CENTRAL INTELLIGENCE AGENCY DIRECTORATE OF INTELLIGENCE

North Korea: Assessing the Impact of Flooding on Agricultural Output (U//FOUO)

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To establish a baseline and methodology for judging the impact of future flooding on agricultural output and by implication North Korea's need for food imports, OSW analysts conducted a comprehensive review of information on major flood events in North Korea since 1996. The four variables related to flooding that appear to have the most influence on agriculture are: the geographic area hit and the total area submerged; rainfall intensity (the amount of rainfall over a period of time); the time of year when flooding occurs and impedes or delays critical farming operations; and the scope and severity of non-agricultural infrastructure damage that distracts the labor force from farming and undermine labor productivity in the fields.

- **Analysis of past floods indicates that the intensity of rainfall and the geographic area where the rainfall occurs are the key variables with the highest predictive power. In the past two decades, when intense rainfall occurred within a narrow time frame in the main crop producing areas, it devastated staple crops as well as homes, roads, and other infrastructure.**

- **On the basis of this methodology and what we know about the timing, extent, and areas affected by flooding this year, we believe that the impact of the September typhoon (Kompasu) on North Korea's staple crops and infrastructure was relatively minor. (U//FOUO)**

OSW Methodology for Judging Flood Impact (U)

OSW analysts reviewed flood events in North Korea over the past 15 years to identify four main variables that can be used to assess the possible impact of future flooding on North Korean harvests. Rainfall intensity and geography of flooding appear to be key variables with the most impact. Critical periods in the agricultural growth cycle—for sowing, growing, and harvesting—and the scope and severity of infrastructure damage are compounding variables that can magnify the impact of major floods in key food producing areas. (U//FOUO)

We assess that the most important variable is the **intensity of rainfall** (amount of rain falling over a number of days). Since the mid-1990s, the rainfall intensity levels for major flood events were:

- 1996: 430-750 mm over 4 days (108-188 mm per day).
- 2006: 300-500 mm over 7 days (43-71 mm per day).
- August 2007: 500-700 mm over 7 days (71-108 mm per day).
- September 2007: 300-400 mm over 2 days (150-200 mm per day). (U//FOUO)

On the basis of the impact of these past flood events, we established a rating system for rainfall intensity that measures the potential significance of damage from major rain events in North Korea:

- Rainfall above 100-150 mm per day during four or more days has the potential to have devastating impacts;
- Rainfall of 70-100 mm per day during four or more days has the potential to generate severe impacts;
- Rainfall of 50-75 mm per day for four or more days has the potential to result in moderate impacts;
- Rainfall of 50-75 mm per day for up to four days has the potential to have low to no impact. (U//FOUO)

The **geographical distribution of rainfall** is another key variable for judging the impact of heavy rain on agricultural output. The impact of floods on agriculture depends on whether they hit the main crop producing areas in Hwanghae and P'yŏngan or not. Paddy rice, the main crop in North Korea, is cultivated primarily in the central, southwestern, and southeastern parts of the country. According to the Food and Agriculture Organization of the United Nations (FAOSTAT), rice paddy occupies around 580,000 hectares of the total arable land in North Korea of slightly more than 2 million hectares. (U//FOUO)

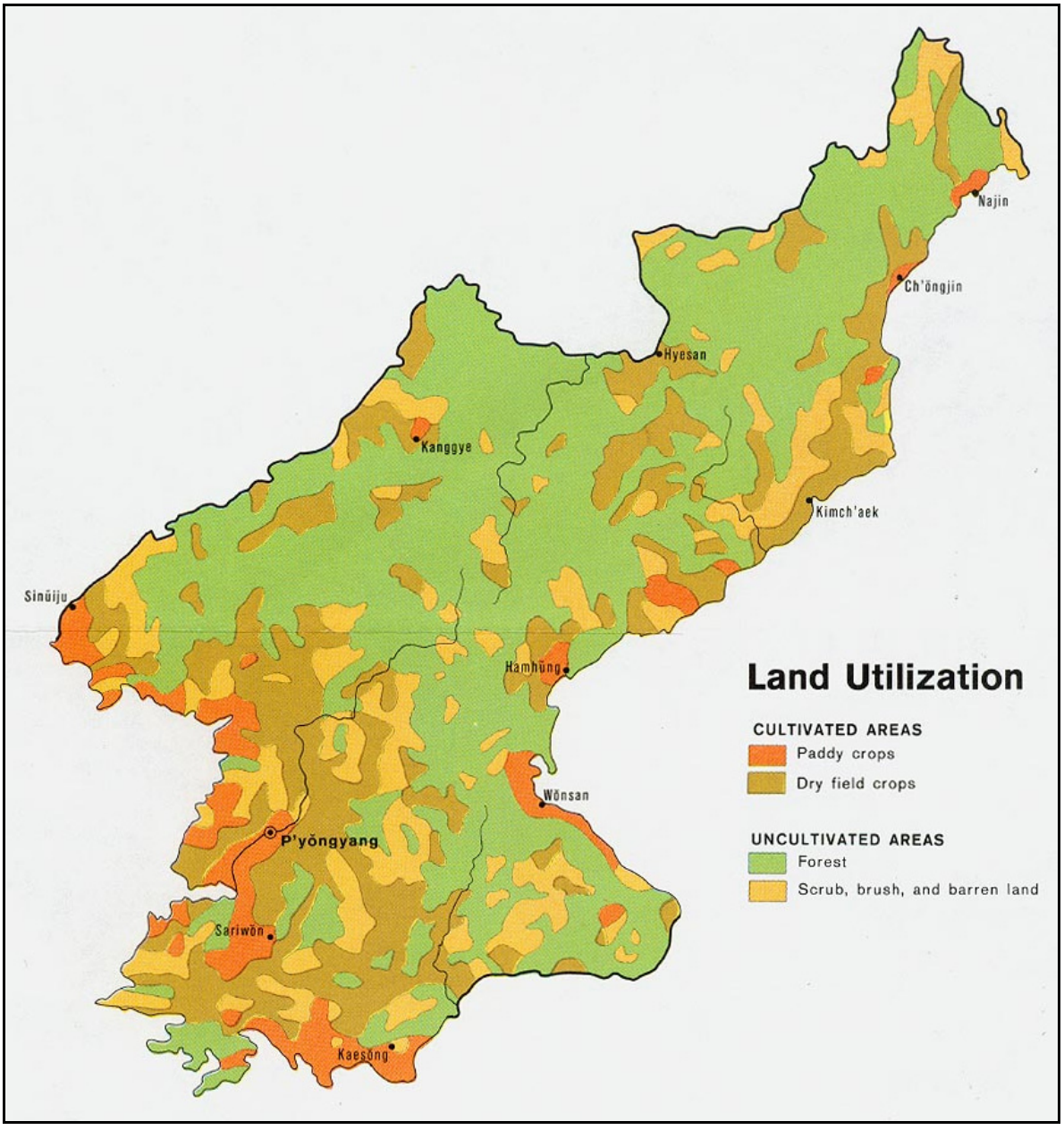
More than 90 percent of the country's staple rice crop grows in five out of nine provinces, namely South and North Hwanghae, South and North Pyongyang, and North Hamgyŏng provinces (see Figure 1). Average annual rainfall in these rice growing areas ranges between 880-1300 mm. About 85 percent of all precipitation occurs during the spring-summer months, with an average of 60 percent falling in June-September. Typhoons are a regular occurrence: their effects are usually felt at least once per growing season—in late summer or early autumn. Hence, every year, the main rice growing areas can expect between 500 to 800 mm of rain between June and September. (U//FOUO)

Other crops—including staples of maize, barley, wheat and vegetables—are more evenly distributed nationwide.

- Maize is grown over an area of about 500,000 hectares distributed evenly across eight provinces.
- Ryanggang province is the largest producer of potatoes.

- South Hwanghae province produces about 23 percent of total grain output in North Korea and is a major producer of other agricultural commodities and livestock. (U//FOUO)

Figure 1. Key North Korean Agriculture Regions (U)



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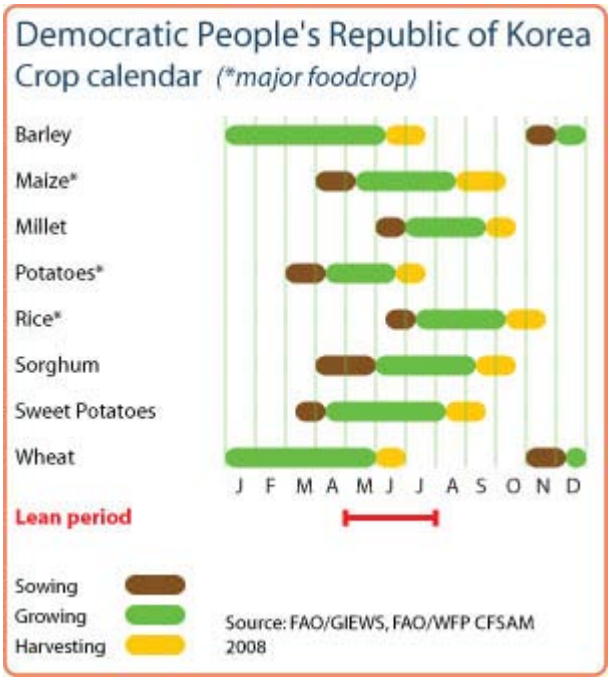
The **agricultural growth cycle** and whether flooding occurs during critical periods in this growth cycle is a compounding variable that must be considered if key agricultural producing areas experience heavy rain. Paddy rice is particularly vulnerable to the possibility of flood damage because its growing cycle coincides with occurrences of heavy rainfall. The risk of damage to paddy rice crops is especially high under three circumstances:

- When rice is sown in the beginning of April;
- When rice stalks are transplanted in paddy fields in late May and early June; and
- At the harvest time in late September and early October. (U//FOUO)

North Korean farmers plant maize in April and harvest it in September. They plant and harvest other staple crops like millet and barley during the periods falling outside the typical flooding season (see Figure 2). (U//FOUO)

The **scope and severity of infrastructural damage** serves as a compounding variable in our assessment of annual flood damage. Heavy rains over prolonged periods of time not only cause flooding of agricultural fields, but also tend to destroy roads, bridges, power transmission lines, crop warehouses, agricultural facilities, and rural homes, which distracts the labor force from farming, undermines labor productivity in the fields, and further reduces agricultural output. (U//FOUO)

Figure 2. Activity Schedule for Key Crops (U)



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A Retrospective Look at Past Floods (U)

The most severe impact to agricultural output occurred in 1996 and 2007. All four elements for severe devastation occurred during these flood events: heavy rain during a short period of time over key agricultural producing areas at a critical time in the agricultural growth cycle combined with major infrastructure damage that impeded farming operations. (U//FOUO)

In July 1996, North Korea experienced severe flooding from heavy rain that fell over a 4-day period from 24-28 July (see Figure 3). According to KCNA, North Korea's government news agency, 117 cities and counties in nine provinces were seriously affected, including the main rice growing areas. KCNA estimated the total damage to be more than $1.7 billion. The worst-hit provinces received between 430-750 mm of rain during the four day period. Flooding destroyed 288,000 hectares of arable land, irrigation networks, river embankments and hundreds of dams and bridges, tens of kilometers of power transmission lines, as well as tens of thousands of houses and public facilities. Railroad traffic was disrupted between the major industrial centers of Haeju and P'yŏngyang, as well as P'yŏngyang and Kaesŏng. (U//FOUO)

In 2007, North Korea was hit twice by heavy rain in mid-August and again in September (by Typhoon Wipha), with seventy to eighty percent of the annual rainfall amount falling during that period.

- According to KCNA, ninety-six counties in the key rice growing provinces were impacted (see Figure 4), with thirty-three severely hit with rainfall amounts of between 760 to 840 mm of rain. KCNA reported that the agricultural fields accounting for about 10 percent of North Korea's total arable land (about 268,000 hectares), including 20 percent of paddy rice and 15 percent of corn paddies, were completely submerged.

- Typhoon Wipha completely destroyed Singwang Bridge in Haeju. In 2007, the following dam structures and generating facilities were seriously damaged: T'ongch'ŏn Power Plant No. 1 (T'ongch'ŏn county, Kangwon); Pujŏn Power Plant No. 6 (Sinhŭng county, South Hamgyŏng); Hŏch'ŏn Hydro Power Plant, (Hŏch'ŏn county, South Hamgyŏng) ; and Puchŏn Power Plant No. 6. Construction of major hydro-power plants, including Yo'nsan Army-People Power Plant (Yŏnsan county, North Hwanghae) and Kŭmjingang Kuch'ang HPP (Chŏngp'yŏng county, South Hamgyong), was delayed. Dozens of power transmission substations were under water and kilometers of cables were buried in mud or destroyed.

- According to a UN report, tens of thousands of houses and public facilities were destroyed in addition to railroads, roads, and thousands of sections of bridges. (U//FOUO)

In 2006, heavy rain lasted for seven days from 14-21 July, adversely affecting thirty-three counties and cities, according to KCNA (see Figure 5). During this event, the total amount of rain was less than during the flood events of 1996 and 2007; the worst hit areas experienced from 300 to 500 mm of rain. Moreover, the impact did not affect the key rice or corn growing areas of South and North Hwanghae. According to North and South Korean sources, anywhere from 23,771 to 92,152 hectares of farmland were submerged and washed away. The amount of infrastructure damage was far less than in the 1996 and 2007 floods. No serious harvest problems were reported (U//FOUO)

Assessing the Impact of the 2010 Floods (U)

Using the methodology above, OSW analysts judge with a moderate degree of confidence that the cumulative impact of the two instances this year of heavy rain on the performance of the agricultural sector probably has been relatively low. Rainfall totals and reported infrastructure damage were far less than during the major events of 1996 and 2007 (see Table 1).

- During a 11-day period in July, twenty-three counties and cities mostly in South Hamgyŏng and North P'yŏngan provinces received from 170 to 306 mm of rain, an average of 17-30 mm per day.

- Typhoon Kompasu during a two-day period in early September brought strong winds and total rainfall amounts of up to 150 mm (or up to 75 mm per day), primarily affecting counties and cities in the South and North Hwanghae and Kangwŏn provinces. According to the North Korean news agency KCNA, 30,550 hectares of standing crops were flooded, buried, or washed away (see Figure 6). (U//FOUO)

Figure 3. North Korean Provinces Receiving Heavy Rain in 1996 (U)

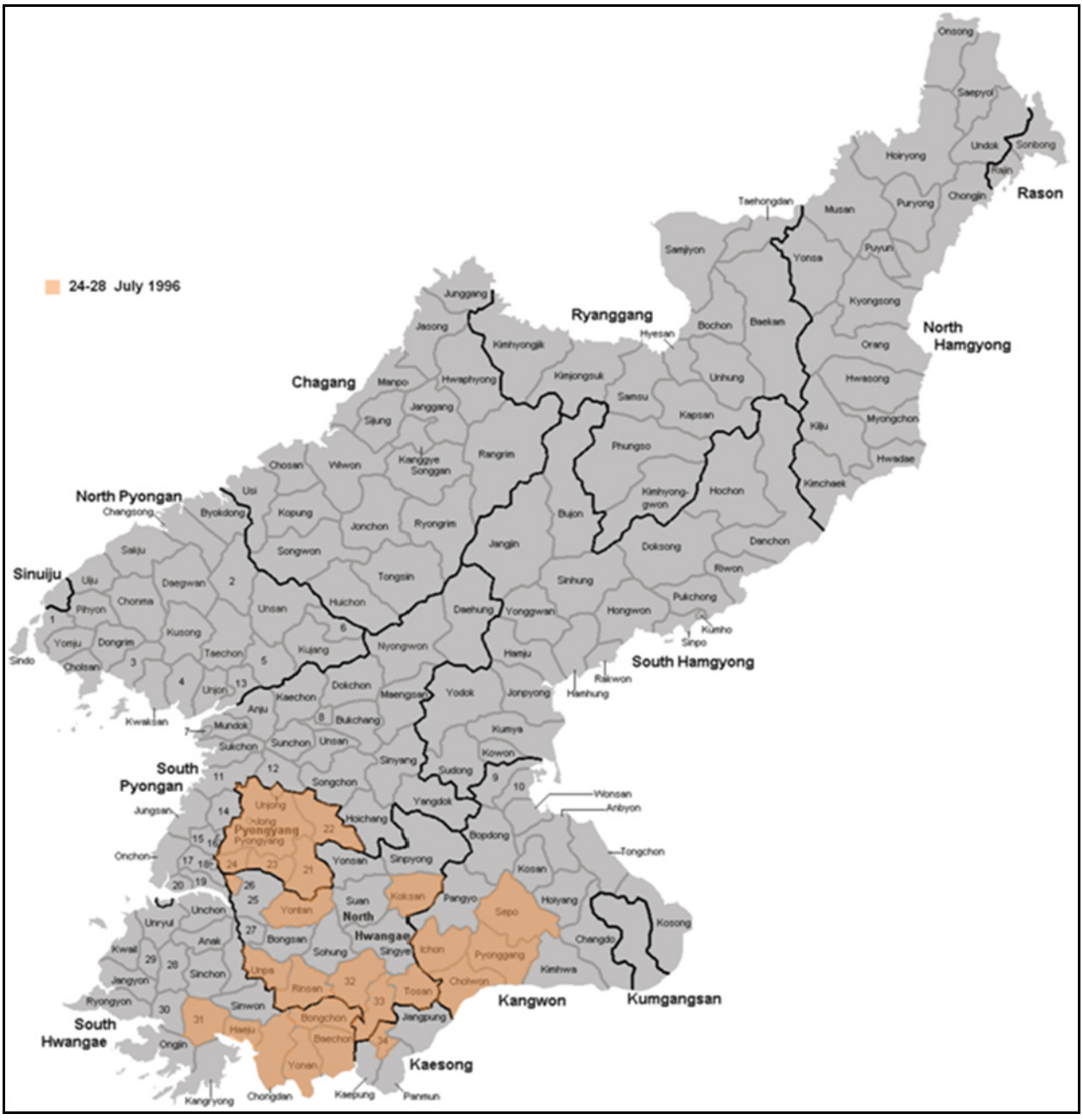

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Figure 4. North Korean Provinces Receiving Heavy Rain in 2007 (U)

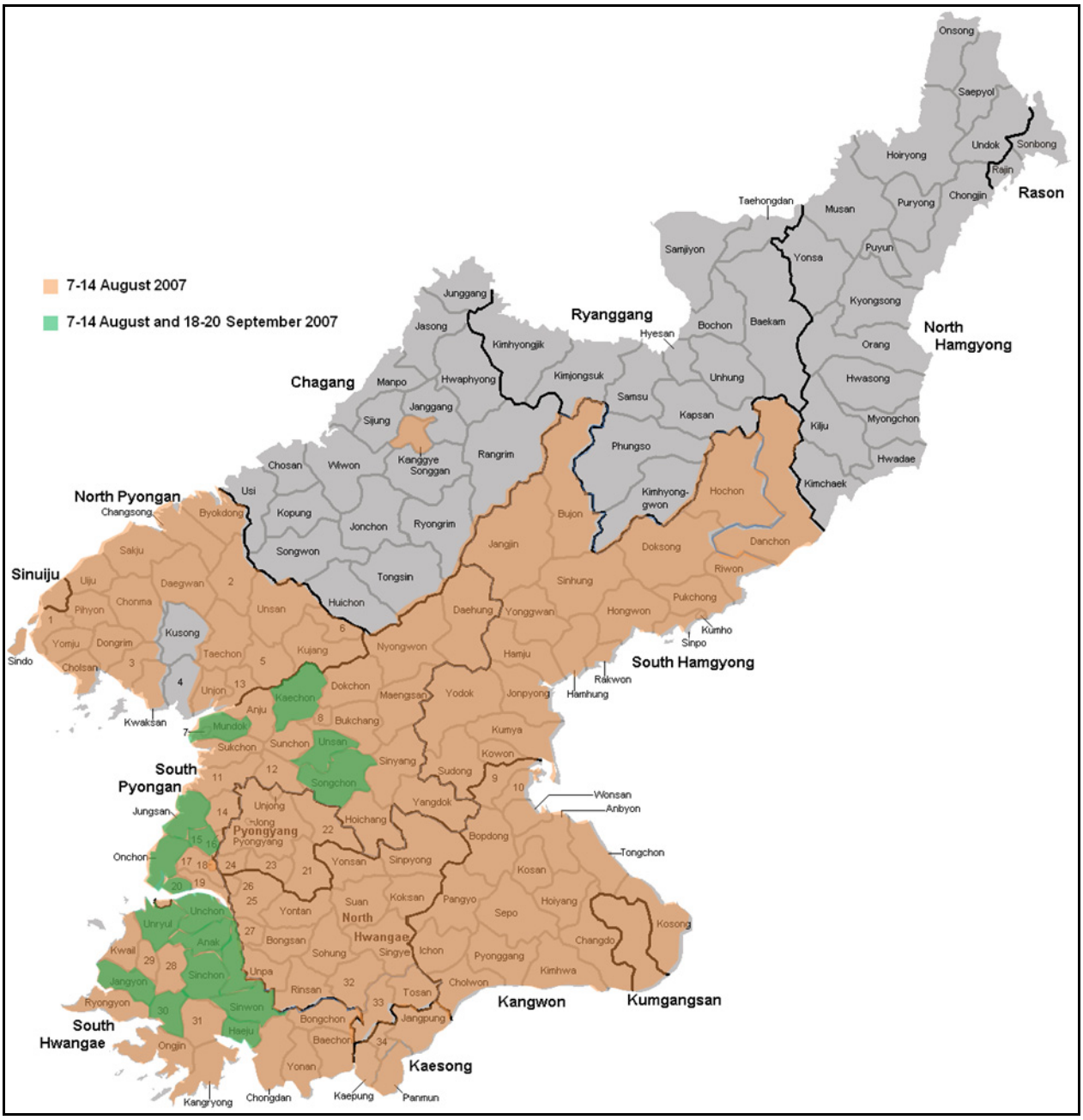

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Figure 5. North Korean Provinces Receiving Heavy Rain in 2006 (U)

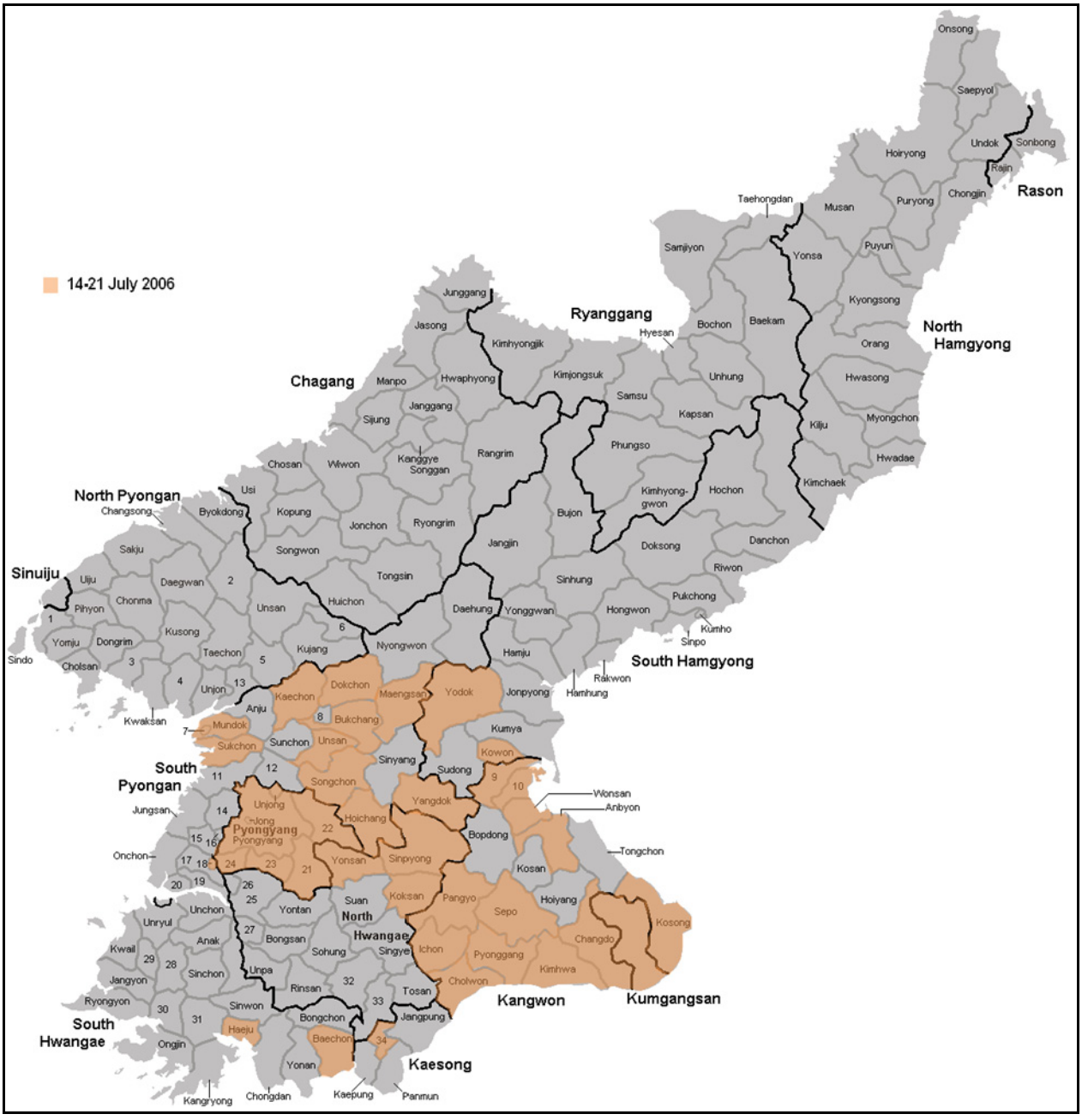

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Figure 6. North Korean Provinces Receiving Heavy Rain in 2010 (U)

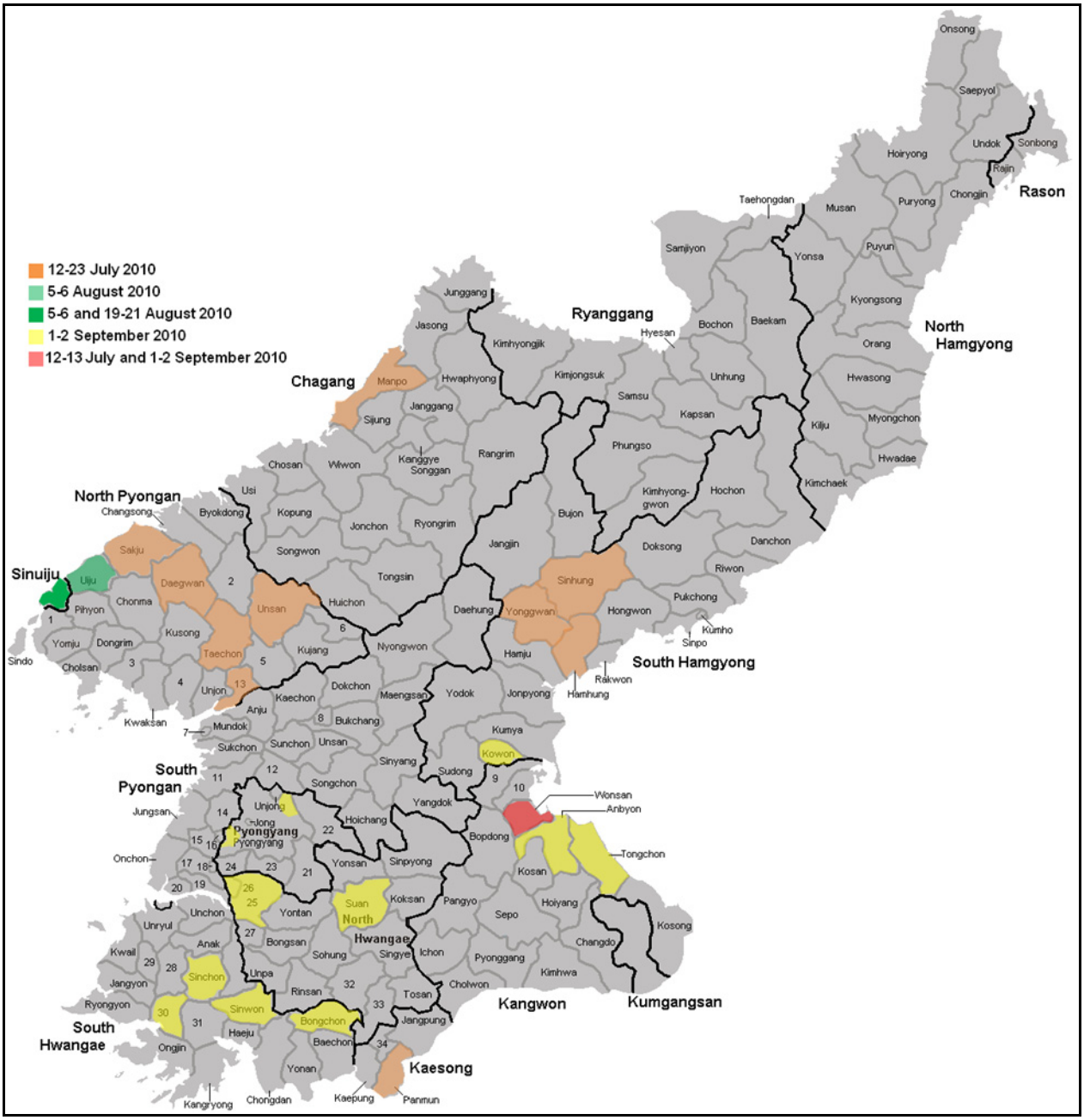

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Table 1. Data on Specific Flood Events (U)

Year	Total Rainfall (mm)	Time of Year	Intensity of rain (mm/day)	Total Area Submerged (hectares)	Length of Power Lines Damaged (km)	Number of Roads, Railways, and Bridges Damaged	Number of Houses and Public Facilities Damaged	Impact
1996	430-750	24 - 28 Jul	108-188	288,000	50	Roads: 7,600 km Road bridges: 535 Railway bridges: 4	Homes: 8,260; Public facilities: 3,825	**Severe**
2006	300-500	14-21 Jul	43-71	23,771 - 99,152	Insignificant damage	Roads: 168 km Road bridges: 231; Railway bridges: 30	Homes : 28,747 (12,500 destroyed; 17,500 partially damaged; 45,000 submerged); Public facilities: 1,180	**Moderate**
2007	300-400	18-20 Sep	150-200	32,278	40	Railway bridges: 23 Roads: 600 km;	Homes : 40,463 destroyed; 67,056 partially damaged; 3,732 submerged; Public facilities: 8,000	**Severe**
	500-760	7-14 Aug	71-108	268,000				**Severe**
2010	50-150	1-2 Sep	25-75	30,550	Negligible damage	Roads: 1 km; Bridges: 4	Homes: 19,307 Public Facilities: 580	**Moderate**
	170-300	12-23 Jul	17-30					**Low**

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