Landmines and Explosive Ordnance in Cambodia: Clearance and Risk

Background: A Legacy of Conflict

Cambodia is one of the most heavily landmine-contaminated countries in the world, with landmines being one of the primary weapons systems for all combatants in civil wars before, during, and after the Khmer Rouge period. The areas of most intense contamination lie along the Thai border, known as the K5 mine belt, and were primarily constructed by the occupying Vietnamese military.

Landmines from all over the world have been found in Cambodia, with the primary source countries being China, the United States, and Russia. Since 1979, more than 65,000 Cambodians have been killed or injured in landmine and explosive war "accidents."

Cambodia was also heavily (and secretly) bombed by the United States, primarily in eastern Cambodia along the Vietnamese border, in order to eliminate cross-border safe havens for various North Vietnamese factions operating in Cambodia (Davies, 1994). The distribution of approximately 120,000 US bombing strikes is shown in Figure 1, based on declassified US Air Force targeting records, provided by the Cambodian Mine Action and Victim Assistance Authority (CMAA).

Since the early 1990s, intense international mine action efforts have attempted to rid Cambodia of landmine and explosive ordnance contamination, but extensive contamination remains (Figure 2), and even official humanitarian clearance operators do not always find all of the explosive hazards while clearing. Using information from CMAA, I examined how effective and thorough official clearance efforts have been, with a specific focus on accident patterns by region and examining the safety of cleared land by comparing the clearance records to records of landmine and explosive ordnance incidents.
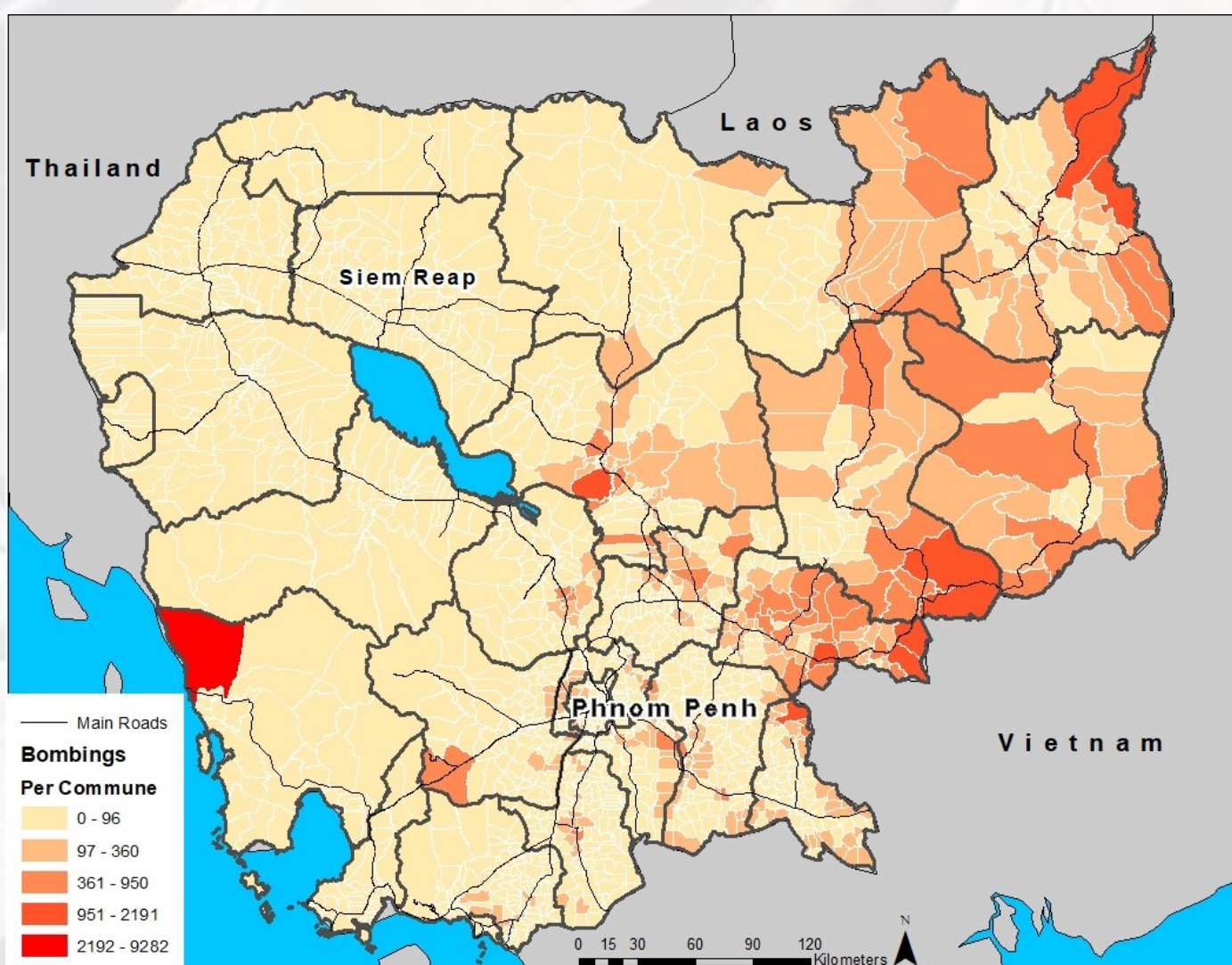
Data

All data used for this study were provided by the Database Unit at the Cambodia Mine Action and Victim Assistance Authority, which compiles information from official humanitarian mine action organizations operating in Cambodia including the Cambodian Mine Action Centre, The HALO Trust, Mines Advisory Group, Norwegian People's Aid, Cambodian Self-Help Demining, and the National Centre for Peacekeeping Forces.

The information provided included a record of US bombing strikes, records of hazardous area clearance completion by all operators since 1992, records of landmine and EO incidents since the mid-1990s, the current "baseline survey" information denoting hazardous areas, and boundary files for Cambodia's provinces, districts, and communes (the lowest administrative level for which shapefiles exist), as well as information regarding major roadways, internal waterways, and neighboring countries (Thailand, Laos, and Vietnam). All information was provided in vector format.

Critical for this analysis was the ability to differentiate between "mine" and explosive remnants of war (ERW, an outdated term for EO) incidents, which was contained within the master list of landmine and EO incidents. Additionally, it was important to know the operator responsible for having cleared specific hazardous areas, the dates on which clearance concluded and the dates on which incidents occurred, as well as the total area (in square meters) that individual operators have cleared in Cambodia since 1992.
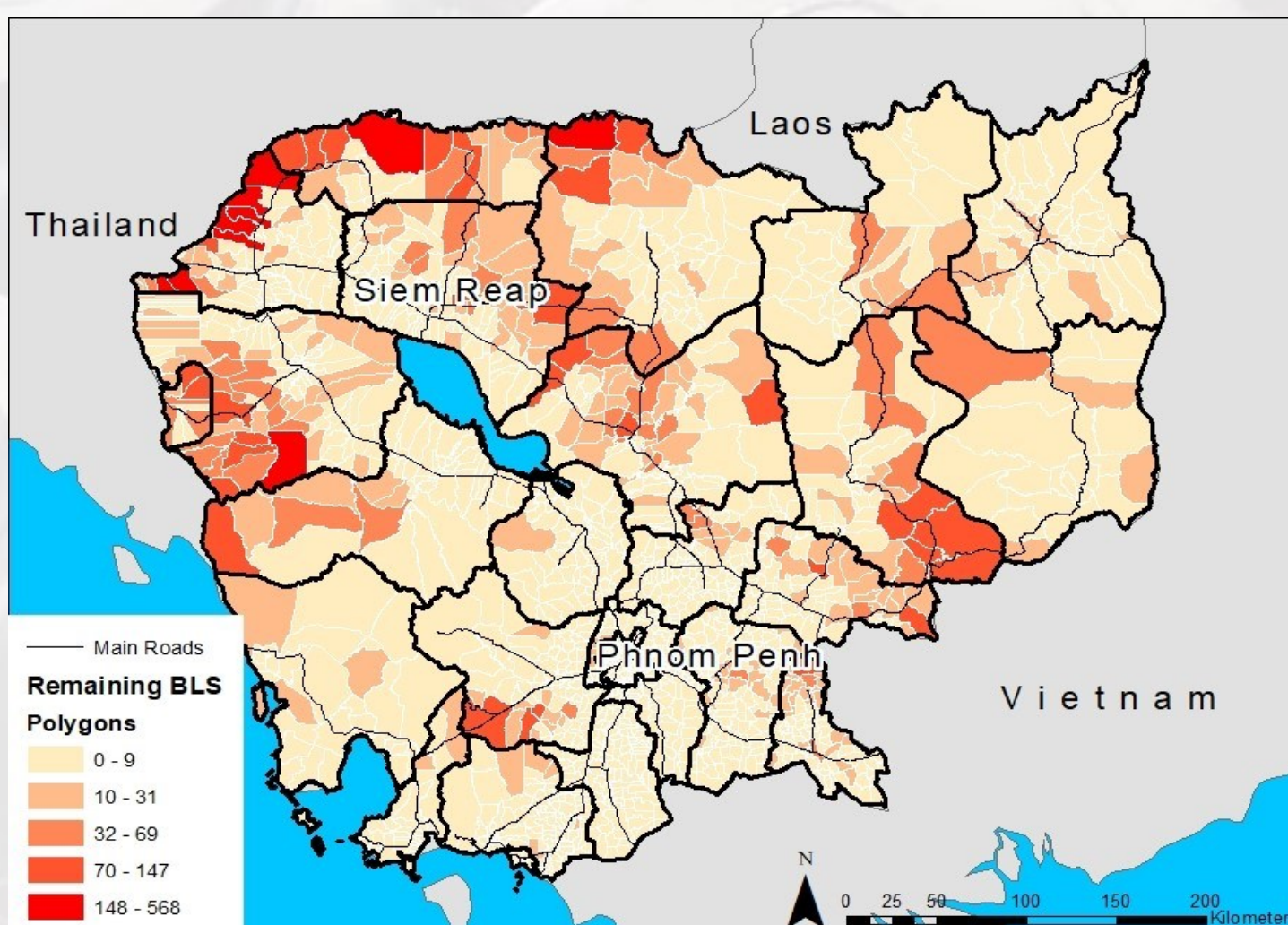
Methods:

To map the density of clearance tasks throughout Cambodia, I calculated the centroid of all clearance polygons by using the calculate geometry feature, and re-plotting the XY coordinates of the clearance polygon centroids. Using the provincial boundaries layer as a mask, I created a raster layer displaying the kernel density of the clearance tasks, shown in Figure 3.

To determine which landmine and EO incidents occurred on cleared territory, I used the "all operators' completion" layer, and used a spatial join to connect the geocoded incidents to the cleared polygons layer. Next, I selected by location the incidents which were contained within the clearance polygons, and then used a SQL query to identify the incidents whose recorded date was after the completion date of the hazardous area clearance. This selection process produced 171 points, which are also show in Figure 3.

I exported the accompanying information for the 171 points to a .csv file, which I analyzed using a pivot table in Microsoft Excel 2019. Using this information, it was possible to produce Figures 4, 5, and 6 , displaying the operators responsible for cleared territory on which accidents occurred, the number of accidents per square kilometer of territory cleared by the same operators, and the distribution of incidents on cleared territory by device type. I also used information in the incidents data provided by the Cambodian Mine Victim Information System (CMVIS, part of CMAA) to determine the overall breakdown of incidents on cleared territory by device type, as it's possible the explosive ordnance may have been moved into cleared territory, but much less likely for landmines.

Methods (continued):

To set the context, I mapped the distribution of US bombing strike by using a spatial join to connect the bombing strikes to the commune boundaries layer. I also mapped the distribution of the remaining BLS polygons by using a spatial join to connect the BLS polygons to the commune boundaries layer.

To show the geographic distribution of different categories of incidents (based on device type), I selected all incidents caused by mines and all incidents listed as having been caused by ERW (IEDs were not present in the geocoded data), and used spatial joins to connect these sub-lists to the commune boundaries layer. I also used a spatial join to connect the entire catalog of geocoded incidents to the commune boundaries, as there are key differences between the distribution of landmine and EO incidents geographically which were not apparent in the aggregate information that is generally presented.

Results:

Figure 3 displays the key piece of analysis which shows that the incidents on officially cleared territory do occur in the most dense areas of clearance, as well as in clusters near the Thai border. The incidents on cleared territory took place primarily in Battambang, Banteay Meanchey, and Oddar Meanchey provinces, which have also seen the lion's share of clearance work over the years. Figure 4 shows that clearance by "Org 1" was responsible for the majority of accidents on cleared territory, but that "Org 3" had the highest rate of accidents on cleared territory per square kilometer of cleared land, at about the twice average rate (Figure 5). Figure 6 shows that the share of accidents on cleared territory is higher from landmines than explosive ordnance, not surprising given the difficulty in detecting deeply buried anti-tank mines.

Conclusions:

The determination that at least 170 incidents have been recorded on officially cleared territory is problematic, because to my knowledge, none of these incidents have been investigated according to the protocols contained within International Mine Action Standards 10.60 "Reporting and Investigation of Demining Incidents," although this standard is written more for those incidents which occur during the demining process itself.

The findings regarding incidents on cleared land are evidence to support conclusions made in Millard et al.'s article which states that community trust in the safety of the product of demining work is critical to ensure that cleared land is put into productive use immediately, which is necessary to recoup (in the aggregate) the resources expended on the demining process (Mulli & Paterson, 2012; Keeley, 2006).

Figure 9 shows the distribution of all incidents in Cambodia, while Figure 7 shows the distribution of only landmine incidents. The mapping of mine and EO incidents, which was supposed to be contextual, was surprising because it shows a high concentration of EO incidents in central and western Cambodia (Figure 8), which is surprising because the bombings which would have produced the majority of the EO contamination (in the form of unexploded cluster submunitons) are concentrated in Eastern Cambodia. This supports econometric analysis that suggests there is significant movement of ordnance from eastern to western Cambodia in order to exploit the higher prices in Thai scrap years compared to their Vietnamese counterparts, which is further supported by the large number of EO incidents which appear along the main road west to Siem Reap from eastern Cambodia (Roberts, 2011).

Figure 1: US Bombings per Commune, 1965-1975

Figure 2: Remaining "Baseline Survey" (BLS) Polygons by Commune.

Landmine & EO Incidents on Cleared Land compared to the Density of Clearance
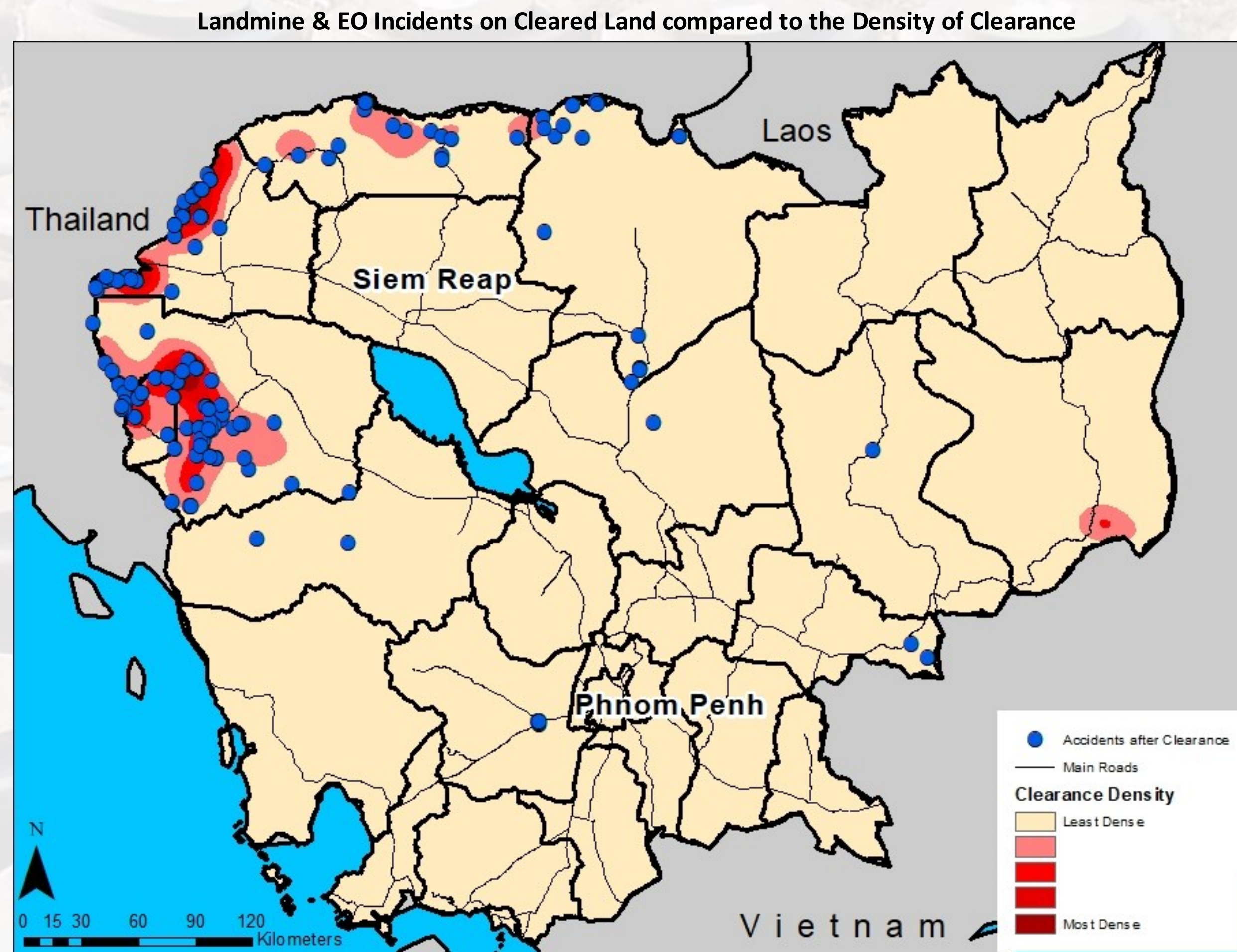

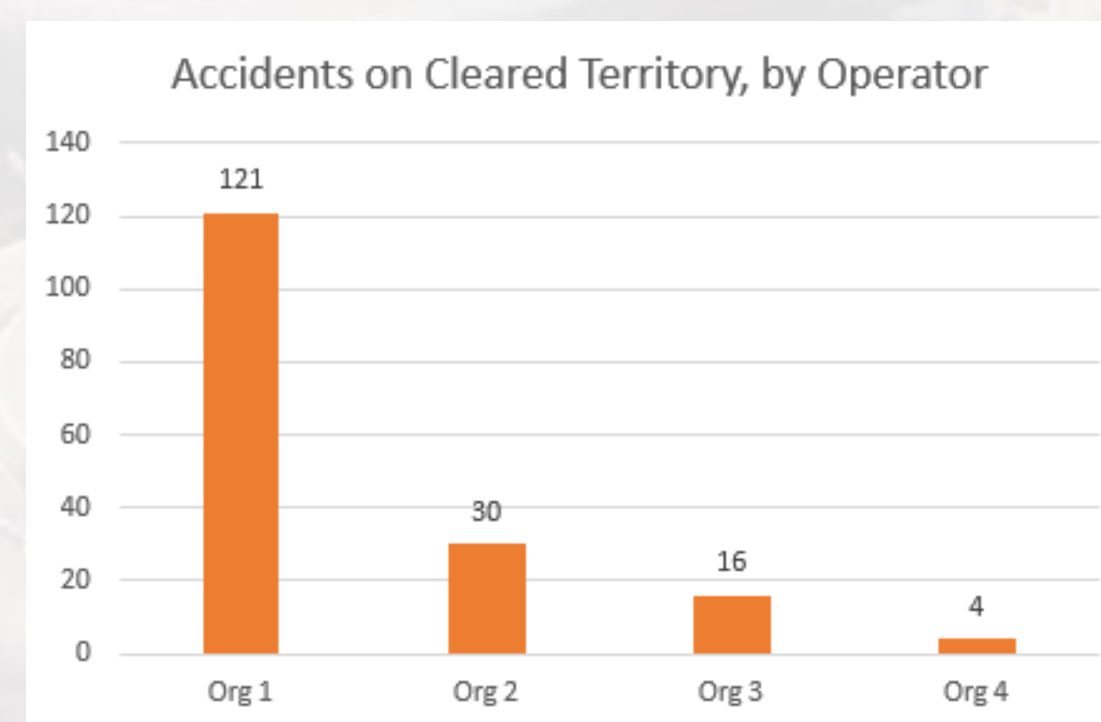Figure 3: Incidents on Officially Cleared Land Compared to Clearance Density.
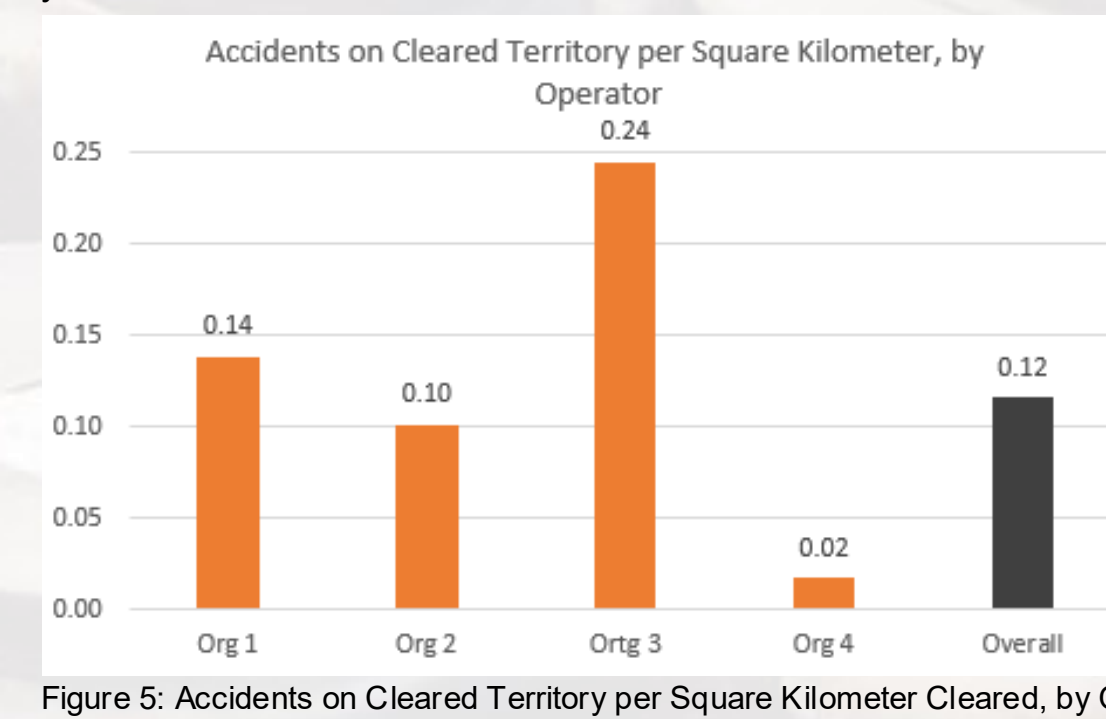

Figure 4: Incidents on Cleared Land, by Operator.

Figure 5: Accidents on Cleared Territory per Square Kilometer Cleared, by Operator.
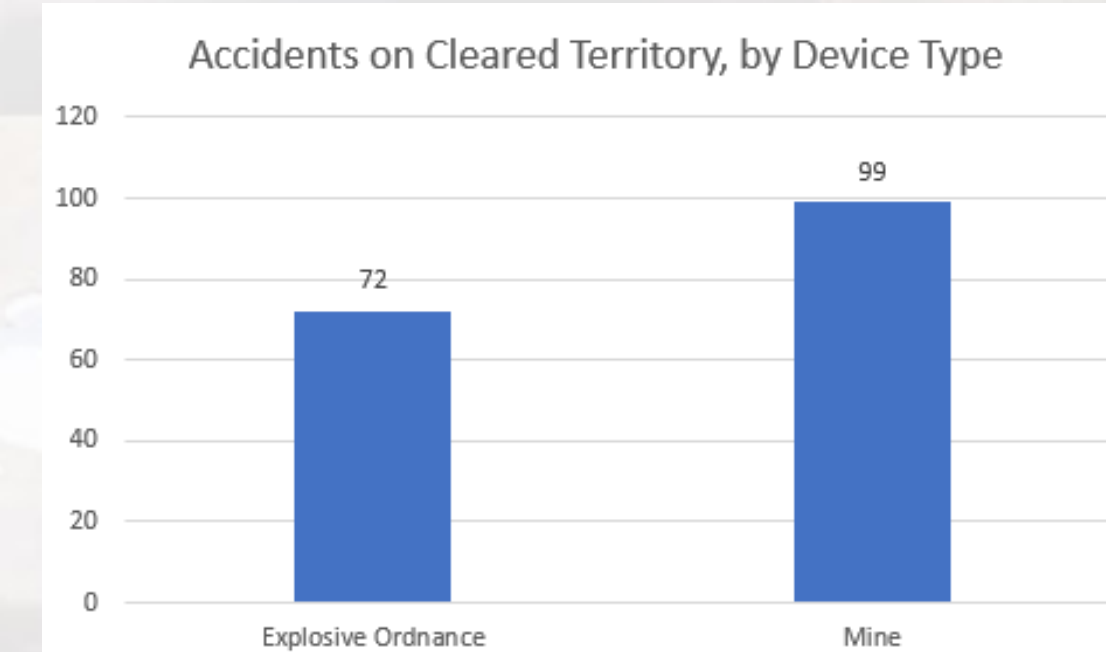

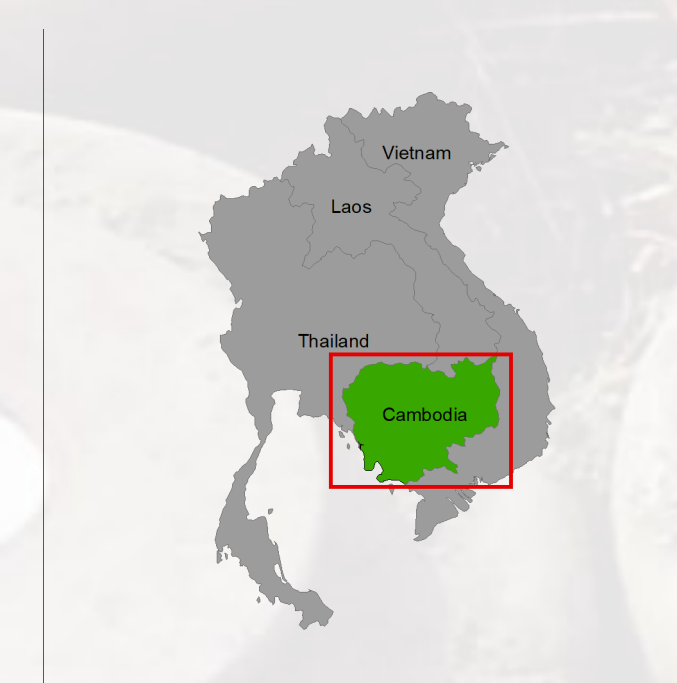Figure 6: Incidents on Cleared Territory, by Device Type.

Figure 7: Mine Incidents by Commune.

Figure 8: Explosive Ordnance Incidents by Commune.
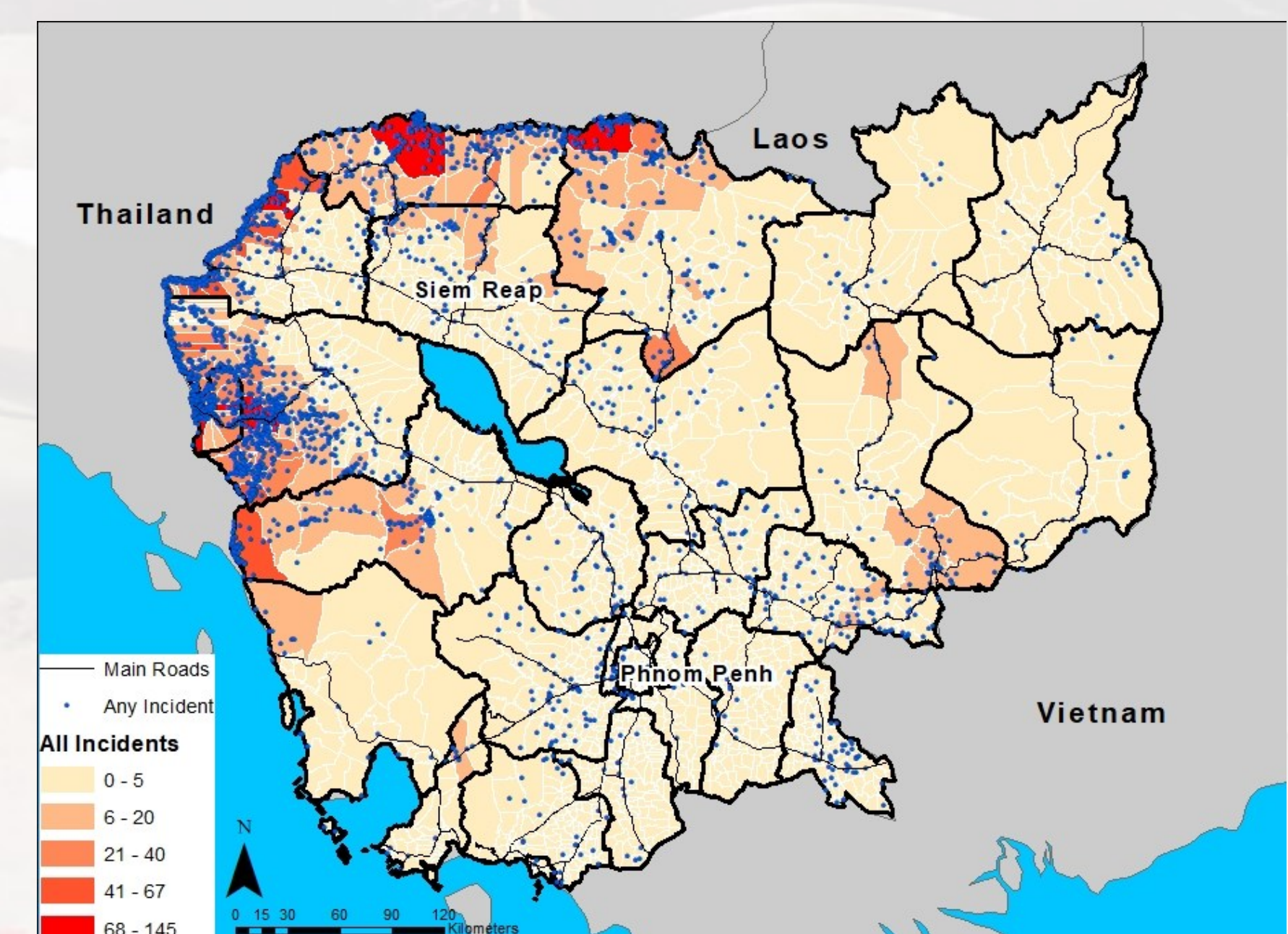
Figure 9: All Incidents by Commune.

Cartography: Jeremy Danz, The Fletcher School of Law and Diplomacy at Tufts University
Data Source: Database Unit, Socioeconomic and Planning Department, Cambodian Mine Action and Victim Assistance Authority & Cambodia Mine Victim Information System
Image: UNDP Cyprus
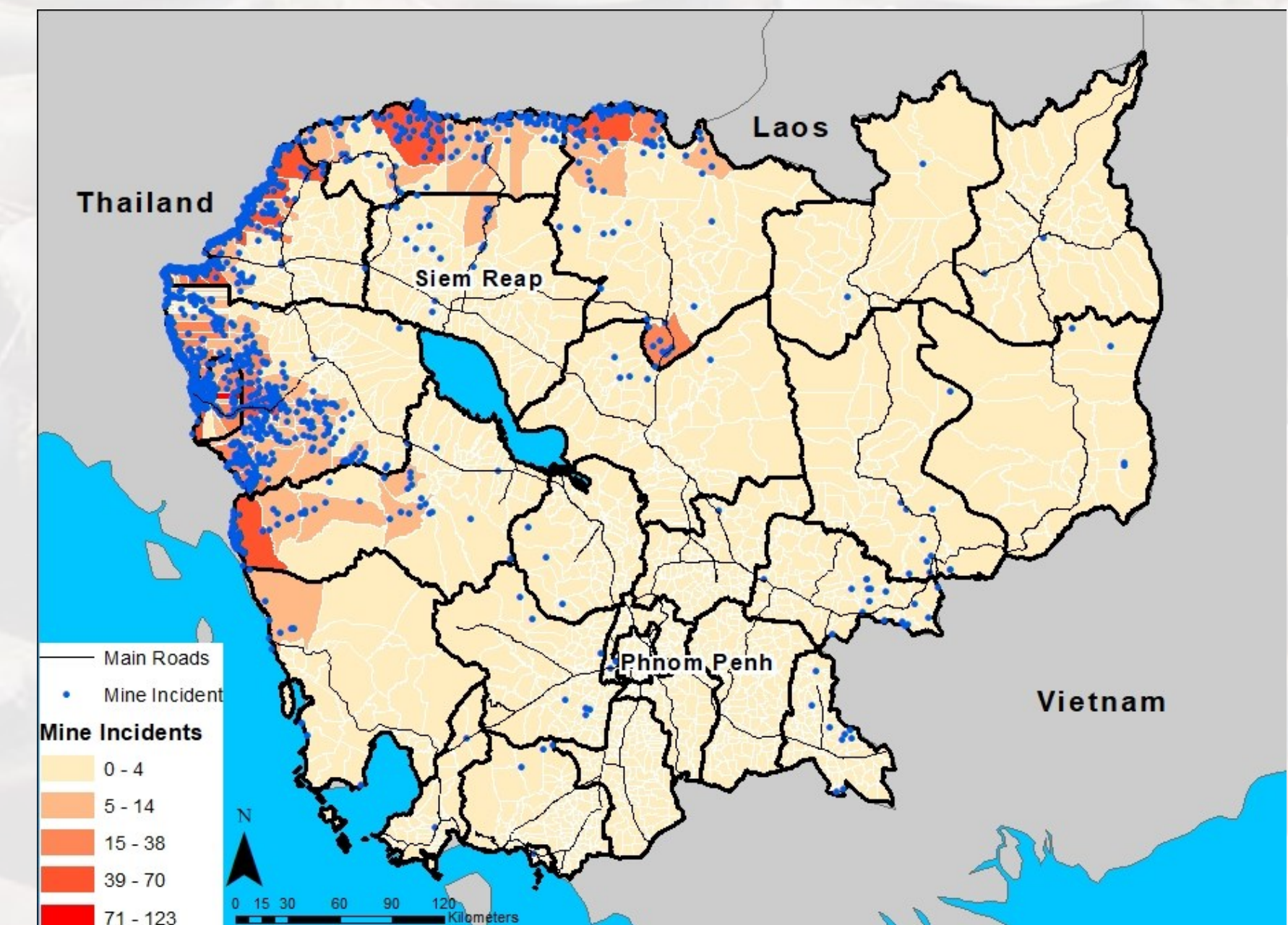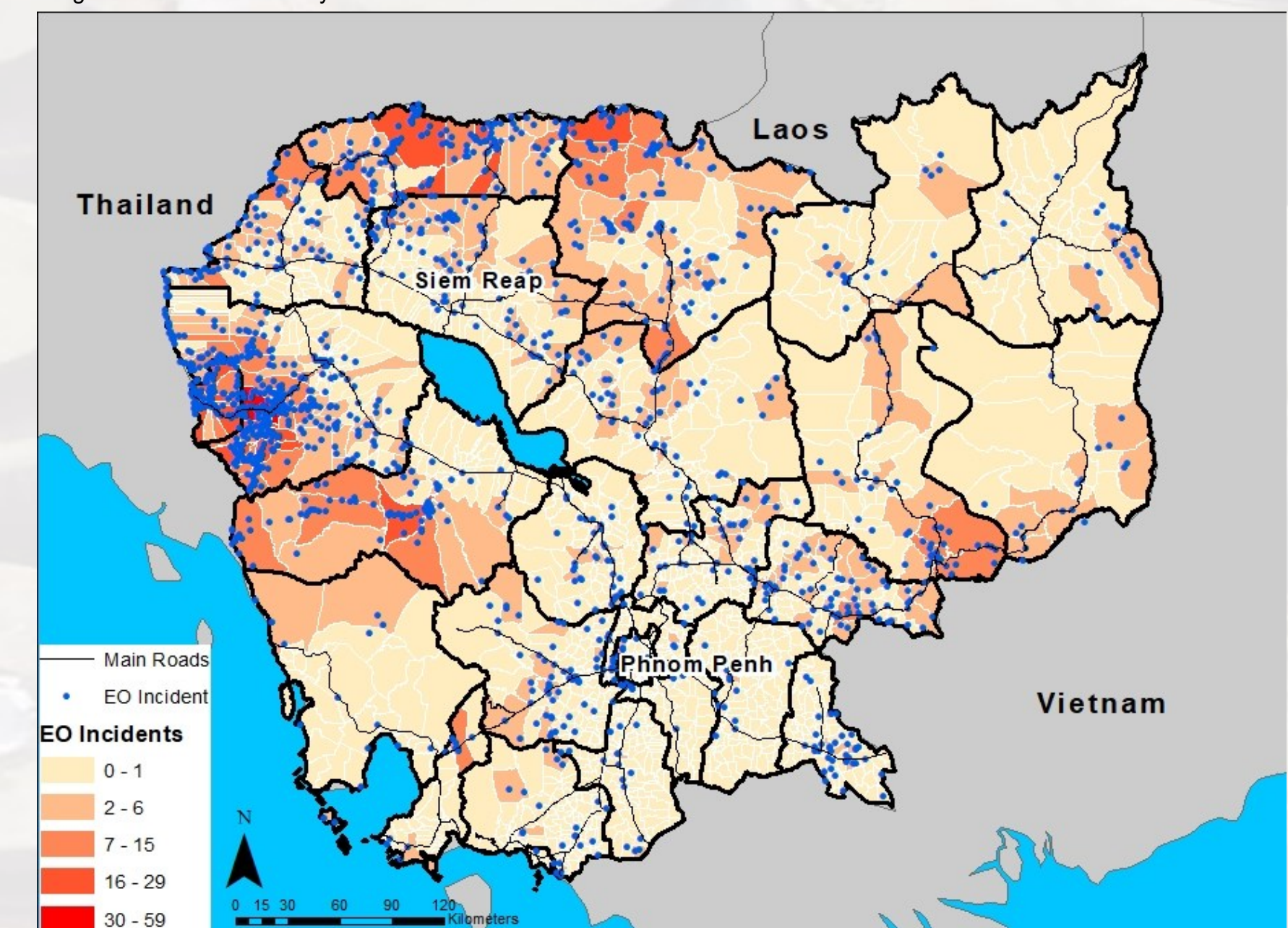NUTR 0231: Fundamentals of GIS, 12 December 2019

References:

Davies, P. (1994). *War of the Mines: Cambodia, Landmines and the Impoverishment of a Nation*. London, England: Pluto Press.

Millard, A. S., Harpviken, K. B., & Kjellman, K. E. (2002). Risk Removed? Steps Towards Building Trust in Humanitarian Mine Action. *Disaster, 26(2)*, 161–174.

Mulli, A. S., & Paterson, T. (2012). Priority-Setting in Mine Action: Getting More Value for the Investment. *Journal of ERW and Mine Action, 16(2)*, 62–65.

Roberts, W. (2011). *Landmines in Cambodia: Past, Present, and Future*. Amherst, NY: Cambria Press.

Keeley, R. (2006) *The Economics of Landmine Clearance*, London, England: University of London.