Microplastics, Macro Problem: Indonesia's Vulnerability to Microplastic Pollution

Introduction

Microplastic pollution is a danger because they impacts food systems. Particularly in archipelagic countries like Indonesia ,which rely on fish for protein and calories, making sure fish resources are not jeopardized by must be a priority (*Managing Food Insecurity Risk*, 2015). The bottom of the food chain, zooplankton, consume microplastics and are unable to egest them and eat nutrient rich algae causing more algal blooms and damage to the rest of the food chain (Cole et al., 2013). Further up the food chain, bigger species of fish struggle to swim and reproduce as a result of toxins carried in biofilms on microplastics (Rochman et al., 2015). For an archipelagic country that already struggles with food security, damaging an important food resource like fish can have serious implications. The aim is to find the areas most vulnerable to microplastic pollution.

Methods

1. Create a new layer of microplastic points within 100 miles of Indonesia
2. Interpolate (IDW) microplastic estimates across country and reclassify using Natural Jenks (Table 1)
3. Measure Euclidean distances from airports and reclassify using 5 manual breaks (Table 1)
4. Convert land cover polygons into raster and reclassify on 5-point scale (Table 1)
5. Weighted overlay three factors to create vulnerability raster
6. Convert resulting raster into polygons
7. Join new polygons with 2nd Administrative level (Kotas)
8. Measure spatial autocorrelation

Table 1		Vulnerability Score				
Factor	Weight	1	2	3	4	5
River Plastics	50%	0 - 84.29	84.29 - 294.83	294.83 - 839.68	839.68 - 2081.92	2081.92 - 7334.90
Land Use	20%	Other, Permanent Snow	Forests	Flooded Croplands/ Forests	Mosaic Vegetation	Croplands, Artificial Area, Water Bodies
Distance to Airports	30%	0.0 - 0.2	0.2 - 0.4	0.4 - 0.6	0.6 - 0.8	≥ 0.8

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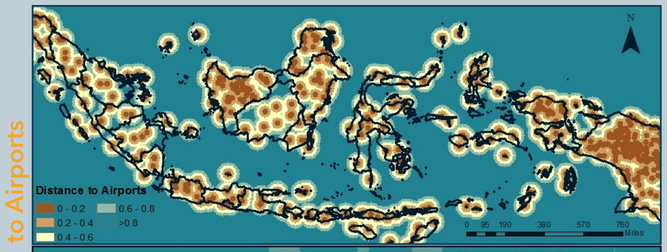
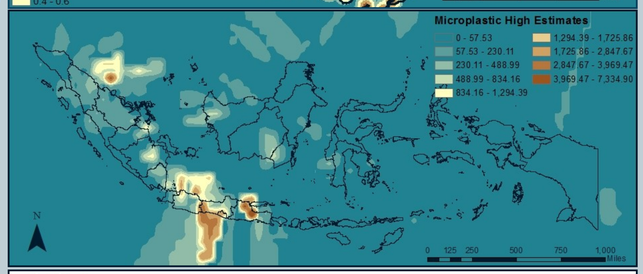
Geographic Coordinate System: GCS_WGS_1984

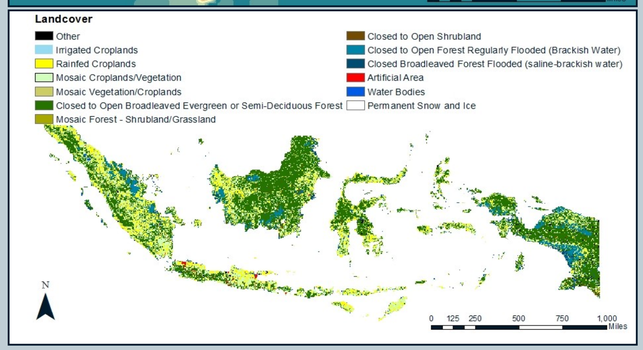
Euclidean Distance to Airports



High Microplastic Estimates



Land Cover

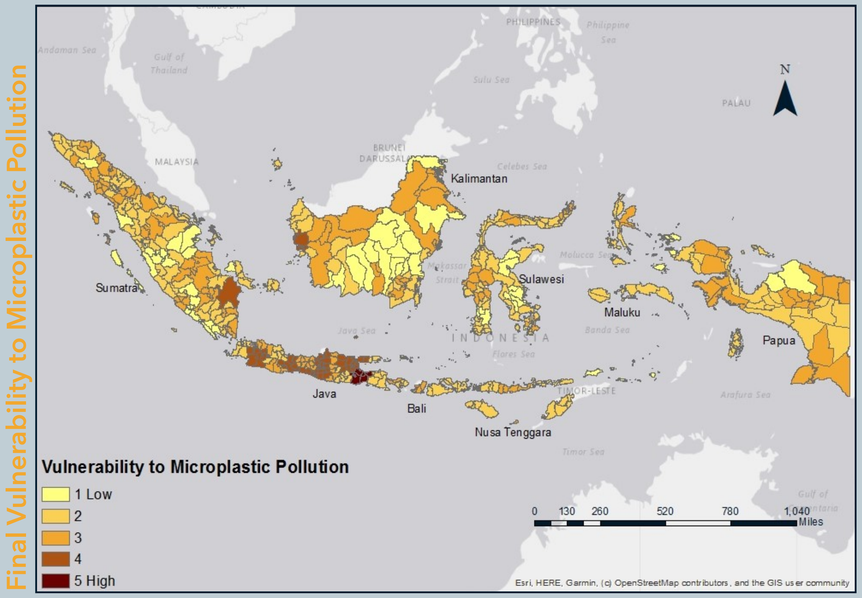


Results

The final map shows vulnerable areas appear to be clustered and there is less than a 1% chance that the clustering of these Kotas is due to random chance. Our analysis reveals that Java island has some of the most vulnerable areas to pollution. The top 5 most vulnerable provinces are all on that same island. Furthermore, the only Kotas ranking 5 for vulnerability are all in East Java (Jawa Timur). Visually, we can see that Java is the most at risk, while it appears that the northern part of Sulawesi, Kalimantan, and Papua are all less vulnerable. However, this could be due to the fact that the analysis excludes nearby countries. The mean vulnerability score for the entire country was 2.48 with a standard deviation of 0.87. All provinces on Java are above the average. The province with the lowest vulnerability score was Kalimantan Tengah; however two other provinces on the island of Kalimantan were above the average vulnerability score.

Data Sources:
Plastic: "*River Plastic's Emissions to the World's Oceans*"; Esri user Wcucr1. 2019.
Administrative Levels: Humanitarian Data Exchange. Badan Pusat Statistik. 2020.
Land Cover: Food and Agricultural Organization; GeoNetwork. 2007.
Airports: Humanitarian Data Exchange. Ministry of Transportation. 2018.
Poverty Percentage: Humanitarian Data Exchange. Badan Pusat Statistik. 2018.

Final Vulnerability to Microplastic Pollution



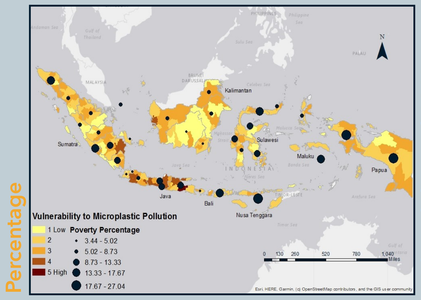
Conclusions

Working with these data, possible errors come from the downloaded land cover file, which was less precise than the online version. Another error is that airports are not a perfect proxy for tourism. Airports were used since they are the most common port of entry into this island nation. (*Statistik Indonesia*, 2018). Finally, the microplastics data is based off of river estimates. It is not wholly accurate to interpolate the data across land, but it is the closest method for accuracy available.

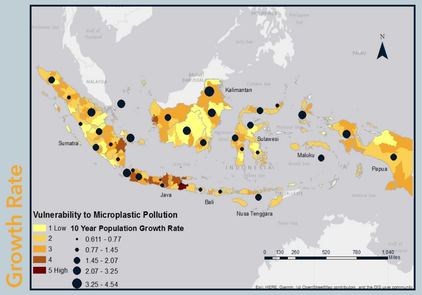
The implications of this analysis are predominantly for food security. This analysis is important for identifying the areas most impacted by microplastics since it affects food security. An analysis like this can be used to inform better protections for water bodies and improved waste management.

Further research should look into the statistical significance between areas that consume the most fish and areas that are most vulnerable. Additionally, looking at factors like population growth rate and poverty rate should be examined further using spatial statistics to determine if there is an association between those factors and vulnerability to microplastics (visualizations below).

Vulnerability and Poverty Percentage



Vulnerability and 10 Year Growth Rate



Managing Food Insecurity Risk. (2015). OECD ILibrary. https://read.oecd-ilibrary.org/agriculture-and-food/managing-food-insecurity-risk_9789264233874-en

Cole, M., Lindeque, P., Fileman, E., Halsband, C., Goodhead, R., Moger, J., & Galloway, T. S. (2013). Microplastic Ingestion by Zooplankton. *Environmental Science & Technology*, *47*(12), 6646–6655. https://doi.org/10.1021/es400663f

Statistik Indonesia. (2018). [Statistical Yearbook].