Human-Water Monitor Conflicts in Indonesia: Spatial Patterns and Mitigation Alternatives

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ABSTRACT

The exponential growth of the human population in the last few decades has had an impact on the exponential increase of agricultural land. One of the consequences arising from the forest land conversions is the increasing number of conflicts between wildlife and humans. Although human-wildlife conflicts are also common in Indonesia, efforts to inventory and monitor the types of conflicts and their distribution are still limited. Mammals and birds are the only two groups of wildlife that are widely studied. This study tries to collect data on the incidences of human-water monitor interactions that are often reported by online news. The collection of news from online media (web scraping) is done automatically using the python package GoogleNews. The collected news articles were stored in a spreadsheet format and processed to obtain information on the location and type of conflict. The scraping process collected 1,838 news articles related to water monitors that represented 189 cases of human-water monitor conflicts. However, there were only 172 conflict cases that had detailed information of the location. The spatial autocorrelation analysis revealed a significant clustering pattern in the Jakarta Metropolitan area. The most common incident was water monitors coming into a house or neighborhood. The reports also uncovered that at least eight people lost their lives and seven water monitors were killed or sold. In addition, there were about 81 captured water monitors with uncertain or untraceable status. Commercially harvesting water monitors, particularly in highly urbanized cities, can be a reasonable solution for this problem.

Keywords: Human-wildlife conflict, spatial autocorrelation, water monitor, web scraping

INTRODUCTION

Conflict between humans and wildlife is a global problem that threatens human welfare and the sustainability of wildlife (Inskip and Zimmermann, 2009; Torres et al., 2018). Human-wildlife conflicts occur when people perceive that wildlife poses a threat to their safety, health, food security, and property (Peterson et al., 2010). The exponential growth of the earth's population and followed by a considerable increase in consumption per capita is the main cause of the surge of human-wildlife conflicts (Crist et al., 2017; Pimm et al., 2014; Rands et al., 2010). The land cover changes, forest degradation, and habitat fragmentation lead to higher possibilities of unexpected humans and wildlife encounters that lead to conflicts (White et al., 2010). The risk of conflict with humans is increasing for several species of wildlife that have the ability to adapt to human-dominated landscapes. The Asian water monitor (*Varanus salvator*) is one of animal species that have capability to exploit anthropogenic land uses (Karunarathna et al., 2017; Twining et al., 2017; Uyeda, 2009). This species is widely distributed in South and SouthEast Asia, ranging from Sri Lanka and India in the West to Indonesia and the Philippines in the East, making it the most widespread species of monitor lizards (Varanidae) (Koch et al., 2007). *V. salvator* naturally inhabit natural forest along rivers and other water bodies and mangroves (Bennett, 1995). However, numerous studies show that *V. salvator* are thriving in rural and urban areas (Cota, 2011; Karunarathna et al., 2017; Kulabtong and Mahaprom, 2015; Lawton et al., 2018; Luskin et al., 2014; Twining et al., 2017). Moreover, this species is able to breed comfortably in a densely populated environment (Cota, 2011). In 2019, officers of North Jakarta Environment Agency found more than 20 eggs of water monitor in a narrow river bank close by bustling residential and industrial areas (Prastiwi, 2019). Although water monitors live in close vicinity of people and pose a serious threat of conflicts, studies about human-water monitor conflicts were extremely scarce (Mazumder et al., 2020; Mou et al., 2021; Rahman et al., 2017).

The IUCN Red List considered *V. salvator* as a species of least concern (Quah et al., 2021), however their harvest and trade is regulated by quota system (MoEF, 2022). The commercial harvest of wild water monitors is mainly for its skin to supply international demand for luxury leather goods (Arida et al., 2020; Khadiejah et al., 2019). In contrast, the trade of meat and other body parts of the water monitors only occurred locally. A small number of ethnic groups in Indonesia consume water monitor meat as a source of protein, and a small minority people in Java Island consume the meat as a novelty-food, for medicinal purposes, and for aphrodisiac (Arida et al., 2020; Arida et al., 2021; Nijman, 2016; Uyeda et al., 2014). This demand suggests that nearly 50.000 *V. salvator* are needed by food stalls around Java Island annually (Nijman, 2015).

The demand for skin and meat of water monitors stimulates the commercial hunting of this species. People in North Sumatra hunt water monitors by using snare traps and sell them to abattoirs (Arida et al., 2020). In West Java, hunters form groups and use trained dogs to catch water monitors for recreational and pest controls (Yudha et al., 2022). Unfortunately, studies about people's perception and attitude towards this reptile in Indonesia is nonexistent.

Reports on this species mostly cover small study areas and left many parts of the water monitor’s distribution area unexplored. Exploration of human-water monitor interactions across Indonesia requires alternative data sources. One source of information that contains data pertaining to human wildlife interactions is the news article (Indraswari et al., 2020; Neagu et al., 2022; Nyhus and Tilson, 2004). Nowadays, news articles are in digital format and can be accessed through the internet at any moment.

This study tried to collect data related to interactions between humans and water monitors that led to conflicts in Indonesia. The data is used to analyze the distribution of cases of human conflict with water monitors by geocoding the location of the incidents.

The main purpose of this study is to reveal the distribution and spatial pattern of humans-water monitor conflicts in Indonesia. Also, this study tries to characterize the human-water monitor conflicts to understand the magnitude and potential solution for this problem. This research is expected to provide a rapid and continuous method for human-wildlife conflicts data collection and monitoring. The results of the research will be useful for stakeholders to understand conflict-prone areas and be able to make policies for human-wildlife conflict management.

METHODS

Scraping of Human–Water Monitor Conflict News Articles

Digital news articles contain rich cultural and historical information (Yzaguirre et al., 2016). These non-traditional data sources are scattered in enormous amounts of web pages. Searching and fetching pertinent data manually is a time-consuming process. In addition, news articles are stored in unstructured format, and therefore make it difficult for further processes and analyses via conventional methods. Accordingly, web scraping or web extraction became a popular solution to solve this challenge. Web scraping is a technique to extract and aggregate information from the internet, and save the data into a structured format (Karthikeyan T. et al., 2019; Zhao, 2017).

Google search engine is the leader of modern web scrapers, they use a web crawler known as Googlebot to index web pages (Kausar et al., 2013). Aside from general type of web searching (horizontal search), Google also provides various searching services for specific media type or content (vertical search). Some of the popular vertical search engines from Google are Images, Videos, Scholar, Patents, Flights, Shopping, News and others. Moreover, information available on a vertical search engine can be accessed manually from a web browser or automatically by using Application Programming Interface (API). There are numerous tools provided by Google or created by a third-party to access Google's API. GoogleNews is a third-party package on the Python programming language that can be used with ease to retrieve news articles from Google News (Hu, 2021).

Several parameters were set for this scraping process. Indonesian language was chosen to limit the searching to news articles in Indonesian. The keyword "water monitor" (*biawak*) was used to fetch all news articles that mention water monitor in its report. Finally, the scraping was limited to the news articles published between 2015 and 2021. The search was performed between 25 December 2021 and 14 February 2022.

The result of this scraping process was a spreadsheet file that was ready to be analyzed. First of all, data must be sorted to exclude media reports that are not related to water monitor conflict. Subsequently, information about location and type of conflicts (appearance of water monitor in settlement areas, human attack, livestock depredation) were extracted from the reports.

Geocoding Conflict Locations

The location data extracted from news articles were in text format. The geocoding process was performed to transform the descriptive location information into geographic coordinates. Google Maps was used as the reference for geocoding the location data. Google Map provides accurate Indonesian administrative data up to village level, and in many regions, hamlet data (*dusun, kampung, banjar, perumahan*, etc) are also available. In addition, Google Maps is an interactive map service, where common users and volunteers called 'Local Guides' are able to add or edit information of places they know really well. This is exceptionally beneficial for determining a geographic position in areas with ambiguous address systems. Moreover, Google Maps has a feature called Google Street View that is very useful for validation of street names, buildings, residential areas, bridges and other landmarks.

The geographic coordinates of the conflict location data are then imported into QGIS software to map the distribution of conflict locations between humans and water monitors (QGIS Development Team, 2020).

Spatial Autocorrelation of Conflicts Data

Spatial autocorrelation measures the association of a variable in a spatial location with the value of the same variable in neighboring locations (Getis, 2010). Various spatial autocorrelation measures and tests have been developed, and they can be grouped into global and local spatial autocorrelation (Anselin, 2010; Bivand et al., 2009; Chen, 2013; Getis and Ord, 1992; Haining, 2009; Ord and Getis, 2001). Global tests summarized all associations of spatial units in a region into one index. Local tests, on the other hand, assess the relationships between a particular spatial unit and its surroundings to find areas where values of the variable are both extreme and spatially identical (Rogerson, 2015).

One measurement that can be applied in a wide variety of situations is Moran’s I (Getis, 2010). This global test is a generalization of Pearson’s correlation coefficient, and presents both the existence and degree of spatial autocorrelation. The Moran’s I can be calculated as follows:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\sum_{i}^{n}(X_i - \bar{X})^2} \quad (1)$$

In this formula, n is the number of spatial units enumerated in i and j. W is a spatial weight and it represents the relationships between a spatial unit and its vicinity units based on contiguity relations, distance or other schemes (Getis and Aldstadt, 2004). X indicates the value of a variable at a specific location (i or j), and$\bar{X}$is the average of the variable. In general, Moran’s I has a value ranging from -1 to 1, a positive value illustrates a positive spatial autocorrelation and vice versa.

A global statistic only discloses whether a spatial autocorrelation exists or not in a large region. Accordingly, local statistics were developed to describe the proximity characteristics of a certain section of the region. Local indicators of spatial association (LISA) is a local statistic that breaks down global statistics into their local components (Anselin, 2010). The LISA statistics consist of local Moran’s I and local Geary’s c statistics, and this study only implemented local Moran’s I. Local Moran’s I can be explained by using the following formula:

$$I_i = \frac{X_i - \bar{X}}{\frac{1}{n}\sum_{i}^{n}(X_i - \bar{X})^2}\sum_{j}^{n} W_{ij}\left(X_i - X_j\right) \quad (2)$$

Local Moran’s I allows the identification of spatial clusters. Locations with significant spatial autocorrelation values indicate clusters of high (hot spot) or low (cold spot) concentration. The output map displays four types of spatial association: HH (high value surrounded by high neighbors), LL (low value surrounded by low neighbors), HL, and LH. Global and local Moran’s I statistics are available in GeoDa, a free and open source spatial analysis software (Anselin et al., 2010).

RESULTS AND DISCUSSION

Results

Web scraping of water monitor news yielded 1,838 records of articles that contain the word ‘*biawak*’ (water monitor). However, only 454 news reports were related to human-water monitor conflicts in Indonesia. The excluded articles were news about the illegal trade of water monitors, extreme culinary, places/islands names, natural tourism, and water monitor conflicts outside Indonesia (Malaysia, Singapore, Thailand, and India).

Some cases of human-water monitor conflicts received considerable attention from the media. One conflict incident may be reported by more than three media outlets. In this regard, these articles were counted as one case of human water monitor conflict. Accordingly, the number of conflicts between 2015 and 2021 were 189 cases. Table 1 shows the number of news articles about water monitor conflict in Indonesia between 2015 and 2021.

Table 1. The number of water monitor news collected from a web scraping process in a seven years period.

Year	**Number of news related to water monitor**	**Number of news about human-water monitor conflicts**	**Number of human-water monitor conflicts**
2015	80	7	6
2016	117	17	7
2017	196	17	11
2018	191	24	16
2019	317	72	35
2020	522	104	66
2021	415	76	48
Total	1,838	454	189

Most media reports mentioned the location of conflicts. There were only 12 articles that did not report the site of the incidents. In addition, there were 15 reports that the geographic coordinates cannot be determined. These 15 reports only mentioned the location in a broader administrative area such as sub-district, municipality/regency, or province. Moreover, there were two news articles that reported different cases of conflicts in a city within one report. As a result, only 172 conflict locations were successfully geocoded.

The geocoding process did not indicate the exact point of the incidents. There was a potential error for each point called uncertainty (Wieczorek et al., 2004). Several reports mentioned that the conflict sites were public buildings such as schools, police stations, or an airport terminal. The uncertainties of these points were less than 50 meters. The description of other conflict locations incorporated names of lane (gang or lorong), neighborhood community (Rukun Tetangga), or hamlet. These conflict sites showed uncertainty between 50 and 200 meters. Furthermore, a few reports only mentioned the conflict sites up to street or village names. The uncertainty of these points were between 300-1,500 meters.

The distribution of points that indicate the location of human-water monitor conflicts can be seen in figure 1. The map shows that human water monitors conflicts occurred in all provinces in Java and Kalimantan Islands. On the other hand, there were two provinces in Sumatra Island with no record of conflict (Bengkulu and Jambi provinces). In Sulawesi Island, the conflicts were only reported from South Sulawesi, West Sulawesi, and Gorontalo Provinces. Also, the conflicts were recorded in small island provinces such as Bali, Bangka Belitung, and Riau Islands.

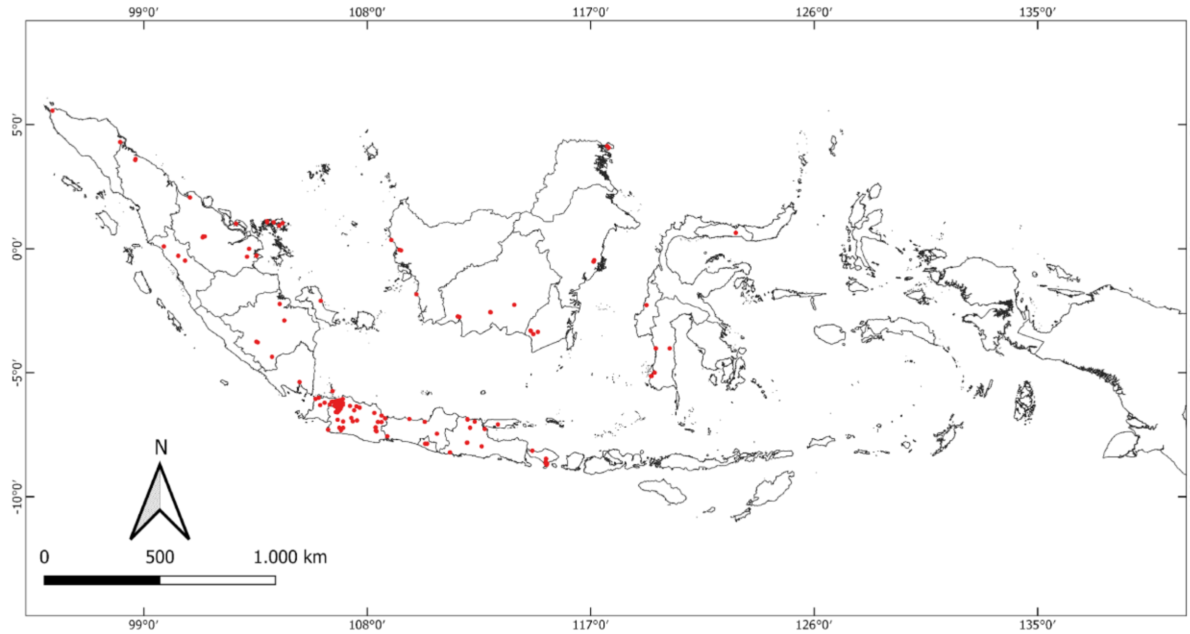

Figure 1. The distribution map of human-water monitor conflicts in Indonesia between 2015 and 2021

The global spatial autocorrelation performed at the provincial level showed that the global Moran's I value was 0.594 and Z-score of 4.55 ($p < 0.01$). This significant positive autocorrelation indicated a clustered spatial pattern of human-water monitor conflicts in Indonesia (Figure 2). Furthermore, the local Moran's I displayed provinces with significant spatial autocorrelation (Figure 3). Three provinces in Java Island (Banten, Jakarta, and West Java) displayed a significant positive autocorrelation. These three provinces had a high number of conflicts and were surrounded by neighbors with a high number of conflicts (High-High). In contrast, a negative spatial autocorrelation (Low-Low) represents a province with a low number of cases and surrounded by neighbors with a low number of cases. South Sumatra was the only province that showed this pattern. Also, two provinces showed spatial outliers. While Central Java had a low number of conflicts surrounded by high neighbors with high values (Low-High), South Sulawesi had a high value surrounded by low neighbors (High-Low).

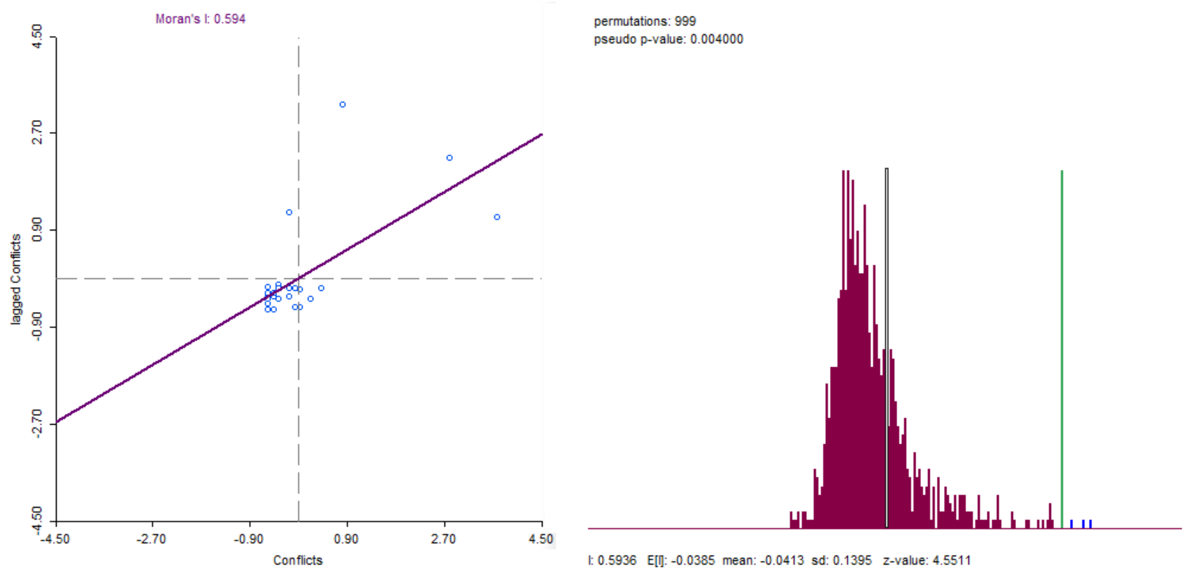

Figure 2. The Moran's scatterplot and histogram showing the values of Global Moran's I, Z-score and p value of the human-water monitor conflicts in Indonesia at provincial level

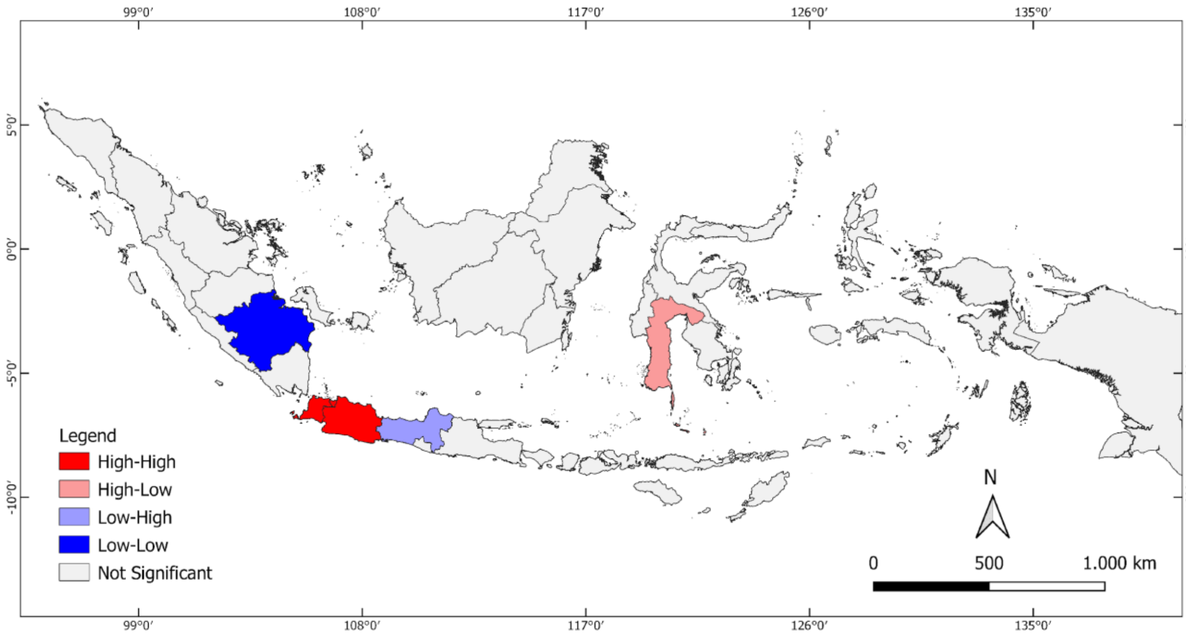

Figure 3. The local Moran's I values show the cluster of human-water monitor conflicts in Indonesia

Provinces in Java Island showed not only significant spatial autocorrelations but also more distributed conflicts data at city/municipality level. Therefore, spatial autocorrelation tests at city/municipality level were performed for this region. The Moran's I value of 0.61 and Z-score of 10.36 ($p < 0.01$) for number of conflicts at city/municipality level confirms a statistically significant clustered pattern (Figure 4). The local Moran's I revealed that the high value clusters were located in Jakarta and its adjacent cities called Jabodetabek area (Jakarta, Bogor, Depok, Tangerang, and Bekasi). In contrast, low value clusters were detected in Central Java (Boyolali, Magelang, and Wonosobo) and East Java (Probolinggo). Moreover, two regions in Western Java, Sukabumi City and Lebak, showed low-high spatial outliers. High-low spatial outliers, on the other hand, were scattered in Central Java, Jogjakarta, and East Java (Figure 5).

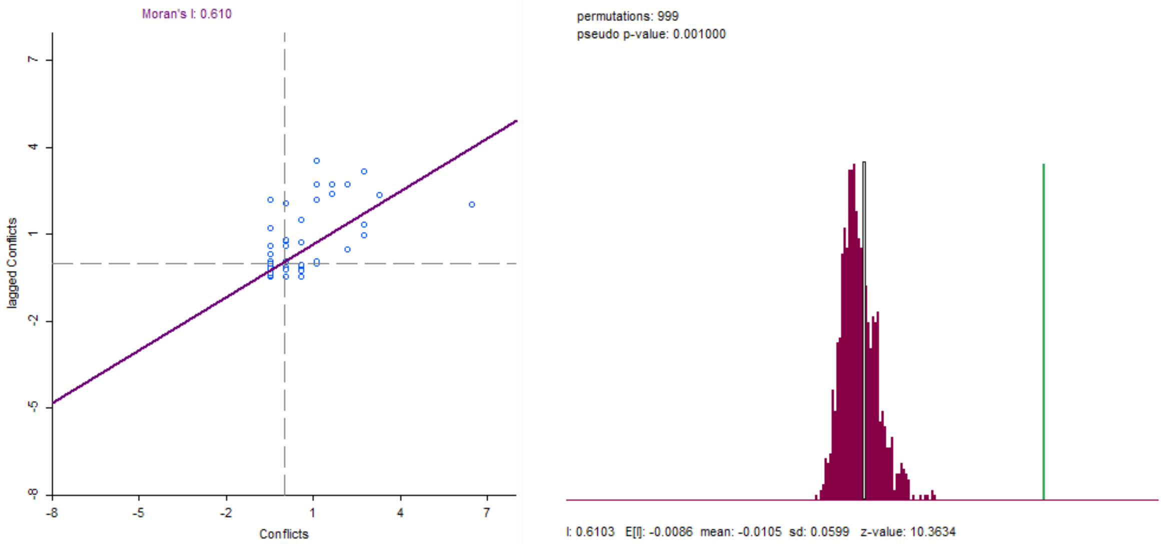

Figure 4. The Moran's scatterplot and histogram showing the values of Global Moran's I, Z-score and p value of the human-water monitor conflicts in Java Island at municipality level

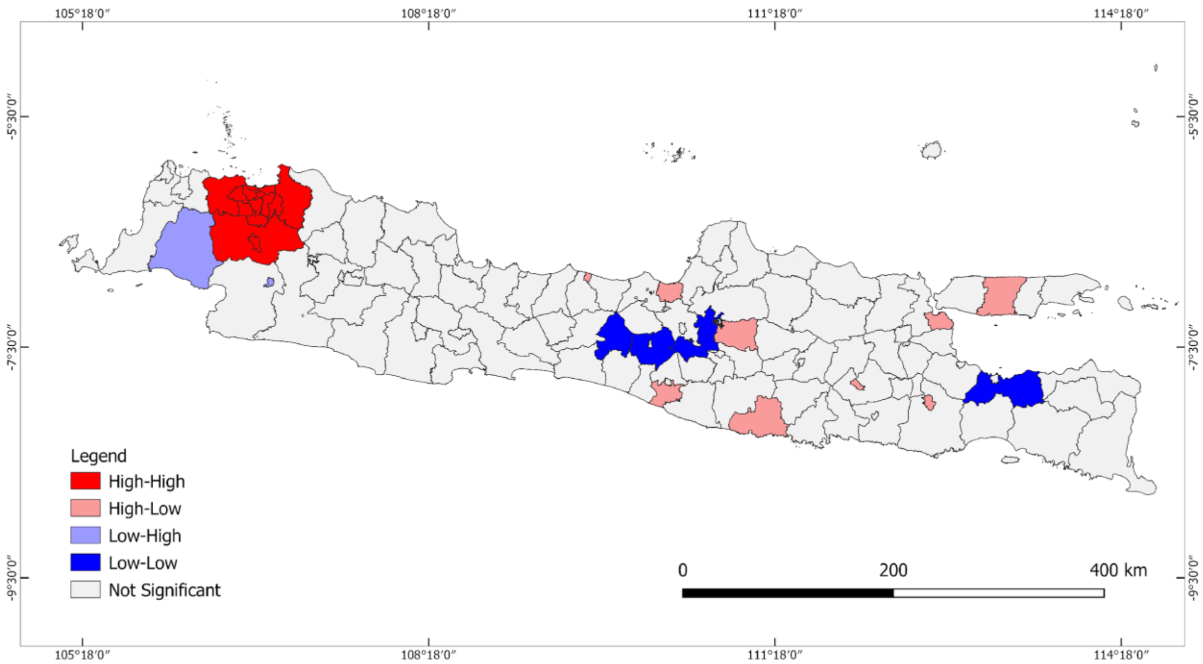

Figure 5. The local Moran's I values show the cluster of human-water monitor conflicts in Java Island

Reports from online media suggested that there were four types of conflicts. The most prevalent incident was the presence of water monitors in a house or neighborhood (146 reports). The second type of conflict was livestock predation, which appeared on 13 news articles. The other two types of conflict were road obstruction (10 cases) and attack on humans (3 cases).

The conflicts took casualties on both humans and water monitors. A widow in Semarang City was found dead in her house two days after she was attacked and injured by a water monitor. Moreover, seven people were drowned in the river, dam, or lake when they tried to catch the reptile, and three people were injured. On the other hand, two water monitors were killed and consumed by the catchers, five were sold, and 81 were captured.

However, only 16 *V. salvator* were explicitly released to nature. Additionally, 10 lizards were kept for pets, 13 others were evacuated but without information where the lizards were being evacuated, and 40 captured water monitors had no information about their status.

Discussion

The results of this study demonstrated several valuable insights. First of all, reports of human water monitor conflicts came from most water monitors distribution areas in Indonesia. Moreover, the web scraping technique was able to extract archive data for up to seven years. Most conflict data provide detailed description of location that allow high accuracy geocoding procedure to be performed.

The geocoded data of human-water monitor conflicts revealed a statistically significant clustered pattern. There are considerably less than 1% chances that the clustered pattern could be the result of random processes both for provincial and municipal levels. The clustered patterns can be clearly observed in three provinces in Java Island, Banten, West Java, and the Special Capital Territory of Jakarta. Further local autocorrelation analysis at city/municipality level confirmed that Jakarta and its surrounding suburbs or Jabodetabek area is the hotspot of human water monitor conflicts. Jabodetabek area is a very densely populated area and it is remarkable to notice that *V. salvator* survive and thrive in this landscape.

Most conflict cases were located in urban residential areas, and only a small proportion of cases occur in rural residential areas, farmlands, or river banks. About 140 locations were lowland areas with altitudes under 100 meters above sea level (masl), and there were only five conflict sites with altitudes above 600 masl. The highest site (894 masl) was located in Bukittinggi regency, and other four sites with elevation between 600 and 700 masl were located in Bandung, Kuningan and Sukabumi. All locations were in close proximity with river, sewer, lake, dam or other reservoirs. It indicates that they use the water bodies as their main refuge. Furthermore, they are very adept at exploiting narrow gaps between houses without being noticed by people. A number of cases revealed that water monitors were able to live on the ceiling of houses for several months, before the owners of the house knew their presence. Also, several water monitors were found in narrow sewers in densely populated settlements in Jakarta and Bandung cities.

The reports suggest that there is no mitigation program to manage human-water monitor interactions particularly in Indonesia. Additionally, there are no articles that discuss the mitigation of human water monitor conflicts from other countries. There was only one publication from Thailand that alluded to a captive station for problem water monitors (Wongtienchai et al., 2021). The "Varanus Farm Kamphaeng Saen" captive station is a temporary shelter for captive lizards before a translocation procedure could be recommended. The establishment of similar captive stations in Indonesia will not only be beneficial for conflict management, but also for population monitoring and other research purposes. Based on a thorough assessment, the captive water monitors from this station may be relocated to their native environment, delivered to captive breeding facilities, or harvested for their skin commercially.

The relocation of water monitors to their native habitat must guarantee that the lizards have a low possibility of returning to residential areas. When suitable remaining natural habitats are limited, the lizards may be harvested for commercial purposes. These water monitors could be sold to farms or abattoirs for their skin and meat. The removal of water monitors from highly dense residential areas could be a win-win solution for urban residents and commercial reptile collectors. Thus, the commercial use of water monitors from conflict cases will fill a small share of the yearly harvest quota.

Reports on the capture of water monitors described that people caught them by using bare hands and ropes. One person or a group of people that had courage to handle the lizard, chased, cornered and grabbed the reptile. Moreover, several witnesses said that there were more than one water monitor roaming their neighborhood by observing their body size. However the report stated that they only caught one water monitor. Efforts to increase the number of captured water monitors in urban areas should be promoted. The use of hunting dogs was an example of a proven method that could multiply the captured animals (Yudha et al., 2022). Another technique that can be implemented in urban areas is by using snare traps (Arida et al., 2020). The capture of water monitors in residential areas should be organized by the authorities or non-profit organizations. This will guarantee that all captured reptiles are well recorded, sent to an appropriate captive station, and released or harvested rightfully.

The paucity of information on the fate of most captive water monitors should be the subject of future study. Water monitors that are sold or have no information must be studied, whether they are consumed for meat or extracted for skin. People in Indonesia consume the meat of water monitors for a number of reasons. In North Sulawesi, people consider the meat of water monitor as a delicacy and they trade the meat in local markets (Taogan et al., 2020). On the other hand, water monitor meat in North Sumatra is a by-product of skin trade. Families in this region regularly consume water monitor meat as an alternative source of protein (Arida et al., 2020). Moreover, Batak tribes of North Sumatra consume water monitor meat as 'tambul', a complementary snack to their social drinking culture (Fentiana, 2019). Water monitor meat is also consumed by people in West Java and West Kalimantan for medicinal purposes and novelty food (Mirdat et al., 2019; Nijman, 2015; Uyeda et al., 2014). People in this area do not buy raw meat and cook it at their home, but consume the cooked meat in food stalls that serve novelty foods.

There are a number of unexplored regions when these studies are compared to the distribution map of human water monitor conflicts in this study (see Figure 1). The interactions between human and water monitors in southern parts of Sumatra, eastern parts of Java, Central and East Kalimantan, and South Sulawesi were overlooked. Reports from several news articles implied that water monitor hunting activities do exist in these regions. Comprehensive investigations will reveal the utilization of this species in that area and the calculation of harvested lizards can be updated.

The final insight from web scraping of water monitor news is that news articles have exhibited as one of promising non-traditional data sources. The collections of conflict data that cover a huge geographic area and longtime range could be achieved quickly, easily, at the least possible cost. However, several excluded reports revealed that only a small proportion of conflict cases were covered by the media. A news report stated that the fire department in Kuningan Regency handled 25 cases of human-water monitor conflicts in 2020 (Kumparan, 2020). However, there were only three cases of conflicts reported by media from the same region at the same time period. Similarly, in 2021 the fire department of Depok City reported that they had 298 cases of wildlife evacuations (Kurniawati, 2021). The evacuated animals included snakes, hornets, water monitors, and dogs, but there were no details about the number of cases for each animal group. On the other hand, there was only one media report from Depok City that year. The same condition also applied in Denpasar, Bali where the authority claimed that they deal with snake and water monitor problems almost every day (Supartika, 2021). But once again, there were only four cases of water monitor evacuation from residential areas that were covered by online media. Despite that fact, it would be a significant contribution for conflict monitoring if a fully automatic extraction of conflict data can be implemented.

The gap between actual and reported conflict cases can be narrowed down by implementing citizen science for human-wildlife conflicts. Data generated by citizens have shown tremendous values that are on the same level with data collected by scientists (Kosmala et al., 2016). Moreover, data collection from citizen science campaigns are cheaper and faster to obtain. One aspect that needs careful attention from citizen science is the quality of the data (Fritz et al., 2019). A number of methods have been implemented to ensure the quality of data, but there are two components that should be prioritized, trained volunteers and standardized tools/devices. Continuous monitoring from online media and citizen science campaigns should become the priority for future research.

CONCLUSIONS

Human-water monitors conflicts do exist in Indonesia as in the news reports, which we collected as data for our analysis. Not only the distribution of conflict cases but also the spatial pattern of the conflicts were analyzed and showed that Jakarta Metropolitan area is the hotspot of conflicts. This phenomenon indicates the capability of *V. salvator* to thrive in highly urbanized cities. However, reports from excluded articles disclosed that many more conflict cases were overlooked by the media. Given the relatively small number of reported cases, we believe there is no systematic program available to manage this problem. The establishment of a captive station and organized removal program in big cities should become the priority of this conflict mitigation strategy. This study also reveals regions that need more consideration for future human water monitor interactions studies.

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