studies in India. Report No. 43946-IN, Social, Environment and Water Resources Management Unit, India Country Management Unit, South Asia Region, New Delhi.

Figure 1: Migration as a function of Rainfall

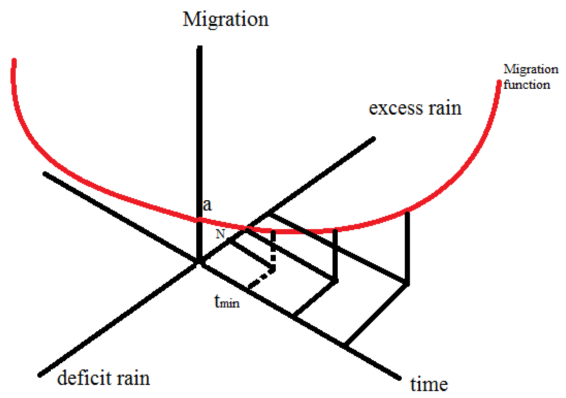

Figure 2: Migration based on diminishing utility due to reduction in Yield.

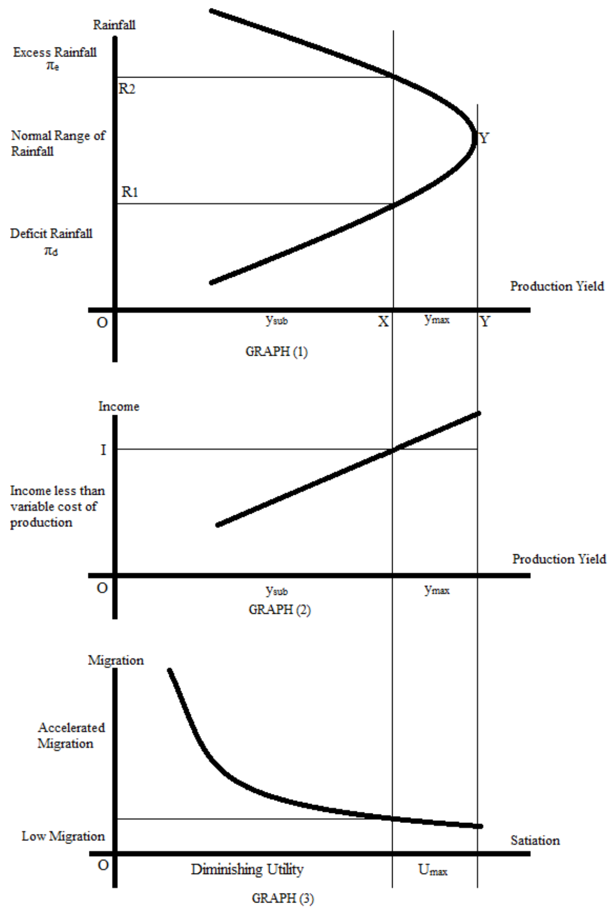

Table 1. State wise Rainfall and Migration

a	b	c	d	e	f	g
States & Union Territories in India grouped as a region	Normal Rain (mm)	Actual Rain (mm)	% Absolute Deviation of Rainfall	Population	Migration	% migration = Migration/ Population*100
GUJARAT, DADRA & NAGARHAVELI, DIU	1359.1	834.9	38.56964167	50976243	68809	0.134982486
RAJASTHAN	1045.9	721.5	31.01634956	56473300	121250	0.214703231
MADHYAPRADESH	2188.1	1538	29.71070792	60385090	133807	0.221589469
CHATTISGARH	1478.6	1054.7	28.66901123	20834530	157921	0.757977262
HIMACHAL PRADESH	1375.9	1016.7	26.10654844	6077453	15690	0.258167361
ORISSA	1452.4	1130.3	22.1770862	36707900	49042	0.133600669
JAMMU & KASHMIR	1117.2	874.1	21.75975653	10070300	17747	0.176231095
ANDAMAN & NICOBARISLANDS	3098.1	2439.1	21.27110164	356650	949	0.2660872
UTTARANCHAL	1906.3	2298.2	20.55814929	8489100	26402	0.31101059
KERALA	2764.8	2202.3	20.34505208	31839000	35211	0.110590785
JHARKHAND	1326.9	1064.8	19.7528073	26946070	99185	0.368087072
LAKSHADWEEP	1589.7	1372.6	13.65666478	61300	178	0.290375204
BIHAR	1224.8	1343.4	9.683213586	82879910	228453	0.275643398
KOKAN&GOA	2756	3008.6	9.165457184	1348900	3806	0.282155831
WEST BENGAL AND SIKKIM	4418.4	4812.5	8.919518378	80763202	74938	0.092787307
ANDHRA PRASHESH & TELENGANA	2642.5	2856.8	8.10974456	75728400	76868	0.101504852
NAGALAND, MANIPUR, MIZORAM, TRIPURA	2011	2173	8.055693685	8366325	8101	0.096828655
PUNJAB	704.2	755.4	7.270661744	24289130	51876	0.21357702
MAHARASHTRA	2745.9	2595.7	5.469973415	96752500	147442	0.152390894
KARNATAKA	5204.3	4938.6	5.105393617	52734986	125796	0.238543725
UTTAR PRADESH	1957.4	2019.9	3.193011137	166053600	363374	0.218829342
TAMILNADU & PONDICHERRY	1027.1	994.6	3.164248856	63086210	73988	0.117280781
ARUNACHAL PRADESH	3741.1	3845.9	2.801315121	1098328	1239	0.112807832
HARYANA, DELHI &CHANDIGARH	722.9	706.3	2.296306543	35836483	107374	0.299622036
ASSAM & MEGHALAYA	2285.5	2315.7	1.321373879	28945140	25297	0.087396364

Table 2: State wise percentage of Absolute deviation of rainfall and percentage of migration (log)

States & Union Territories in India grouped as a region	**%ADR**	**$\ln(\%M_{pt})$**
JHARKHAND	19.7528073	-0.999435761
UTTARANCHAL	20.55814929	-1.167928316
BIHAR	9.683213586	-1.288647286
ANDAMAN & NICOBAR ISLANDS	21.27110164	-1.323931203
HIMACHALPRADESH	26.10654844	-1.35414722
KARNATAKA	5.105393617	-1.433202652
UTTAR PRADESH	3.193011137	-1.519463114
PUNJAB	7.270661744	-1.543757763
MAHARASHTRA	5.469973415	-1.881306386
TAMILNADU & PONDICHERRY	3.164248856	-2.143184379
ANDHRA PRASHESH & TELENGANA	8.10974456	-2.287648683
ASSAM & MEGHALAYA	1.321373879	-2.437301596

Table 3 : Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.678[a]	.459	.405	.35758

a. Predictors: (Constant), PERADEV

b. Dependent Variable: LNPERMIG

Table 4 : ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.085	1	1.085	8.488	.015[a]
	Residual	1.279	10	.128		
	Total	2.364	11			

a. Predictors: (Constant), PERADEV

b. Dependent Variable: LNPERMIG

Table 5 : Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.015	.172		-11.726	.000
	PERADEV	.037	.013	.678	2.913	.015

a. Dependent Variable: LNPERMIG

Figure 3: Regression Fit for Rainfall and Migration

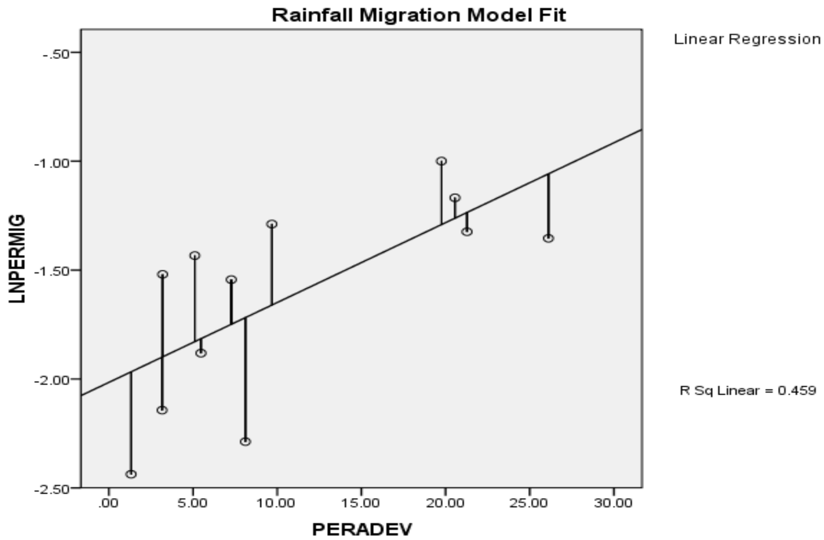

Figure 4: Change in the Migration with Rainfall deviation