Floods and internal migration in the world

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http://humanitariancoalition.ca/pakistan-floods-2010
Extreme weather events

Climate changes may increase extreme weather events

Hirabayashi et al. (2013) Nature Climate Change
## Extreme events as the global risk

**Global Risks Report**

The 5 risks most likely to happen in the next 10 years

<table>
<thead>
<tr>
<th>Rank</th>
<th>Risk</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Extreme weather events</td>
</tr>
<tr>
<td>2</td>
<td>Natural disasters</td>
</tr>
<tr>
<td>3</td>
<td>Cyber attacks</td>
</tr>
<tr>
<td>4</td>
<td>Data fraud or theft</td>
</tr>
<tr>
<td>5</td>
<td><strong>Failure of climate change mitigation &amp; adaptation</strong></td>
</tr>
</tbody>
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Source: Executive Opinion Survey 2017, World Economic Forum
Challenges

High public attentions… but few scientific evidences
(de Shrbinin et al. 2012; IPCC 2014)
Previous studies

Temperatures and migration in South Africa

The influence of climate variability on internal migration flows in South Africa

Mastrollio et al. (2016)

Floods and migration in Bangladesh

Unveiling hidden migration and mobility patterns in climate stressed regions: A longitudinal study of six million anonymous mobile phone users in Bangladesh

Lu et al. (2016) Global Environmental Change

Few studies focus on the global scale
Objective

The relationship among floods, internal migration and economic conditions across the globe
Flooded areas

Global river and inundation model:
the Catchment-based Macro-scale Floodplain model (CaMa-Flood) (Yamazaki et al. 2011)

- Resolution: 5’ × 5’ (approximately 10 km × 10 km at the equator)
- Term: 1960-2013
- Anomaly of flood areas at each country

Tanoue et al. (2016)
Population migration

IDMC Global Report on Internal Displacement 2017 Disaster Dataset

• Term: 2008-2016
• Event basis
• Data sources: national government authorities, UN agencies and other international organizations, civil society organizations, news media etc.
• Internal migration that caused by “Flood”, ”Storm”
• Rate of population migration to total population (World bank 2017)

http://www.internal-displacement.org/countries/
Economic condition

World Bank (2017)
• Gross Domestic Production
• Term: 1960-2016
• Each country

http://www.worldbank.org/
Statistical Analysis

Generalized linear mixed model (GLMM)

Migration to total population~ $\beta_0 + \beta_1 \times GDP + \beta_2 \times \text{anomaly of flooded areas} + \beta_3 \times GDP \times \text{anomaly of flooded areas} + \phi_j$

$\beta_i$ is coefficient of explanatory variables
$\Phi_j$: Random effect, Year
Floods & Internal migration

Average rates of internal migration that related with flood 2008-2016

Countries in African, South, Southeast Asian, the northern Andes had high rate of internal migration

Data from IDMC
Result of GLMM

- Anomaly of flooded area (+)
- Interaction of flooded areas and GDP (-)

Bar means standard error
Rich countries have few number of migrants.
Flooded areas & Migration

Economic level
- High
- Upper
- Middle
- Lower
- Low

Rate of migrants to total population in 2010

Small floods ← 0 → Large floods

Anomaly of flooded areas
Flood in Pakistan, 2010

The heaviest rainfall events from the previous
  • July was up 772% from normal
  • August rainfall was up 1483%
Flood in Pakistan, 2010

Huge impact on society
• 14-20 million people affected
• 1.1 million homes were damaged (Kirsch et al. 2012)
Flooded areas & Migration

The graph illustrates the relationship between the anomaly of flooded areas and the rate of migrants to the total population in 2011, categorized by economic level. The economic levels are:
- High
- Upper Middle
- Lower Middle
- Low

Small floods are represented on the left side of the x-axis, while large floods are represented on the right side. The y-axis denotes the rate of migrants to the total population in 2011. The graph shows the distribution of data points for different countries, indicating how the anomaly of flooded areas correlates with migration rates across various economic levels.
Floods in Philippine, 2011

Tropical storm “Washi”

- 0.6 million people affected
- 28,000 homes were damaged

NASA Earth Observatory
Precipitation during Dec.15-19
Floods in Philippine, 2011

Philippine has large number of disaster-related migrants for several years
Future flood projection

Flood frequency are projected to increase in some of these countries.

Hirabayashi et al. (2013) Nature Climate Change
Limitations & Future tasks

Definition of “a large flood”
• We consider only “flooded areas”
• We’ll try to consider “flood affected population”

What kind of a flood is matter?
• Are there any threshold (a critical point) of flooded areas?
• Are there any other triggers to human migration?
Summary

Although the public attention is increasing, there are few knowledge about the migration that are associated with extreme weather events across the globe.

- Internal migration that caused by flood were mainly occurred in African, South, Southeast Asian, the northern Andes regions.

- Flooded areas itself may relate with internal migration.

- Interaction of flooded areas and economic condition may affect population migration.
Conclusion

Floods may have critical impacts on population migration especially in middle and low income countries.