GIS-BASED SPATIAL ASSESSMENT OF RESORTS IN CALAMBA CITY, LAGUNA, PHILIPPINES

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ABSTRACT:

Mount Makiling Forest Reserve (MMFR) supports the water requirements of many towns in its periphery. One of the towns that benefit from the forest reserve is Calamba City, known for its resort-based tourism. The number of resorts in Calamba has significantly increased from 193 in 1998 to 466 in 2014 which has an implication on water consumption on which one of the initial steps in the monitoring aspect is the determination of its spatial distribution. Therefore, this study aims to determine and analyze the spatial distribution of resorts in Calamba City using Geographic Information System (GIS) to generate a distribution map of all the operating resorts showing the hotspots and clustering of resorts. The study recorded 852 resorts in Calamba City. The dense resort areas and the most significant hot spot area are located at Miramonte Village (Purok 6) and Purok 5 of Barangay Pansol. The result indicates a concentration of resorts in certain regions which raised concerns and should further be studied in terms of sustainable water use and environmental impact. The baseline data generated by this study will supplement the existing data of Calamba City on its resorts and help the local government in formulating effective land use and water extraction policies for the resort-based industry for a more sustainable management and conservation.

1. INTRODUCTION

The Mount Makiling Forest Reserve (MMFR) is an important watershed that supports the domestic, agricultural, and industrial water requirements of Calamba City in Laguna. A vegetation gradient of grassland second-growth forest at the base to a dipterocarp forest and mossy forest at the high altitude exists in the forest reserve (Fernando, 2004). The MMFR covers a combined area of 4,244 hectares, encompassing portions of Los Baños, Bay, and Calamba City in Laguna province, as well as Sto. Tomas in Batangas province. It falls under the authority of the University of the Philippines Los Baños and is overseen by the Makiling Center for Mountain Ecosystems within the College of Forestry and Natural Resources. As a dormant volcano, there are plentiful hot springs and groundwater sources, fostering the development of numerous resorts in Los Baños and Calamba. These resorts leverage the availability of natural hot spring water for their swimming pools and baths. In 2013, MMFR was declared the 33rd ASEAN Heritage Park in recognition of its important role in conserving the floral and faunal biodiversity of the Philippines.

Over the years, the number of resorts in Calamba has significantly increased from 193 in 1998 to 466 in 2014 (Jago-on et al. 2017). There was also an increase in the number of tourists in the city. The surface water and ground water used by the resorts-based industry in the town are derived from the watersheds of the Mount Makiling Forest Reserve. The increase in the number of resorts has implications when it comes to water consumption. The volume of water pumped from the ground by resorts is increasing, and some resorts dispose of used pool water every day, which can be considered a wasteful practice. Large volume of ground water that is rapidly consumed by human communities include not only young or modern groundwater, but possibly even groundwater that took hundreds or thousands of years to collect (Nikiforuk, 2015). The study of Gleeson et al. (2016) concluded that modern groundwater is a finite resource with a spatially heterogeneous distribution defined by geographic, geologic and hydrologic conditions, and emphasized the need to better manage and protect the resource. Online resources state that pool water needs to be replaced once every 2 to 3 years (Sanders, n.d.; Taylor, 2020) to as long as every 5 to 7 years (swimdeepblue.com, 2018; Goodwin, 2018) depending on factors such as the number of daily users, climate, type of water, and frequency of pool maintenance (Goodwin, 2018). One of the initial steps in the monitoring of water extraction by the hot spring resorts is the determination of its spatial distribution as according to Jago-on et al. 2017, the increasing number of hot spring resorts in the area and the increased number of visitors entail greater demand for groundwater to be used in the pools. However, monitoring the actual groundwater extraction is a challenge, as most of these resorts operate without water use permits, as required by the Water Code of the Philippines.

Spatial thinking, using geographic information system (GIS), helps in identifying patterns (Aghajani et al., 2017). GIS can give critical information about resources and improve resource planning and management (Baral, 2004). Airports in China were mapped to identify spatial correlations (Chen, Barros, and Yu, 2017). Spatial analysis also has its application in other fields of studies. Hotspot analysis was conducted in Turkey to identify the existence of the spatial structure of Hepatitis A (Dogru, et al., 2017). In China, the spatial variability of forest litter carbon was identified using cluster analysis (Fu, et al., 2014). These studies were able to show the importance of GIS in doing spatial analysis. Hotspot analysis can also be used to describe the spatial structure of other entities such as resorts. In the same breath, ground validation is also important in ensuring the reliability of the data. The accuracy of analysis and interpretation is dependent on the quality of the documentation (Neruda, 2017).

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In the case of Calamba City, spatial distribution and analysis of all resorts was not conducted since 2017. The resort development study of Jago-on (2017) in Calamba City did not include the complete mapping of all resorts. In conducting cluster analysis, it is important to include all the resorts in Calamba City through inventory and mapping. The baseline data generated by this study will supplement the existing data of Calamba City on its resorts. GIS can be effective in determining trends for land use planning.

A spatial pattern, also known as a spatial distribution pattern or the study of spatial distribution, is an analysis tool used to study people or objects in terms of their physical location (Denomme, 2023). It includes understanding the spatial arrangements of these entities with respect to one another and their surroundings. The most common types of spatial pattern are uniform patterns, random distribution spatial clustering.

Patterns, densities, concentrations, and dispersion are only a few of the ways that spatial distribution can be examined and explained and the factors that can influence spatial distribution include natural factors like terrain, climate, soil, and resources, as well as human factors like settlement patterns, infrastructure development, economic activities, and social behaviors. Spatial distribution analysis plays a significant role in forestry by providing insights into the arrangement, pattern, and dynamics of forest resources, trees, vegetation, and habitat characteristics. Some specific applications of spatial distribution analysis in forestry include: forest inventory and management, biodiversity conservation, timber harvesting and planning, habitat modeling and wildlife management, climate change impact assessment and more.

Cluster analysis, on the other hand, is a technique to group similar observations into a number of clusters based on the observed values of several variables for each individual (Sinharay, 2010). Each cluster includes the entities, which are similar to the other entities in this cluster and differ from the variables included in the other clusters. In addition to a clarification of the relations between the variables, such analysis allows to disclose hidden structures in the obtained data and to decrease data complexity and efforts required for further data analysis (Novoselsky and Kegan, 2021). Within forest management, cluster analysis aids the direct estimation approach by identifying and grouping similar and homogeneous objects—like forest stands and compartments (referred to as FMUs)—into clusters (also known as domains or small areas).
Researchers and analysts can learn about patterns, trends, and disparities through the analysis of spatial distribution while cluster analysis can aid in ecosystem classification, conservation planning, and environmental management which are both well utilized in this research.

As mentioned, Jagoon et al. 2017 had already conducted similar study in the resorts industry not just in Calamba but also in Los Banos which includes barangay Lalakay, Tadlac, Bambang and Baybayin. The research relies on secondary data obtained from local government agencies, specifically the Business Permit and Licensing Offices (BPLO) of Calamba and Los Baños. This data includes lists of registered hot spring resorts, out of which only 65 were surveyed. The survey aimed to gather details on various aspects of the resorts and their operations, such as establishment dates, pool sizes, water replacement frequency, peak and off-peak months, well depths, observed water volume changes over time from pumps, and the respondents' awareness of any water-related regulations or laws pertaining to usage and management. A reliable, updated and complete database of resorts in Calamba is needed for proper monitoring and management, which is the primary objective of this study. The results will be able to support the Calamba City local government in their policies on land use and water extraction by the resort-based industry.

The next section of this research paper discusses the materials and methods of the study which is the geotagging of resorts, hotspots and cluster analysis and exposure assessment followed by results and discussions, conclusions, and recommendations.

2. MATERIALS AND METHODS

Calamba City is one of the towns that surround the Mount Makiling Forest Reserve. It is one of the six component cities of Laguna Province and has a first-class city status. It has a total area of around 144.80 square kilometers, and the majority are built-up areas (43%) followed by agricultural areas (25.81%) and grassland areas (10.14%). As of 2020, the population of Calamba reached 539,671 individuals, making it the most densely populated local government unit in Laguna. Positioned 50 kilometers (31 miles) to the south of Manila and 37 kilometers (23 miles) west of Santa Cruz, Calamba is flanked by different regions: it faces Laguna de Bay to the east, is bordered by Cabuyao to the north, Los Baños to the south, and Sto. Tomas and Tanauan in Batangas to the west. Being merely 54 kilometers away from Metro Manila, the city attracts numerous migrants due to its status as an industrial haven. Recognized as the heart of CALABARZON (Cavite, Laguna, Batangas, Rizal, Quezon) because of the abundance of companies in the area, Calamba stands as the primary industrial center outside of Metro Manila. Because of the proliferation of numerous hot spring resorts, Calamba is considered as the "Hot spring capital of the Philippines" and these have become the pillars of tourism industry in the city (CPDO, 2007, as cited by, Jago-on et al. 2017).

2.1 Geotagging of Resorts

The geographic location of resorts was collected using KoBoToolbox (www.kobotoolbox.org). It is an open source platform for the collection, management, and visualization of data which can be used online and offline on phones, tablets, or any browser. The resort inventory activities in Barangay Pansol were conducted in February and March 2020 while the inventory activities in other Barangays of Calamba were conducted from October to November of the same year (Figure 1).

Figure 1. Geotagging activity in Barangay Pansol, Calamba City.

The coordinates were further processed in Google Earth Pro to minimize the locational error and duplications. The status of the resorts inventory was verified using the existing list of registered resorts obtained from the Business Permits Office of Calamba City.

2.2 Hot Spot and Cluster Analysis

The collected coordinates were processed in a Geographic Information System (GIS) software to generate a distribution map of all the operating resorts showing the hotspots and clustering of resorts. The density and hot spot maps of the resorts were generated using the kernel density tool and optimized hot spot analysis tool of ArcGIS (10.6). The Kernel Density tool calculates the density of point features around each output raster cell (ESRI, n.d.). It is a non-parametric technique for density estimation in which a known density function, the kernel, is averaged across the observed data points to create a smooth approximation (Budde, 2019). Larger values of the search radius parameter result in a simpler, more generalized density raster (Awad and Abed, 2023). Since the resort inventory point features did not have a Z-value, the population field for the Kernel Density was set to none. Furthermore, the search radius was not used while the method was set to planar. Areas with numerous resort points are expected to have high density which is an indicator of clustering. The hot spot analysis tool identifies statistically significant hot spots and cold spots using the Getis-Ord Gi* statistic (ESRI, n.d.). It utilizes vectors to pinpoint locations in your data by aggregating points of occurrence into polygons or converging points that are in proximity to one another based on a calculated distance. This analysis categorizes elements when they exhibit similar high (hot) or low (cold) values within a cluster. Hotspot Analysis, also referred to as Getis-Ord Gi* (pronounced G-I-star), examines each element in the dataset while considering neighboring elements. While a feature might possess a high value, it may not qualify as a statistically significant hotspot. For a feature to be considered a significant hotspot, it must be surrounded by other high-value features. These shapes typically denote administrative boundaries or a customized grid structure. This tool was used to identify spatial pattern and crash severity in Ohio (Alam and Tabassum, 2023). It was used in the hot spot analysis of resorts in Calamba City because it can distinguish local event clusters that have high and low feature attribute values. Considering the extent of the study area, the fishnet size was arbitrarily set to 50m. The hot spot analysis tool is expected to pinpoint areas with concentrations of resorts.

2.3 Exposure Assessment

Exposure assessment involves determining or measuring the extent, frequency, and duration of contact with a substance, as well as understanding the population exposed and their distinctive traits. Ideally, this process outlines the origins, methods, avenues, and uncertainties involved in the assessment, serving as a crucial phase in risk assessment. Landslide and flood susceptibility maps were obtained from the DENR Mines and Geosciences Bureau to assess the exposure of resorts to hazards. The potential groundwater recharge suitability (Sandoval and Tiburan, 2019) was also used to identify resorts that are in poor potential groundwater recharge.

3. RESULTS AND DISCUSSIONS

A total of 852 resorts were geotagged and recorded in the City of Calamba (Figure 2). Out of the total recorded resorts, 371 resorts (43.54%) are registered in the Tourism office while 481 resorts (56.46%) are not registered. In terms of resort type, 830 resorts (97.42%) are classified as private while 22 resorts (2.58%) are classified as public.

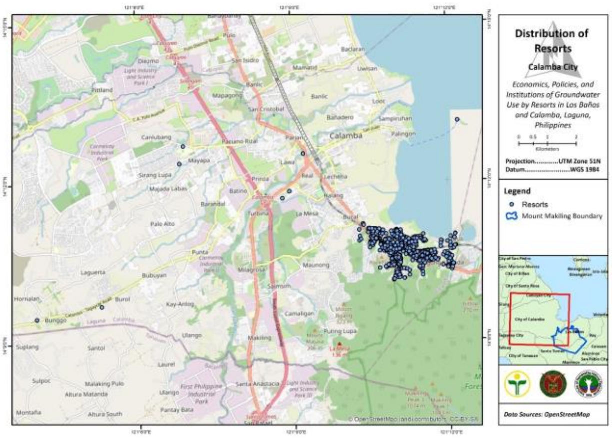

Figure 2. Distribution of private and public resorts in Barangay Pansol, Calamba City.

Most of the recorded resorts were from Barangay Pansol (Figure 3) followed by Barangays Bucal and Bagong Kalsada. Most of the private and unregistered resorts recorded in the inventory were also from Barangay Pansol.

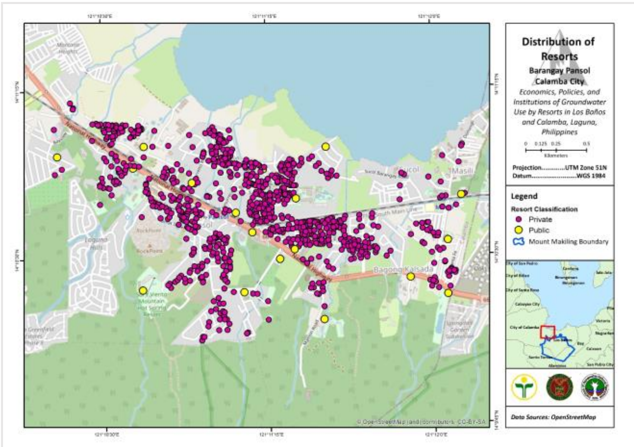

Figure 3. Distribution of private and public resorts in Barangay Pansol, Calamba City.

The kernel density tool of ArcGIS showed that the dense resort areas in Calamba City are located at Miramonte Village (Purok 6) and Purok 5 of Barangay Pansol. The presence of closely spaced resorts in these areas contributed to the high-density values. The less dense resort areas are found in portions of Barangay Puting Lupa and Barangay Bucal.

Based on the results of the Optimized Hot Spot Analysis on a 50m grid size fishnet, around 341.75 hectares in Calamba City are classified as statistically significant hot spot areas with a 99% confidence level (Figure 4). On the other hand, around 43 hectares in Calamba are classified as statistically significant hot spot areas with a 95% confidence level. The most significant hot spot area based on the z-score and p-score values of the Getis-Ord Gi* statistic is located at Miramonte Village (Purok 6) in Barangay Pansol.

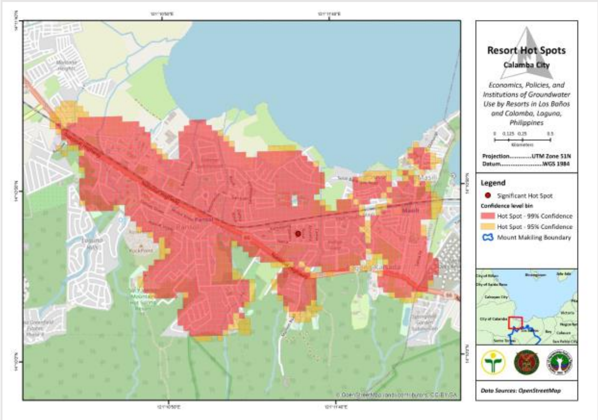

Figure 4. Resort Hot Spots in Calamba City.

Based on the geohazard susceptibility maps, most of the resorts in Calamba City have low to moderate susceptibility to flooding (Figure 5). However, there are 41 resorts and 9 resorts in Barangay Pansol that are moderately susceptible and highly susceptibility to landslides, respectively. The moderately and highly susceptible resorts are found adjacent to the Mount Makiling Forest Reserve.

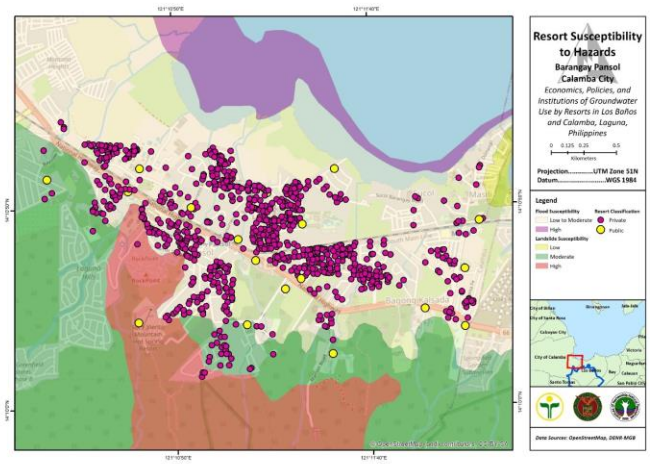

Figure 5. Resort susceptibility to hazards in Barangay Pansol, Calamba City.

Potential artificial groundwater recharge sites were identified in Mount Makiling Forest Reserve using ten factors and weighted overlay (Sandoval and Tiburan, 2019). The resulting potential artificial groundwater recharge contained five descriptive classes ranging from very poor to very good suitability. The overlay of the resorts and potential artificial groundwater recharge showed that most of the resorts in Calamba are approximately within areas that have moderate suitability for groundwater recharge (Figure 5). Around 97 resorts near the national highway are approximately within areas that have poor suitability while 30 resorts near the lakes are approximately within areas with good suitability.

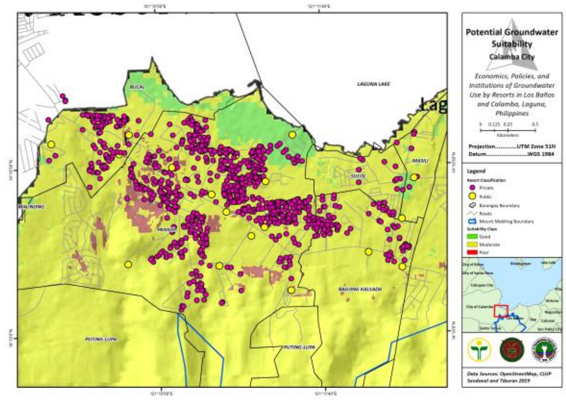

Figure 5. Groundwater Recharge Potential (Sandoval and Tiburan, 2019) in Calamba City.

4. CONCLUSION AND RECOMMENDATIONS

This study successfully analyzed the spatial distribution of resorts in Calamba City that straddles important sub-watersheds of the Mount Makiling Forest Reserve (MMFR). The generated resort density map revealed distinct clusters, with Miramonte Village (Purok 6) I Barangay Pansol as the most distinct hotspot. The result indicates a concentration of resorts in certain regions which raised concerns and should further be studied in terms of sustainable water use and environmental impact. This study provides a more accurate baseline for resort management, particularly in business permit issuances and sustainable land use policies.

The findings offer valuable insights for Calamba City's local government in formulating effective land use and water extraction policies for the resort-based industry. Considering the significant clustering in Miramonte Village (Purok 6), targeted regulations and monitoring measures could be implemented to ensure sustainable water usage and environmental conservation.

The cluster analysis through a 100% inventory of resorts serves as a crucial baseline for future planning. It is recommended that the local government unit utilizes its comprehensive dataset for guiding the establishment of new resorts, updating business permits, and implementing sustainable tourism practices.

The exposure assessment, on the other hand, provides information for identifying vulnerable resorts to natural hazards. Local authorities should consider these susceptibility patterns in formulating disaster preparedness and mitigation plans to ensure the safety of residents and tourists. Regulating development in regions with poor water recharge suitability is also recommended.

Stakeholder engagement and public awareness campaigns are also recommended to foster awareness within the community, resort owners, and tourists on the environmental impact of excessive water usage, and the benefits of sustainable practices in preserving MMFR.

Continuous monitoring and updating of resort developments, conducting regular resort inventory and environmental assessments will provide an evolving understanding of situation, enabling timely adjustment of policies and practices.

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