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Predicting the Likelihood of Human-Elephant Conflict and Assessing Patterns in Elephant Movements Over Varying Habitat Conditions in the Kavango-Zambezi Area

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ABSTRACT

In the Kavango-Zambezi area of southern Africa, three million people live within areas frequently traveled by free-ranging elephants. As the region continues to develop rapidly, urban and agricultural settlements further encroach upon the land that these elephants use. As elephants come into more frequent contact with urban and agricultural areas, human populations face financial loss through crop damage and the potential for injury from direct conflict with elephants. Elephant populations are also at risk of injuries from conflict as well as illness related to the consumption of waste. In order to implement human-elephant conflict mitigation strategies, local conservation groups need to be informed on best practices for coexistence. This project aided The Ecoexist Project and Connected Conservation in understanding the ecological factors that drive elephant movement into human settlements and provided Earth observation data to support conflict management in the future. The team used Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI) data to create land use land cover maps and calculate vegetation indices, and used TerraClimate data to analyze drought conditions. These classified maps allowed us to display a time series of human settlement from 1990 to the present and were made explorable alongside other environmental variables in an updated Google Earth Engine (GEE) tool. This project also provided heat maps that show the risk of human-elephant conflict based on historical data of human-elephant conflict (HEC) locations. This analysis will provide support for conservation experts in determining best practices for future mitigation and prevention of human-elephant conflict.

***Figure 1*. The study region,** encompassing areas in Botswana, Zimbabwe, and Namibia.

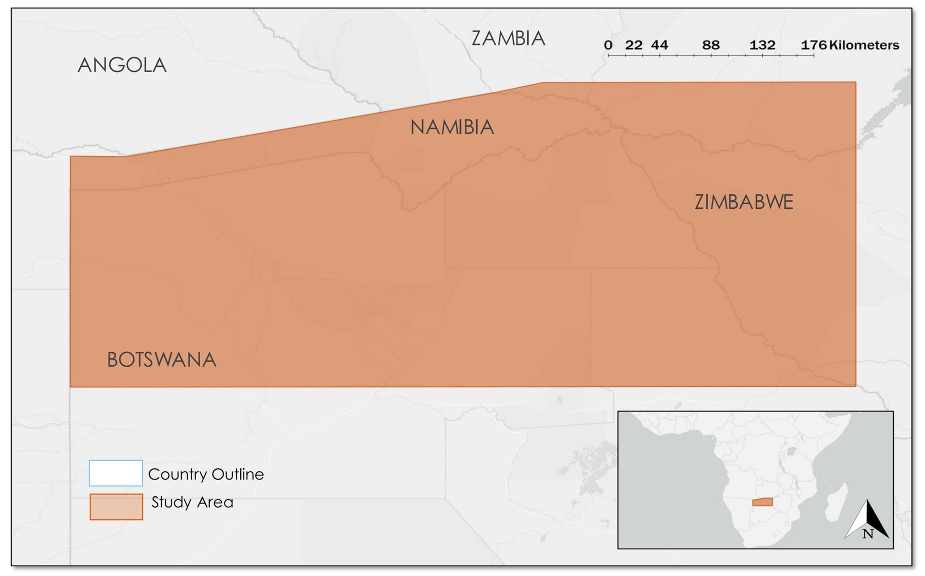


***Table 1*. Summary of datasets**

Dataset or Sensor	Variable
Landsat 5 Thematic Mapper (TM) Surface Reflectance Tier 1	Normalized Difference Vegetation Index (NDVI) Soil Adjusted Vegetation Index (SAVI) Land Use Land Cover (LULC)
Landsat 8 Operational Land Imager (OLI) Surface Reflectance Tier 1	NDVI, SAVI, LULC
TerraClimate Monthly Climate & Climatic Water Balances for Global Terrestrial Surfaces	Palmer Drought Severity Index (PDSI), Surface temperature, Precipitation accumulation
Shuttle Radar Topography Mission (SRTM) Elevation	LULC

LAND USE LAND COVER CLASSIFICATION: METHODOLOGY

***Figure 2*. Overview of LULC classification via Random Forest Algorithm performed in Google Earth Engine.**

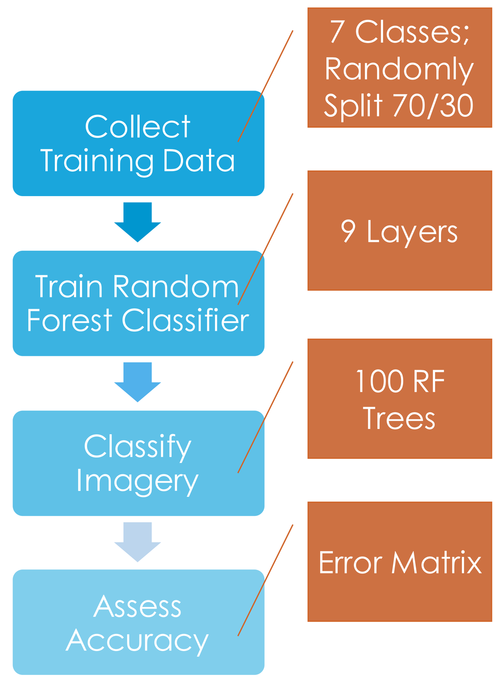


***Table 2*. LULC classes of interest.**

Class	Land Cover
0	Bare
1	Urban
2	Agriculture
3	Water
4	Wetland
5	Woodland
6	Grassland

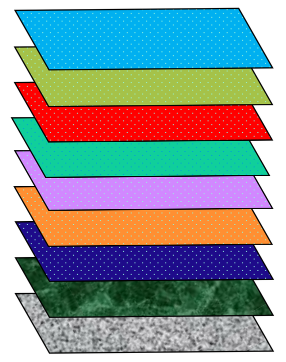


***Figure 3*. The nine layers used by the Random Forest Classifier.**

LAND USE LAND COVER CLASSIFICATION: RESULTS

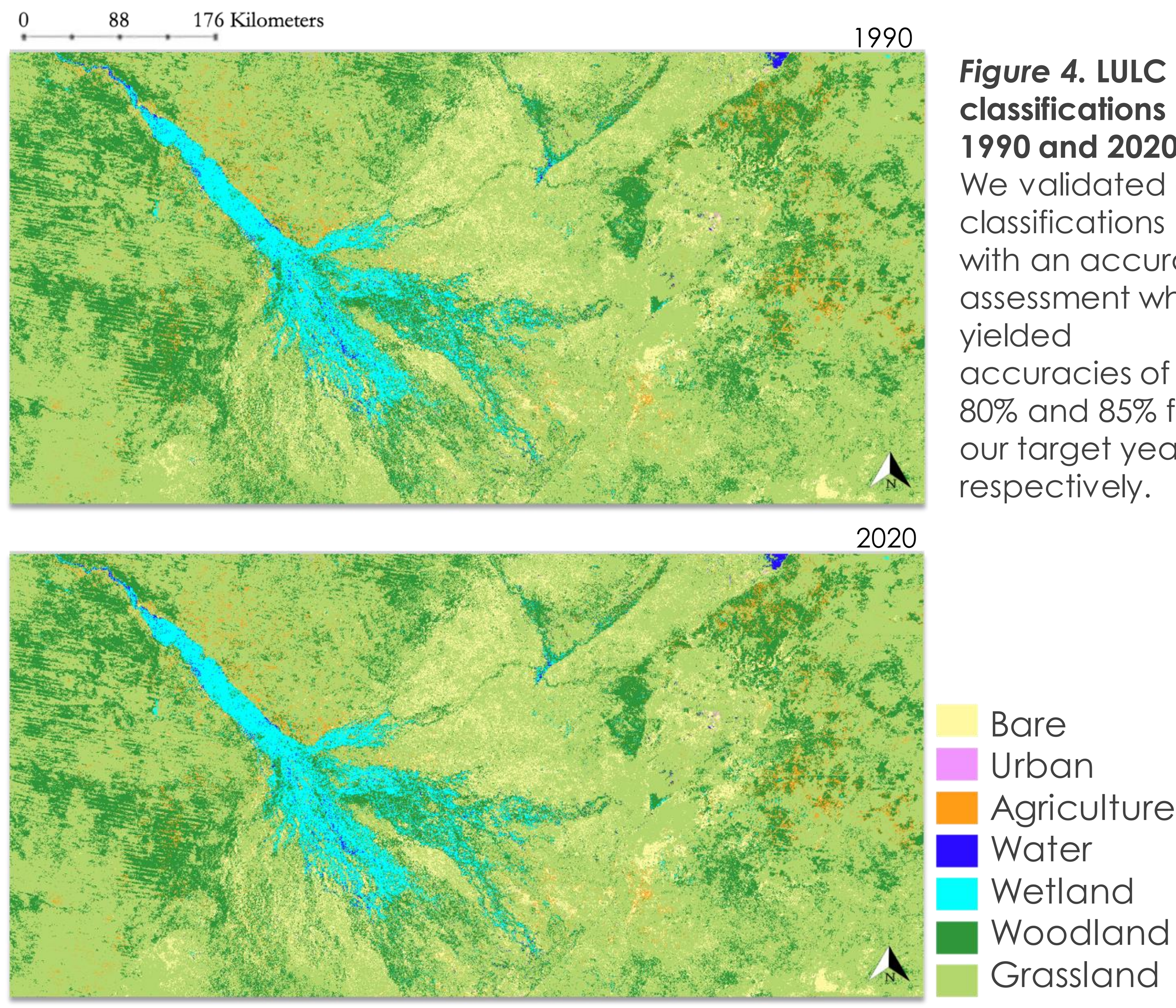


***Figure 4*. LULC classifications for 1990 and 2020.** We validated our classifications with an accuracy assessment which yielded accuracies of 80% and 85% for our target years, respectively.

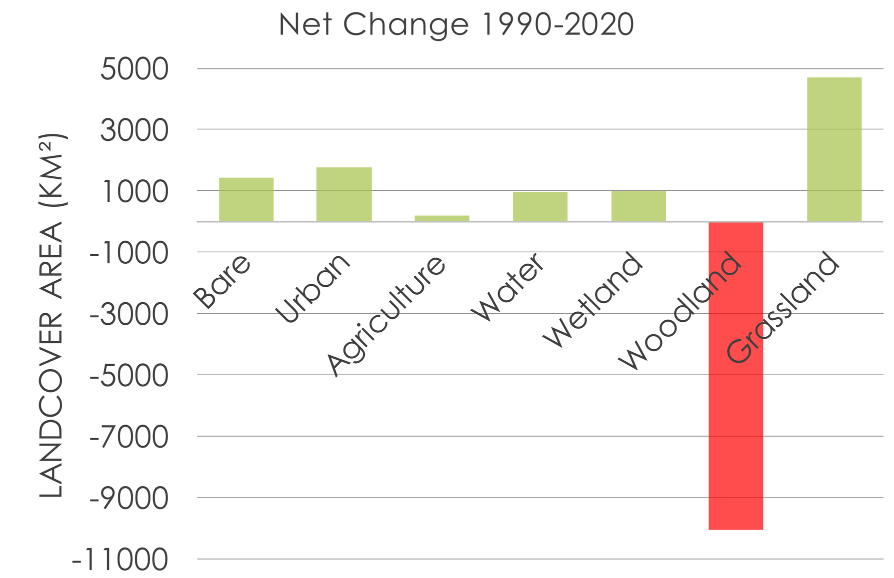


***Figure 5*. Land Cover Change (1990-2020).** There was a notable loss in woodland cover, nearly 10,000 km². Agriculture increased only slightly over the last two decades when compared to urban, which increased by almost 2,000 km².

HEC INCIDENCE ANALYSIS: METHODOLOGY

Human-induced Habitat Fragmentation

Variable Dry Season Span

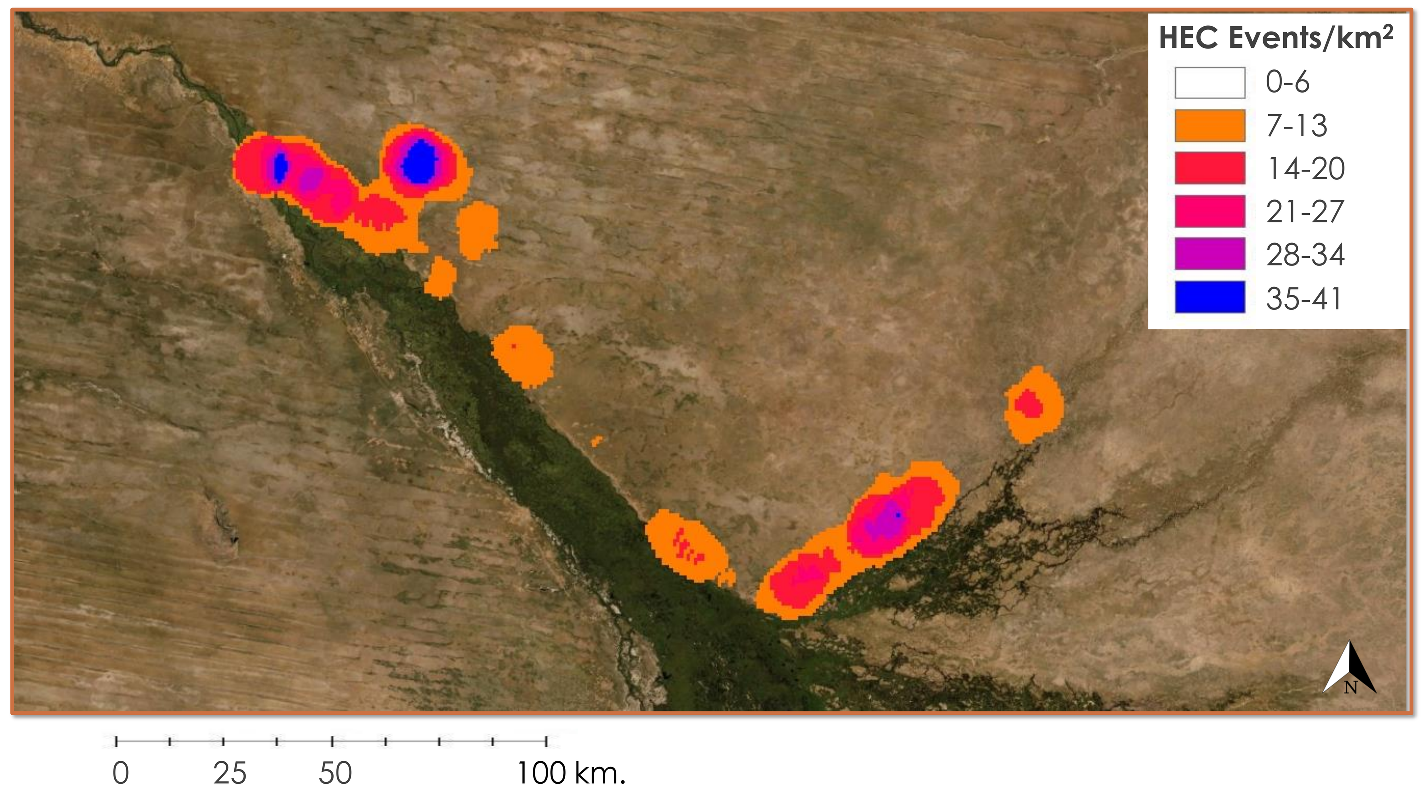
Elephant Presence in Residential & Agricultural Areas

Partners at Connected Conservation and The Ecoexist Project provided us with Human-Elephant Conflict (HEC) incidence reports for Victoria Falls and Botswana. This data spanned the years 2008 to 2019. In addition to GPS coordinates, attributes related to both farmer and elephant demographics, agriculture, and more were recorded. **Which areas are getting raided the most? Could this data highlight key areas to focus conservation efforts on?**

Images: The Ecoexist Project

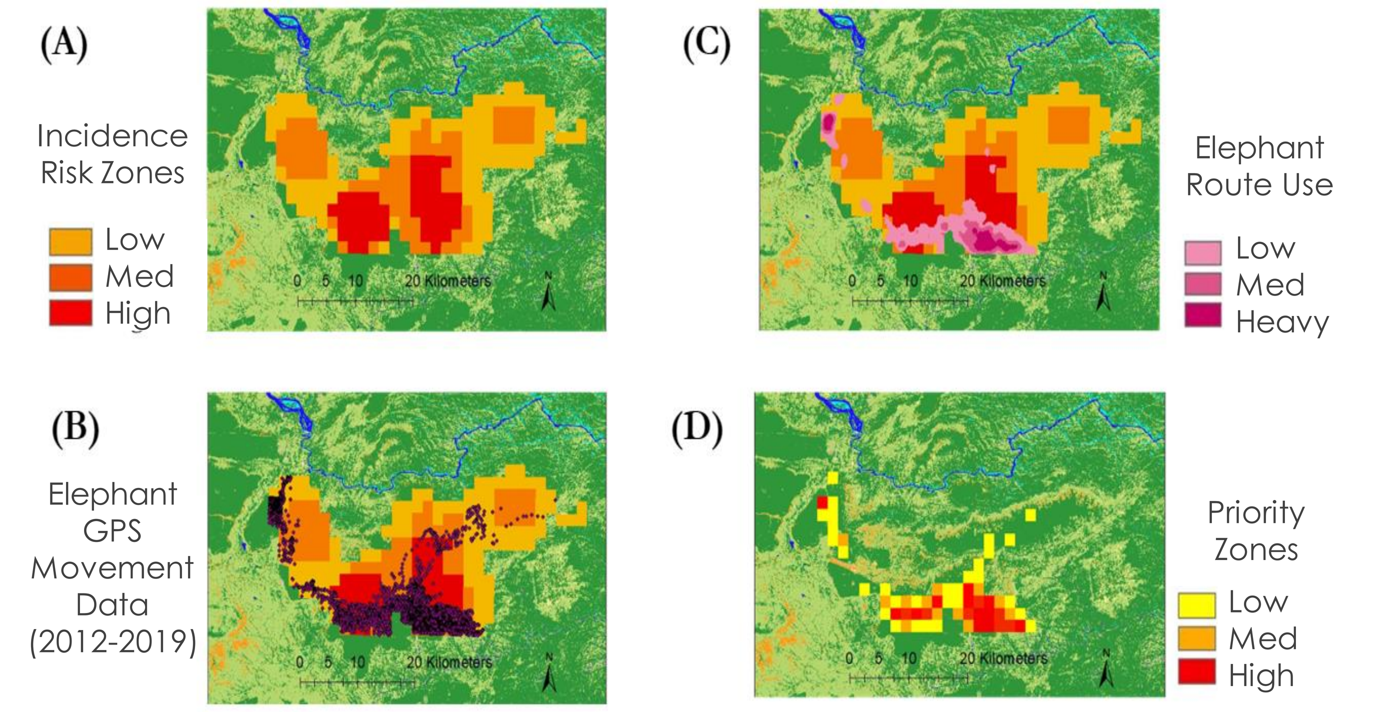
HEC INCIDENCE ANALYSIS: RESULTS

***Figure 6*. Heatmap of Human-Elephant Conflict historical incidence (2008-2019) in the Okavango Delta region, Botswana.**



HEC INCIDENCE ANALYSIS: ELEPHANT GPS DATA

***Figures 7a-d*. The HEC incidence data for Victoria Falls** was sharpened using additional elephant GPS tracking data from 2012-2019. This highlighted priority zones for conservation and avoidance efforts to be focused at based on corridor usage frequency.



CONCLUSIONS & ACKNOWLEDGMENTS

Available woodland elephant habitat **declined** while urban and agricultural lands **expanded**, based on our Land Use Land Cover classification results. Woodland habitat available to elephants declined by **10,000 km²**. Hopefully, Google Earth Engine tool will allow partners to continuously monitor human-elephant conflict drivers. One branch of **future work** includes incorporating more high resolution imagery that could help differentiate between riparian vegetation and wetlands to create two distinct classes.

Ferrell Osborn, Malvern Karidozo (Connected Conservation); Dr. Graham McCulloch, Dr. Anna Songhurst (The Ecoexist Project); Marguerite Madden, Sergio Bernardes, William Langbauer, Andrea Presotto, (Advisors); Darcy Gray, Crystal Wespestad (Fellows); Jennifer Gallucci, Jonathan Moallem, Erika Munshi, Katherine Markham, Anastacia Makati (Special Contributors)

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