Spatial Distribution of Disasters by Track of Typhoons in Korea

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• Damages caused by typhoons in each sector

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• The Korean Peninsular has been affected by two or three typhoons from June to September each year. So we usually suffers from tremendous damages by extreme precipitation related to the typhoons.

• Disasters by typhoons account for approximately 60% of the total amount of damages for the recent 10 years from 2002 to 2011 (National Emergency Management Agency (NEMA), 2012).

• Recently, the frequency of typhoons affecting Korea shows a increasing trend and its intensity is getting stronger and stronger. Because of these increased and enhanced typhoons, the amount of damage is also soaring (Lee et al., 1992; Park et al., 2006).

• The pattern of damages can be different according to the track of typhoons, which brings different distribution of precipitation, and intensity of damages.

• There are some studies on the scale of typhoon damages and cause analysis by track of typhoon (Kim et al., 2007; Ahn et al., 2008), but researches about spatial distribution of disasters by track of typhoons are not well investigated.

The purpose of this study is to investigate the spatial distribution of disasters by the track of typhoons in Korea.
II. Data and Methodology -1

Step. 1. **Selection of weather station for analysis**
- Selection of weather stations which have no missing data during the typhoon period.

Step. 2. **Selection of typhoons and classification of tracks**
- Case of daily precipitation exceeds 80mm at one and more weather station during the typhoon period was selected.
- Typhoons were classified into 3 patterns based on the typhoon track.

Step. 3. **Damage analysis**
- Total damages by typhoons from 2002~2011.

Step. 4. **Spatial analysis**
- Spatial distribution of disasters by the track of typhoons.
II. Data and Methodology

- **Research period**: Recent 10 years (2002-2011)
- **Daily precipitation data from KMA**
  (Korea Meteorological Administration)
  - Total 335 stations
    - 64 Weather stations
    - 271 Automatic Weather Systems (AWS)
- **Disaster data by typhoons from NEMA**
  (National Emergency Management Agency)
  - Disaster annual report
    - Total damages and Casualty
- **Typhoon information from RSMC-Tokyo**
  (Regional Specialized Meteorological Centre)
  - Best-track data of typhoons

< Spatial distribution of weather station >
II. Data and Methodology

< Classification of typhoons by the track >

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Num.</th>
<th>Typhoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Sea-passing type</td>
<td>6</td>
<td>RAMMASUN(0205), MINDULLE(0407), KALMAEGI(0807), KOMPASU(1007), MEARI(1105), MUIFA(1109)</td>
</tr>
<tr>
<td>Southern-region-landfall type</td>
<td>5</td>
<td>RUSA(0215), MAEMI(0314), EWINIAR(0603), NARI(0411), DIANMU(1004)</td>
</tr>
<tr>
<td>East Sea-passing type</td>
<td>10</td>
<td>LINFA(0304), SOUDELOR(0306), NAMTHEUN(0410), MEGI(0415), SONGDA(0418), NABI(0514), WUKONG(0610), SHANSHAN(0613), USAGI(0705), MALOU(1009)</td>
</tr>
</tbody>
</table>

- Typhoon tracks were classified into **3 patterns based on the location of the typhoon**.
- The number of typhoons for each pattern is 6, 5, 10.
III. Result - Damages by the typhoon

Total amount of property loss during recent 10 years: 10.2 billion USD
- 60% of total property loss in nationwide
- Life loss: 85 person/year

- Some public facilities such as roads and bridges account for about 77% of the total damages.
- ETC. such as fish farm and vinyl greenhouse take about 15% of total damages and followed by farmland, structure, and ship.

< Typhoon damages in each sector >

[Source: National Emergency Management Agency]
### III. Result - Damages for each pattern

#### < Average damages of the typhoon affecting the Korean Peninsula >

<table>
<thead>
<tr>
<th>Pattern of typhoon tracks</th>
<th>Damage Type</th>
<th>Total damages (Billion USD)</th>
<th>structure (million USD)</th>
<th>Ship</th>
<th>Farmland (ha)</th>
<th>Public facilities (ha)</th>
<th>etc.</th>
<th>Casualty (person)</th>
<th>Flooding area (ha)</th>
<th>Crops (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Sea</td>
<td></td>
<td>103</td>
<td>2.9</td>
<td>0.5</td>
<td>1.6</td>
<td>72.7</td>
<td>25.0</td>
<td>5</td>
<td>912</td>
<td>20,781</td>
</tr>
<tr>
<td>Southern-region-landfall</td>
<td></td>
<td>2,307</td>
<td>49.6</td>
<td>8.5</td>
<td>132.3</td>
<td>1,769.3</td>
<td>347.4</td>
<td>200</td>
<td>17,512</td>
<td>108,503</td>
</tr>
<tr>
<td>East Sea</td>
<td></td>
<td>52</td>
<td>1.0</td>
<td>0.2</td>
<td>1.0</td>
<td>45.9</td>
<td>3.8</td>
<td>3.8</td>
<td>3,202</td>
<td>4,763</td>
</tr>
</tbody>
</table>

- The most damage by typhoons has occurred in Southern-region-landfall pattern.

- Typhoons of Yellow Sea pattern caused more damages than East Sea pattern except for the flooding area.
III. Result - Spatial distribution of disasters by typhoon

- Spatial distribution of disasters by typhoons appears around the eastern coastal regions and southeast regions of the Korean Peninsula.

- So the spatial distribution of disasters by typhoons are closely related
  1. Counterclockwise rotation of the typhoon
  2. Distance to the coast
  3. Topographic effects

- Spatial distribution of disasters by typhoon tracks will be different.
  - Because meteorological characteristics is different along the typhoon track.
• During the last 10 years, total 6 typhoons affected by the Korean Peninsula and some of them go north toward Yellow sea or recurve and then make a landfall in Korea.

• When the center of a typhoon is located at 34°N, as shown in average 850hPa synoptic chart, we can know that southwest of Korean Peninsula is affected by the typhoon.
When we examine damage by typhoon along each area, the portion of ETC. is 24%, which is more than 15% shown in total damage by typhoon from previous slide.

### Cause Analysis of typhoon damage

<table>
<thead>
<tr>
<th></th>
<th>West case</th>
<th>East case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>77.8</td>
<td>73.7</td>
</tr>
<tr>
<td>Wind</td>
<td>88.9</td>
<td>42.1</td>
</tr>
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</table>

(Ahn et al., 2008)

In previous study, the cause of damages by the typhoon that goes north toward Yellow Sea is the influence of wind, damage scale of facilities such as fish farm and vinyl greenhouse is increased.
Spatial distribution of disasters by typhoons appear around the west regions. But does not look that matches the overall pattern.

As shown in previous slide, when we summarize on damage type and the spatial distribution of damage.

To predict and prepare about disaster of typhoon by Yellow Sea-passing pattern, research is needed considering the speed and direction of the wind.
• In this pattern total 5 typhoons are included
• **Because typhoon center makes a landfall in Korean Peninsula, the greatest damage can occur.**
• If we examine average synoptic chart when typhoon center makes a landfall in Korean Peninsula, Korean Peninsula is influenced by typhoon.
The field of public facilities such as road and bridge did a damage of 1,769 million USD and particularly, which is done damage by typhoons such as RUSA (2002), and MAEMI (2003).

According to Park et al. (2006),
- The frequency of typhoon landfall in the Southern region is low, but its intensity and damages are high.

< Typhoon damages in each sector >
• Damage is concentrated in the eastern and southern regions of the peninsula.
• The spatial distribution of damages by typhoon pattern that make a landfall in the southern region is generally **coincident with the pattern of extreme precipitation.**
  → We can know that this is **classified based on main mountains of Korean Peninsula.**
• Spearman correlation coefficient between the region of extreme precipitation and damage amount is very high as 0.71 (p < .01).
III. Result - East Sea-passing pattern

- A total of 10 typhoons affected by the Korean Peninsula during the last 10 years.
- **Typhoon tracks close to Korean Peninsula and then goes toward East Sea after recurving rapidly.**
- Because of easterlies~southeasterlies inflow, damages are happened in south and east regions close to typhoon.
III. Result - East Sea-passing pattern

- Detailed damage is concentrated in public facilities.
- According to previous studies, the cause of damages by the typhoon that goes north toward East Sea is the influence of precipitation.

**Cause Analysis of typhoon damage**

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*(Ahn et al., 2008)*

- Typhoon damages in each sector:
  - Public facilities, 45.98, 88%
  - Farmland, 1.00, 2%
  - Ship, 0.24, 1%
  - Structure, 1.03, 2%
  - ETC., 3.84, 7%

*million USD*
III. Result - East Sea-passing pattern

- Spatial distribution of disasters by typhoons occur on the windward slopes of the mountains.
- The spatial distribution of typhoon disaster is similar to the pattern of extreme precipitation.
- East Sea passing typhoon pattern inflicts the least damage because typhoons turned sharply away.
IV. Summary and Future Work

- Spatial distribution pattern of the disaster by typhoons are closely related to the track of typhoons and geographic factors.
  - Southern-region-landfall pattern: distinct difference depending on the topography of major mountain regions.
  - East-Sea pattern: closely related distance to the coast.

- The main cause of the spatial distribution pattern of disaster by the track of typhoons seem to be related to meteorological factors.
  - Southern-region-landfall pattern and East-Sea pattern are closely related with extreme precipitation pattern.
  - But Yellow-Sea pattern does not look that matches the overall pattern It seems to be related to wind.

- In the future, detailed damage classification by track of typhoons and correlation analysis among the weather factors should be followed.
Thank you for your attention

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