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Geolocalization of apiaries in areas at risk of natural disasters using Geographic Information Systems in Villa Clara, Cuba

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Abstract

The honey bee depends on environmental conditions for its optimal development, its food base must be in healthy ecosystems and in equilibrium with diverse and abundant blooms, as well as abundant water. Cuba is exposed to different natural hazards and is affected every year by extreme meteorological phenomena. The objective of the study was to georeferenced apiaries in areas at risk to natural disasters in order to establish beekeeping reorganization and mitigation measures based on Geographic Information Systems (GIS). The work was carried out in Villa Clara province, Cuba. 100% of the apiaries and beehives were identified and an informative platform was created to locate them with the agroecosystem and their environment. The program Quantum GIS (QGIS, 2013) version 3.2.1 was used, a commercial and free GIS package for the basics of geospatial research, which made it possible to create an interactive platform of thematic layers for the evaluation and geographic analysis in relation to the apiaries and their environmental surroundings. The design of the information platform with thematic layers based on GIS facilitated the visualization of areas densely populated by beehives with bee colonies, the integral analysis of beekeeping agroecosystems, the identification and georeferencing of apiaries in areas at risk from natural disasters, and made it possible to establish measures for beekeeping reorganization and mitigation of meteorological events, such as flooding due to heavy rains, sea penetration, strong winds, and forest fires.

Keywords: Apiaries; Beekeeping; Meteorological events; Information platform; Reorganization; Villa Clara

1. Introduction

Beekeeping is an activity of great importance for Cuba [1], not only because of the economic contributions from the production of honey, wax and propolis, which in themselves are high, but also because of the pollinating action of these insects on wild plants and those used by man for food and ornamental purposes, contributing to the conservation and maintenance of many ecosystems [1-3]. The honey bee depends on environmental conditions for its optimal development; its food base must be in healthy ecosystems and in equilibrium with diverse and abundant blooms that provide a balanced energy and protein source, as well as abundant water [1,3,4].

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If climate change affects pollinator dependent crop production, this will have major implications for global food security because pollinating insects contribute to the production of 75% of the world's major food crops [5-7].

A Geographic Information System (GIS) is a novel tool provided by Geomatics, which allows capturing, storing, manipulating, analyzing and displaying geographically referenced information in all its forms, in order to solve complex territorial planning and management problems [8]. The applications and real-time information of Geographic Information Systems is essential for the georeferencing and identification of properties with basic beekeepers and for decision-making and identification of the needs of beekeepers [9].

Used the Geographic Information System (GIS) for the management of beekeeping farms in the province of León, Spain, the study allowed to accurately delimit the areas where there are restrictions to develop beekeeping activity, and through spatial analysis achieved other Results of beekeeping importance such as the characterization of the hives based on the suitability of their location and the identification of the farms that did not comply with the regulations on restrictions to develop the beekeeping activity [10].

There are multiple factors that affect the health of pollinators, but the most relevant are related to climate change, intensive agricultural practices, changes in land use, pesticides, diseases and parasites, and invasive alien species, according to the UN [11]. In disaster risk reduction, the use of GIS in the Risk Reduction Management Centers (CGRR) has contributed to raising the awareness of local authorities and the population in general about the dimension of the risks to which they are exposed and consequently to act on the causes that originate them.

The objective of the study was to georeferenced apiaries in areas at risk from natural disasters in order to establish beekeeping reorganization and mitigation measures based on Geographic Information Systems.

2. Methodology

2.1. Location of the experimental area

The research was carried out in the province of Villa Clara, Cuba, located in the center of the Cuban archipelago, with a territorial extension of 8 662.4 km^2 including 719.2 km^2 of adjacent keys, which are part of the Sabena-Camagüey or King's Archipelago Gardens. Its position is between 21^o 57' and 23^o 9' North Latitude and 78^o 55' and 80^o 45' West Longitude. It is bordered on the north by the Atlantic Ocean, on the south by the provinces of Cienfuegos and Sancti Spíritus, on the east by the province of Sancti Spíritus and on the west by the province of Matanzas. The province is made up of 13 municipalities where beekeeping activities are developed.

The coasts, which have an irregular configuration and are characterized by being low and swampy, reach a length of 191.0 km to the north being this the only maritime border, highlighting the keys Santa María, Ensenachos, Las Brujas, Fragoso and Esquivel among others. The highest elevations are located in the Sierra de Trinidad, belonging to the Guamuhaya massif, being the highest elevation of the province the Pico Tuerto with 923 m of altitude. The Sierra Guaniquical also stands out, with 869 m [12].

2.2. Climate of the area where the research was carried out

The historical behavior of the mean annual temperature ranges between 24.0 and 25.2°C, being higher in Caibarien and lower in Yabu. The historical average annual minimum temperatures are high with a provincial average ranging between 18.9 and 21.8°C, with the lowest value in the area of Santo Domingo and the highest in the region of Caibarien. January is the month with the lowest average values for the entire province. The average maximum historical average temperature for the province ranges between 28.9 and 30.8°C. The hottest months are July and August with average maximum values between 31.4°C and 33.4°C.

The historical average rainfall according to the 1961-2000 standard (E.A.H. V.C) is 1 295 mm, for a rainy period of 991.1 mm and a low rainfall period of 303.9 mm. The rainiest month is June with historical values of 203.0 mm and the least rainy month is December with 31.9 mm.

The annual average historical relative humidity ranges between 77 and 79 %, with the lowest value in the Santo Domingo area. The average wind speed ranges between 8.9 and 12.05 km/h taking into account the calms with higher values on the coast and lower in the interior, the predominant annual direction is from the East. The annual average historical cloudiness for the entire province is 4/8 of overcast sky oscillating values between three and five eighths of overcast sky [13].

2.3. Hydrology of the area where the research was carried out

Most of the rivers that flow through the region are permanent, with little flow and their levels vary greatly throughout the year. The main rivers are: Sagua la Grande with 2 188 km^2 of watershed and 144 km of length, dammed in its lower course by the "Alacranes" dam (second in Cuba in capacity, with 365 million m^3), Sagua la Chica with 1 055 km^2 of watershed and 91km of length, with the Minerva reservoir, Agabama, with 1 713 km^2 of catchment area and 118 km in length - shared with the province of Sancti Spíritus, the Cana River and the Zaza River, while the Hanabanilla, located in the local mountainous territory (the Sierra of Trinidad). The Palma Sola dam in the municipality of Corralillo also stands out for its reservoir capacity. In general, the territory has a water reservoir capacity of 1 012.331 million m^3, distributed in 12 reservoirs. The territory also has a network of drainage canals, in areas of the northern plain, for agricultural purposes. From the hydrographic point of view, the province can be catalogued among those with a not very dense fluvial network (the fluvial density is 0.7 kilometers per square kilometer of territory).

2.4. Soil and vegetation of the province

The province presents varied types of geological substrates and soils that condition the existence of different types of vegetal formations and a rich and varied flora. The highest harvest peaks are reached with wild flora, such as the Indian creeper, the purple bellflower and the white bellflower, the forest formations are found mainly in the flat areas and deep soils, reaching a certain height in the mountainous massif of Guamuhaya.

The semi-deciduous mesophyll forest is found in the northern plains and calcareous heights of the northern mountain range of Las Villas, as well as in the Monte Ramonal protected area and most of the mountainous territory of Manicaragua, in the Hanabanilla protected area; in the latter, in the less exposed areas associated with watercourses, there is also mesophyll evergreen forest. The swamp forest is located associated with low and swampy areas of the northern plain and near the coast where it can alternate with the evergreen microphyllous forest.

2.5. Sample size analyzed

The study was carried out with 100% of the apiaries and the total number of hives present in each of the municipalities of Villa Clara province, for which the primary database used was the register of beekeepers containing the municipalities, names of producers, code of each beekeeper, geographical quadrant according to the Epizootiological Surveillance System (SIVE), number of apiaries and hives with bee colonies, Res. 760/2012 [1].

2.6. Creation of an interactive platform of thematic layers for the evaluation and geographic analysis of apiaries and their environmental setting

Quantum GIS (QGIS) version 3.2.1, a free commercial GIS package for the fundamentals of geospatial research [14], was used as a working tool for assembling the database, which made it possible to create an interactive platform of thematic layers for the evaluation and geographic analysis in relation to apiaries and their environmental surroundings. The database with the georeferencing of the apiaries was processed using the Microsoft Excel tabulator for Windows and the geographic quadrants according to the Epizootiological Surveillance System (SIVE) of the Institute of Veterinary Medicine, currently the National Center for Animal Health (CENASA).

Thematic layers were created with the geographic information of interest and others with the spatial location of all the apiaries, which were superimposed on each of the layers with the content of the risk areas according to the study to determine which apiaries and which producers were located in each risk zone for their classification.

The database to determine the risk areas for flooding due to intense rainfall, sea penetration, strong winds, intense droughts and forest fires were calculated, processed, mapped and issued based on the Methodological Guidelines for the Conduct of Hazard Studies, Vulnerability and Disaster Risks of Flooding by Sea Penetration, Flooding by Intense Rainfall and Affectations by Strong Winds, Intense Droughts and Rural Fires, and by the Risk Assessment Group of the Environment Agency (AMA) of the Ministry of Science, Technology and Environment (CITMA) and its realization responds to Directive No. 1. 1 of 2010 of the President of the National Defense Council "For Disaster Reduction" [12].

The conceptual basis used for the development of the hazard, vulnerability and risk studies was the one described by the National General Staff of the Cuban Civil Defense [15]. The methodology comprises four general phases: the first phase, the identification of hazard scenarios, the second, the hazard calculation, the third, the vulnerability calculation and the fourth, the risk estimation. An informative platform was developed based on a GIS that allowed the integral analysis of its entire database

3. Results and discussion

3.1. Thematic layers for the analysis and spatial georeferencing of apiaries

A total of 18 thematic layers were designed with geographic data, in one of which the spatial location of the apiaries in the province was updated, as well as their geoding, according to SIVE, and in seven of them the location of the apiaries was georeferenced, For the analysis of the areas at risk of natural disasters, satellite images with the georeferencing of the apiaries were used to analyze their interaction with the surrounding environment (main highways, roads, sidewalks, population settlements, factories, industries, etc.). An interactive platform for comprehensive analysis and decision making for reordering and mitigation was achieved (Figure 1a-l).

Figure 1a Political administrative division

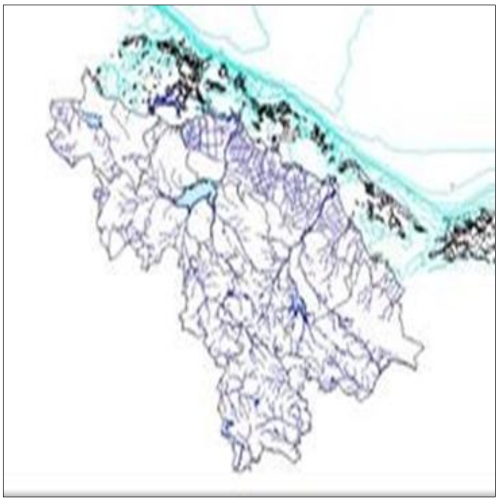


Figure 1b Hydrographic basins

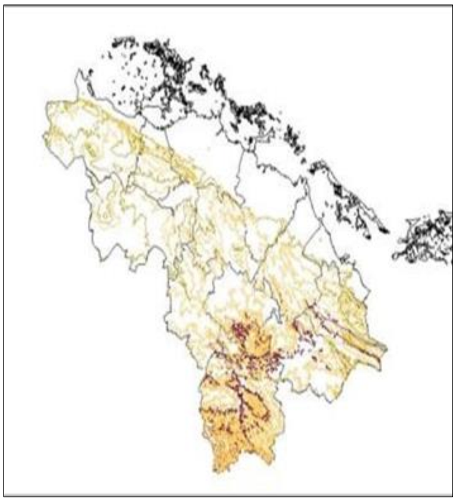


Figure 1c Altitudes

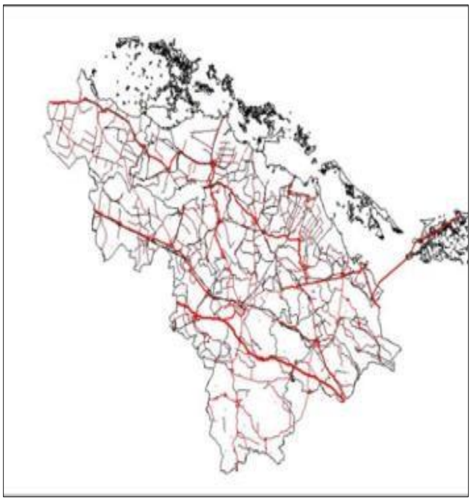


Figure 1d Main roads

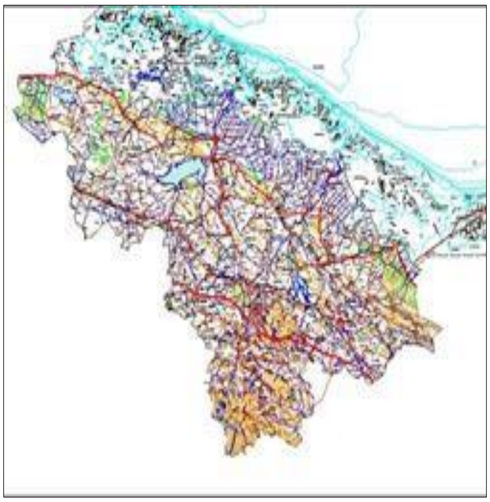


Figure 1e Vectorized layers

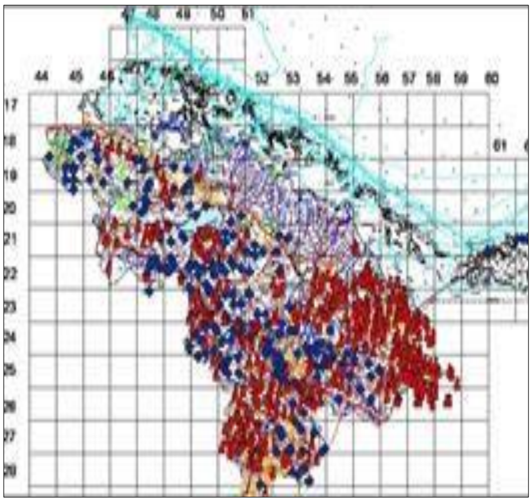


Figure 1f Location of apiaries according to SIVE

Figure 1g Densely populated areas

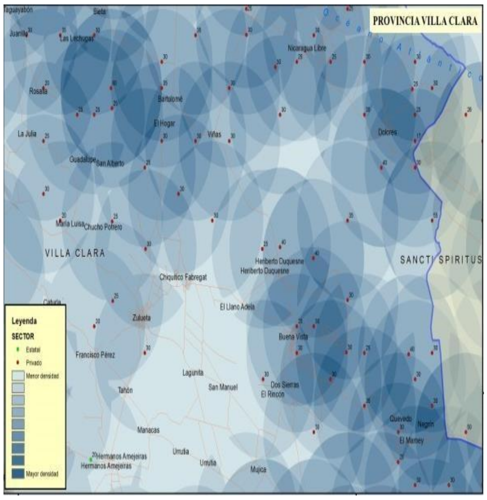


Figure 1h Radii of 3 km2 from the apiary

Figure 1i Matagua Queen bee center

Figure 1j Georeferenced apiary of Veguita

Figure 1k Apiary at Hanabanilla

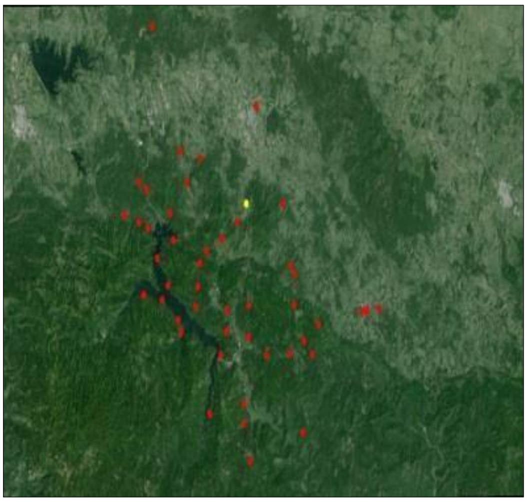


Figure 1l Apiaries in areas of the Hanabanilla

Figure 1a-l Thematic layers elaborated and analyzed using Quantum GIS software (Version 3.2.1)

The application of the geographic information system made it possible to create 18 thematic layers with agroecosystem data and a precise location of the apiaries, which functioned as a multi-criteria platform for a better understanding of the dynamics of the bee populations in relation to the surrounding environment.

3.2. Georeferencing of apiaries in areas at higher risk of flooding due to heavy rains

The GIS allowed the identification of 101 apiaries in areas at higher risk of flooding due to heavy rains and 3 296 hives with their colonies involved in these areas, which represented 15.5% of the total number of apiaries in the province and 18.8% of the hives (Table 1).

Table 1 Apiaries and beehives identified in areas at risk of flooding due to heavy rains

	Posts positions		**Trashumant post**		**Total**	
Municipalities	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**
Santo Domingo	20	540			20	540
Caibarién	19	513	2	60	21	573
Placetas	18	486			18	486
Sagua la Grande	10	270	9	345	19	615
Manicaragua	7	189			7	189
Camajuaní	4	108	2	100	6	208
Encrucijada			10	685	10	685
Total	78	2 106	23	1 190	101	3 296

Note: Fixed stands: are sites that do not move in search of food. Trashumant stands: apiaries and hives that move in search of food.

A spatial distribution of apiaries (low risk) in the face of heavy rains (Figure 2) showed that the municipalities of Santo Domingo, Caibarien, Placetas and Sagua la Grande have the largest number of apiaries and beehives involved in these risk areas, and in the case of Caibarien, Sagua, Camajuani and Encrucijada (high risk) are municipalities with coastlines where more than 1. 000 beehives move to their coastline (trashumant) every year in search of the potential of the beehives (trashumant), Sagua, Camajuani and Encrucijada (high risk) are municipalities with coasts where more than 1,000 beehives move to their coasts (trashumant) every year in search of the melliferous potential of the mangroves. This coincides with Pérez (2007) [16], who states that this practice is carried out in search of food and greater honey production, increasing hive yields.

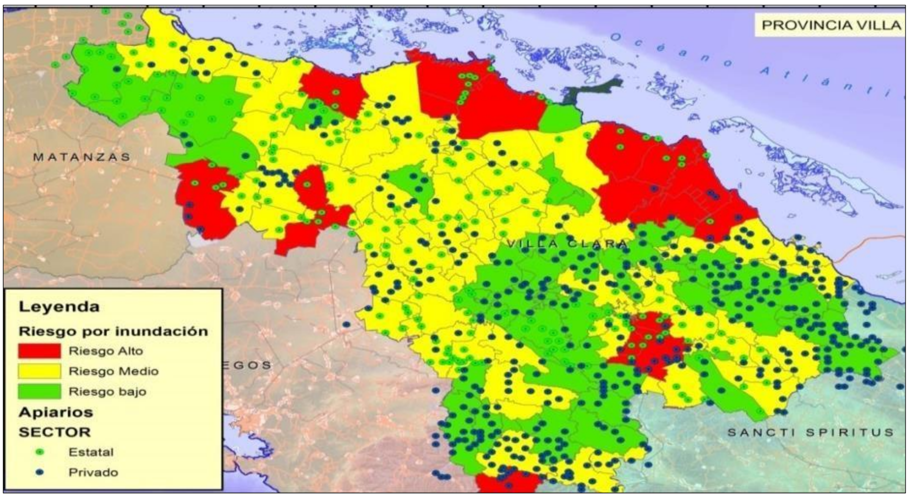


Figure 2 Areas at risk of flooding due to heavy rains

Flooding due to intense rainfall that occurs in these areas, susceptible for the accumulation of large volume of water is given by their morphology and insufficient drainage capacity, further influenced by factors of soil impermeability, underlying rocks, runoff retention by vegetation cover and flows discharged by rivers according to their category order [13].

3.3. Georeferencing of apiaries in areas of flooding due to sea penetration

The GIS allowed the identification of 31 apiaries in areas at higher risk of flooding by sea penetration and 1,421 beehives involved in these areas, which represents 4.8% of the total number of apiaries in the province and 8.2% of the beehives.

The municipalities with the most apiaries and beehives in areas at risk of flooding due to sea penetration are: Encrucijada and Sagua followed by Camajuani and Corralillo, which add 22 apiaries and 1 130 hives that generate positions that are occupied every year in the period from May to August; unlike Caibarien and Remedios, where the nine apiaries and 261 hives are fixed positions that are maintained the rest of the year, because there is available melliferous potential (Table 2).

Table 2 Apiaries and beehives in areas of inundation by sea penetration

	Posts positions		**Trashumant posts**		**Total**	
Municipalities	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**
Encrucijada			11	625	11	625
Sagua			8	395	8	395
Corralillo			1	30	1	30
Caibarién					5	140
Remedios	5	140			4	121
Camajuaní	4	121	2	80	2	80
Total	9	261	22	1 130	31	1 391

The areas at risk from sea penetration, which affect coastal areas (Figure 3) involve five of the 13 municipalities of the province and cover a coastline of 297.48 km in length. These sea penetrations are basically associated with the passage of tropical cyclones and cold fronts, which are favorable climatic conditions for the occurrence of these events.

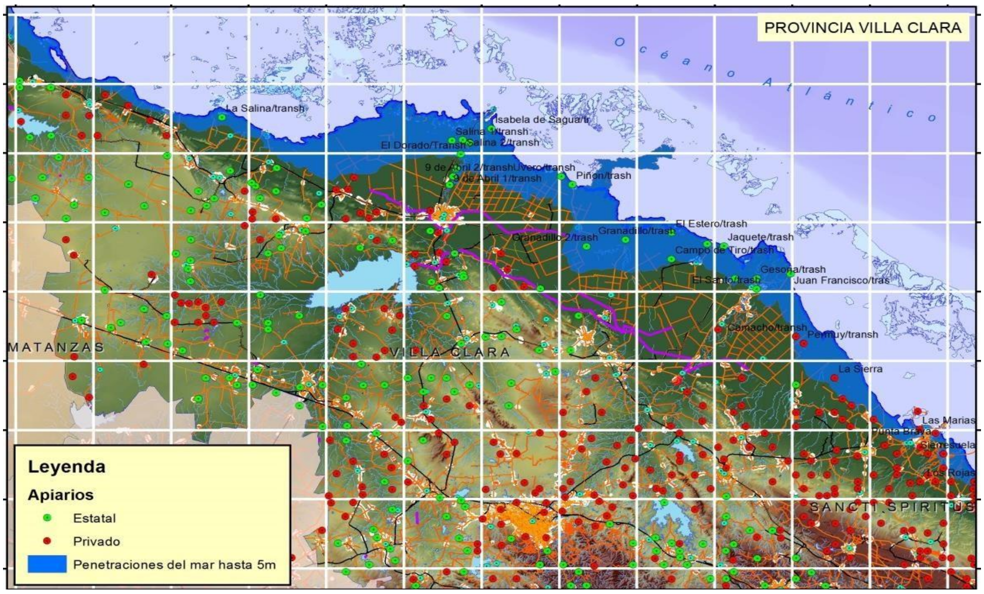


Figure 3 Apiaries located in areas of inundation by sea penetration

Villa Clara province presents an area of 614.02 km2 of mangrove forests, 26.97 km2 of grasslands and 57.02 km2 of swamp forests [12]. Beekeeping is directed towards these territories by virtue of taking advantage of the honey potential, meaning the period from May to August which represents the second most important harvest in the province with 22.8% of the honey produced.

In identifying this vulnerability, we agree with Pérez et al. (2005) [16] who state that the behavior of flooding in this area is influenced by its proximity to a low bathymetry platform and the existence of an insular system of small keys and cays of the "King's Gardens" archipelago, which form an east-west barrier along its entire length, as well as the persistence of mangroves in an extensive coastal strip and in the insular system. We also agree with Hernández and Marzo (2009) [17] who point out that this mangrove belt has a double effect, containing the onslaught of the mass of water that tends to penetrate when the event occurs and retaining the water that has penetrated together with the water accumulated by rainfall runoff on its return to the sea.

3.4. Georeferencing of apiaries in areas at risk due to strong winds

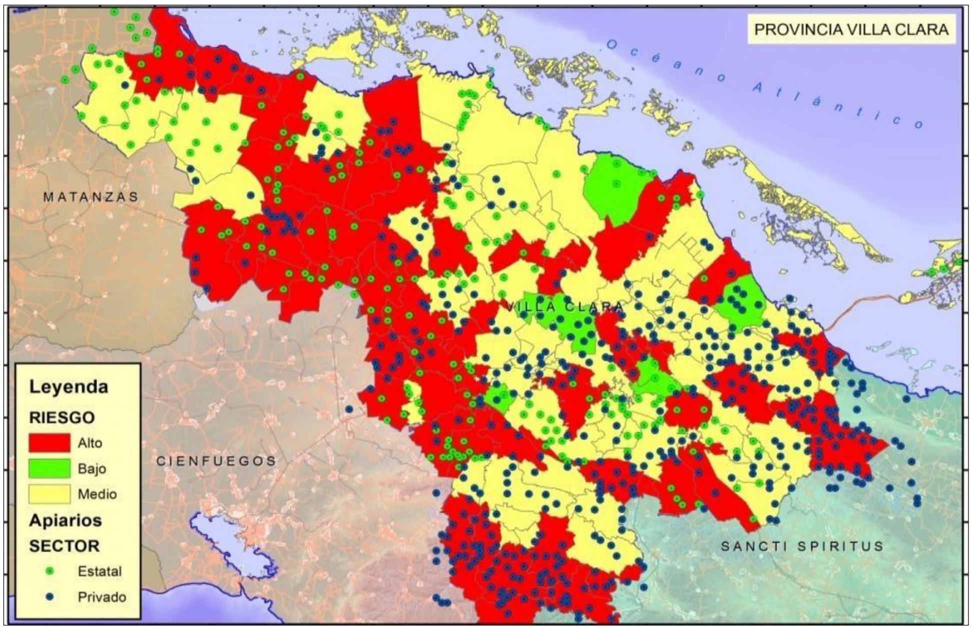


Figure 4 Areas at risk from high winds in the event of a category five hurricane

All the municipalities presented risk areas before strong winds, and the most significant were: Santo Domingo, Ranchuelo and Manicaragua, followed by Corralillo and Remedios (Figure 4). The danger of damage due to strong winds is of a more generalized incidence in the province, given its position in the center of Cuba in the Caribbean region, with the effect of extreme hydrometeorological events that generate strong winds, causing impacts on the population, cultivation areas and ecosystems in all their extension, where tropical cyclones are the most dangerous phenomena for Villa Clara [12].

It agrees with Allen (2020) [18] who states that high wind speeds can significantly reduce a bee's foraging efficiency, due to increased hesitancy to take off. Georeferenced apiaries in high risk areas represent 51.3% of the total in the province and 60.3% of the hives (Table 3).

Table 3 Apiaries and beehives identified in high wind risk areas

	Posts positions		**Trashumant posts**		**Total**	
Municipalities	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**
Corralillo	23	635	1	25	24	660
Quemado	13	1 010			13	1 010
Sagua la Grande	10	270			10 3	270
Encrucijada			3	185	11	185
Camajuaní	11				13	300
Caibarién	11	300	2	60	43	372
Remedios	43	312			13	1 319
Placetas	13	1 319			15 5	295
Santa Clara	15 5	295			52	847
Cifuentes	52	847			41	110
Santo Domingo	41	110			90	1 440
Ranchuelo	90	1 440			24	1 219
Manicaragua	11	1 229			13	2 420
Total	327	2 420	6	270	333	10 457

The municipalities with the highest number of hives involved were Manicaragua, Remedios, Santo Domingo, Ranchuelo and Quemado de Güines, representing 42.7% of the total for the province and 70.9% of the total number of vulnerable hives.

This appreciation of the danger coincides with what was pointed out by Lugo (2016) [19], who states that high intensity winds are a destructive force to ecosystems and fragile physical structures that are in their path, such as beehives.

3.5. Georeferencing of apiaries in areas at risk of intense drought

The only municipality that is at risk of drought in the rainy season is Encrucijada (Figure 5-a; 5-b), while in the low rainfall period there are Quemado, Santo Domingo, Ranchuelo, Santa Clara, Camajuani, Manicaragua and Encrucijada again. In this municipality, the risk in both periods of the year (rainy and low rainfall) is high. In both periods, the agrometeorological hazard reaches the same value, which is also the case with total vulnerability. This result is attributed to the depletion of the soil's productive moisture reserve for a very long time due to the absence of rain, which was pointed out by Solano et al. (2007) [20].

It coincides with the criteria issued by Apiculture [21], that consider that the high temperatures and the scarcity of water put pressure on the hives during the summer. Extreme heat and drought have always been great enemies of bees. In summer the hives get hot, the bees struggle to cool their hive and beekeepers have to intervene much more frequently. The drought has caused a sharp decline in nectar sources. The lack of water has affected the development of many plants that bees feed on. Their weakening causes irreversible damage and makes them more vulnerable to being infected by pathogens and parasites.

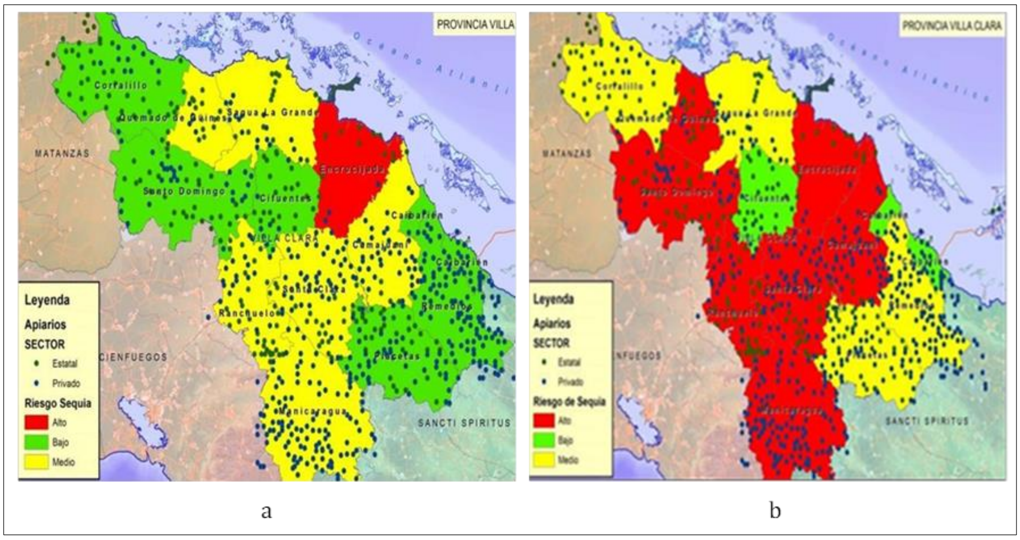


Figure 5 5a Municipality at risk of drought (rainy period); 5b Municipalities at risk of drought (low rainfall period)

The number of apiaries and hives involved in drought risk areas represents 71.5 % and 76.3% respectively (Table 4). It should be noted that despite the period involved, the effects of these droughts have not caused serious problems to the hives, but to the ecosystem, an aspect that coincides with the findings of Centella et al. (2006) [22] who refer in particular to the melliferous flora and the water supply in certain areas that have caused production losses, especially in the months of February to June when the drought is prolonged.

Table 4 Apiaries and beehives identified in areas of intense droughts

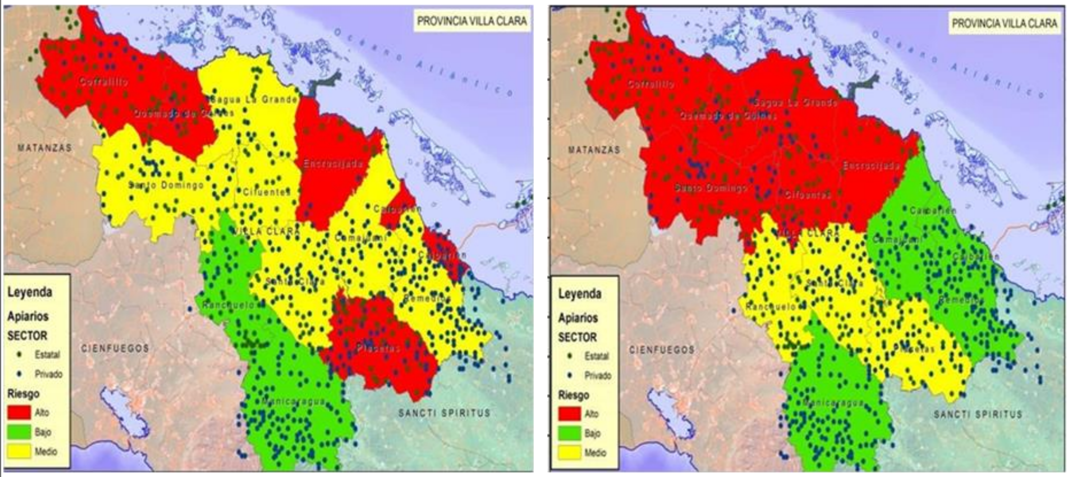
	Rainy period		**Low rainfall period**		**Total**		**Total**
Municipalities	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**	**Queen CA**
Santo Domingo			63	1825	63	1825	
Remedios			112	3 484	112	3 484	
Santa Clara			65	1 770	65	1 770	2
Ranchuelo			45	1 095	45	1 095	2
Manicaragua			128	3 503	128	3 503	2
Camajuaní			40	1 312	40	1 312	
Encrucijada	10	735	10	250	20	985	
Total	10	735	463	13 239	473	13 974	6

Note: Rainy period (May-October) and low rainfall period (November-April), CA Bee Center.

3.6. Georeferencing of apiaries in rural fire risk areas

The municipalities with the largest rural areas at high risk of fire during the rainy season were: Corralillo, Quemado, Encrucijada, Caibarien and Placetas (Figure 6a). In the case of the low rainfall period, those with the highest risk are: Corralillo, Quemado, Sagua la Grande, Santo Domingo, Cifuentes and Encrucijada (Figure 6b) however the most significant is that Corralillo, Quemado, Sagua and Encrucijada maintain the risk criteria for both periods, these are the most vulnerable to these events.

We agree with the criteria of Fernandez and Vanina (2013) [23] who state that, in both periods the occurrence of fires increases, due to the drying of vegetation and topsoil and the increase in temperature, periods of drought are prone to the occurrence of forest fires, whose effects are usually devastating for flora and fauna. Fires are the cause of the destruction of refuge, feeding and reproduction sites for fauna in general, with the corresponding loss of habitat for numerous species and deterioration of biodiversity. When droughts alternate with hurricanes, the destructive effect of fires increases due to the contribution of combustible material (dead biomass) generated by hurricanes.



a b

Figure 6 6a Fire risk by municipality, rainy period (May-October); 6b. Fire risk by municipality, low rainfall period (November-April). Adapted: CITMA AMA 2018

These results are in agreement with Solano et al. (2007) [20] who showed that the greatest damage from forest fires has historically occurred in swamp grasslands and savannahs, but in recent years they have occurred in natural forests, forest plantations with fluctuating humidity and in non-forest areas, including sugarcane plantations, pastures (cattle basins) and herbaceous communities, where fires can occur due to uncontrolled burning or induced by people who violate safety measures.

In the georeferencing of the number of apiaries in these risk areas (Table 5), 206 apiaries were identified during the rainy season and 184 during the rainy season, representing 31.7% and 28.4% respectively; as for the municipalities where the risk is repeated, the difference between apiaries and beehives is due to the transhumance of beehives in the May-August period coinciding with the rainy season.

Table 5 Apiaries and beehives identified in fire risk areas

	Rainy period		**Low rainfall period**		**Total**		**Total**
Municipalities	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**	**Apiaries**	**Beehives**	**Queen CA**
Santo Domingo			63	1 825	63	1 825	
Corralillo	55	1 563	38	1 353	93	2916	55
Caibarién	22	600			22	600	22
Placetas	65	1 430			65	1 430	65
Quemado	22	605	18	500	40	1 105	22
Sagua la Grande	32	1 055	22		54	1630	32
Cifuentes			33	783	33	783	
Encrucijada	10	250	10	685	20	935	10
Total	206	5 503	184	5 781	390	11 224	206

We agree with Manso and Carrillo (2018) [24] who point out that in Cuba more than 60% of the occurrence of forest fires occur in reforested areas and that another cause of deterioration of vegetation cover is related to the fact that in the areas devastated by fires secondary vegetation is established, which in many cases limits the recovery of the forest by preventing the natural regeneration of the original species, as well as the incomplete restoration of the affected areas. In addition, hurricanes cause severe and abrupt damage to the physical structure of ecosystems, while at the same time increasing the intensity and duration of fires due to the large amount of combustible material they bring.

We agree with Prendergast and Stanley (2020) [25] who point out that forest fires the bushland would be slow to recover and this would impact honey production into the future. These results are in agreement with Melathoporlis et al. (2020) [26] who point out that he ash itself can interfere with the bees' ability to breathe, smell, taste, as well as have other effects on their physiology. However, Galbraith et al. (2019) [27] found that fire severity served a strong driver of bee diversity: 20 times more individuals and 11 times more species were captured in areas that experienced high fire severity relative to areas with the lowest fire severity.

In general, with the use of thematic layers elaborated and analyzed with Quantum GIS software, it was possible to georeferenced apiaries and beehives, both in the state and private sectors of Villa Clara province, as well as to identify the main risk areas in case of intense rains, sea penetration, strong winds, intense droughts and forest fires in the rainy and not very rainy periods.

The diagnosis laid the groundwork for incorporating other productive and colony health variables in the hives to facilitate a beekeeping reorganization strategy and mitigation and resilience measures in the face of the impact of natural disasters on beekeeping in the territory under study. All of which in a second stage, will lead to an evaluation of the impact of meteorological and sanitary events on productivity in the beekeeping sector.

This is in correspondence with the precepts of Lugo (2016) [19] and the criteria issued by the "Global Agricultural Information Network" (GAIN), USDA (2015) [28] which consider that within the control of epidemiological structures it is necessary to carry out a beekeeping arrangement through a system of geographical location and records that allow implementing a regional or national sanitary plan of the hives.

In Cuba, the methodology to be used for the reordering and location of apiaries is still in force and is inserted with the Epizootiological Information and Surveillance System (SIVE) by geographic quadrant, implemented by the National Center for Animal Health (CENASA) for all species established by the World Organization for Animal Health (OMSA), linked to the reordering system.

We agree with other authors [1,29], currently the World Organization for Animal Health (OMSA), in that the ordering allows combining the existing honey potential and hive densities in each territory of the country, conceived for the promotion and spatial distribution of apiaries and queen bee nurseries in the various landscapes and beekeeping ecosystems, adjusting the number of hives according to the honey potential in an economic flight radius of two and a half to three kilometers away and queen bee nurseries at five kilometers respectively.

We also agree with Soto et al. (2015) [30] and with the Global Agricultural Information Network, who consider that a Land Management Proposal or territorial planning, "basically consists of designing, based on the elaborated diagnosis, a territorial model or objective long-term image and defining the necessary measures to move in the direction of making it a reality". The territorial planning proposal is embodied in a Territorial Planning Plan (POT), which instrumentalists the proposal by projecting its strategic objectives in space. In addition, with Lugo (2016) [19] who demonstrated that, with the reorganization measures applied in the Zapata Swamp, Matanzas, Cuba, the search for new routes to new locations was favored and with adequate management and sanitary control, it was possible to increase production.

4. Conclusion

The design of the information platform with thematic layers based on Geographic Information Systems facilitated the visualization of areas densely populated with beehives and bee colonies, the integral analysis of bee agroecosystems, and the identification and georeferencing of apiaries in areas at risk from natural disasters. In addition, the GIS made it possible to establish beekeeping reorganization and mitigation measures for meteorological events such as flooding due to heavy rains, sea penetration, strong winds, intense droughts and forest fires.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no area of conflict of interest.

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