



FUNDING PROPOSAL TO THE GREEN CLIMATE FUND

**-IRES-CUBA-
INCREASED CLIMATE RESILIENCE OF RURAL
HOUSEHOLDS AND COMMUNITIES THROUGH THE
REHABILITATION OF PRODUCTIVE AGROFORESTRY
LANDSCAPES IN SELECTED LOCALITIES OF THE
REPUBLIC OF CUBA**

APPENDIX 2.2

**Effects of Climate Change on the Physical-
Geographic and Socioeconomic Conditions of
Selected Territories of the Central and Eastern
Regions of the Republic of Cuba**

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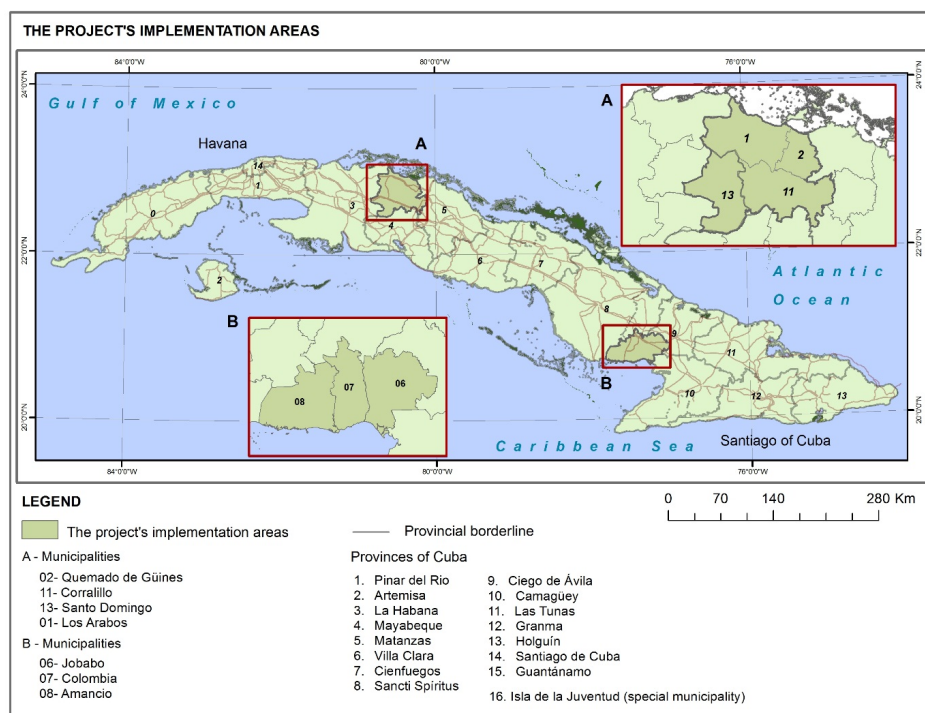
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I. INTRODUCTION

As the effects of climate change on Cuba's physical-geographical and socio-economic conditions are accentuated, the areas affected by the agricultural drought increase and the cultivated lands decrease, a chain of processes that cause the decrease of agricultural lands is generated, the expansion of areas occupied by invasive plants such as Marabu, more compatible with arid environments, food production decreases, urban and rural employment decreases, and the exodus of the population in general, rural in greater magnitude, increases, at the beginning in search of better income, and then as a survival mechanism. These processes create tensions in the territories and migrations towards urban spaces that do not have the capacity to generate employment or appropriate infrastructure for the reception of migrants. It is a dynamic that feeds back from the fact that no measures to prevent and mitigate land degradation are adopted, and plans and projects are not drawn up to combat drought, climate variability and other consequences derived from climate change.

Seven municipalities of Cuba have been selected for this research, hereinafter referred to as project implementation areas (AIP), four belonging to the Central region and three to the Eastern region. The area occupied by these municipalities is 5 104.6 km², with a resident population in 2017 of 240 939 inhabitants for an average density of 47.20 inhabitants / km². As can be seen in the table, they differ in the amount of population and area, as well as in their density. They represent 4.65% of the total surface of Cuba and 2.14% of its population. Its density is less than half the value of this indicator for the country, which is 102.2 inhabitants / km² (Table 1). Its location is shown in figure 1.

Figure 1. Location of the project implementation areas (AIP)



Source: Prepared by the authors

Table 1. Surface extension, resident population and population density, year 2016

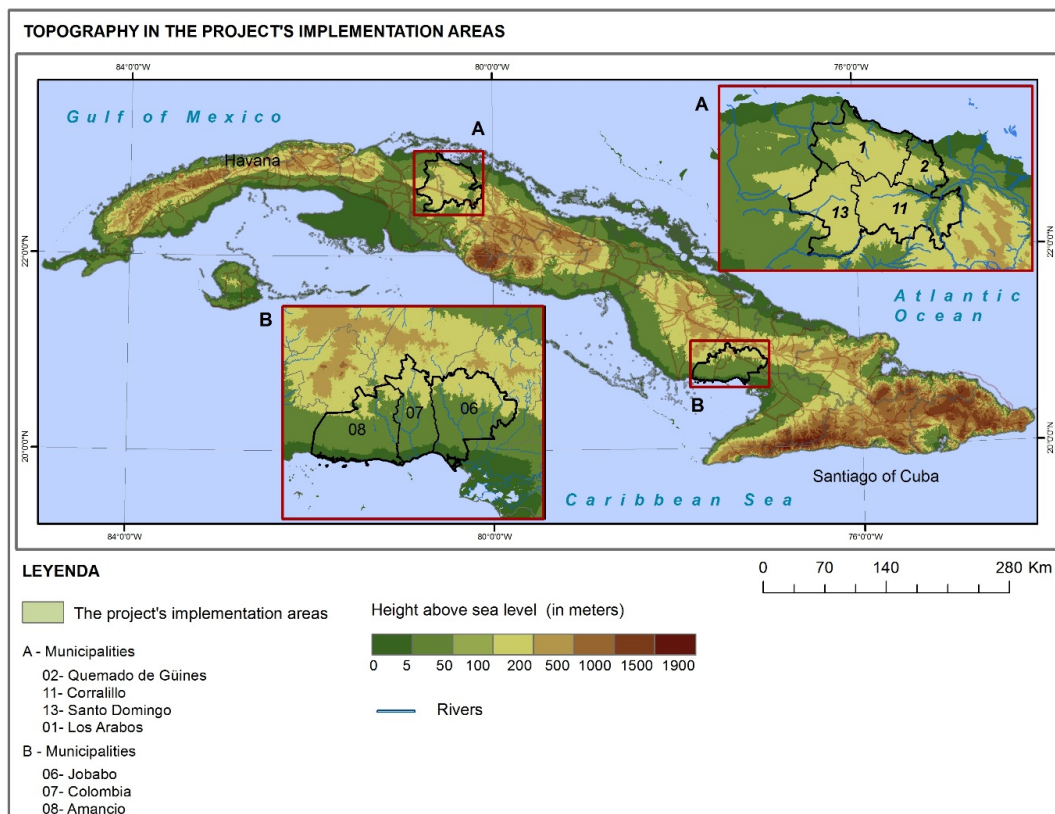
Municipality	Surface (km ²)	Total Population (Inhabitants)	Density (Inhab/km ²)	Masculinity Index (men for every 1000 women) (a)
Central Region	2 806,5	120 757	43,03	1 029
Los Arabos	758,4	24 274	32,01	1 033
Corralillo	837,3	26 089	31,16	1 031
Quemado de Güines	332,8	21 586	64,86	1 050
Santo Domingo	878,1	50 035	56,98	1 016
Eastern Region	2 298,1	120 182	52,30	1 057
Jobabo	885,6	43 611	49,24	1 072
Colombia	560,0	32 412	57,88	1 042
Amancio	852,5	38 491	45,15	1 051
Total	5 104,6	240 939	47,20	1 043

(a) 2017

Source: ONEI (2017). Statistical yearbook of Cuba. Edition 2018. Havana

From the point of view of the relief, they are characterized by being part of the cumulative marine-fluvial plains and abrasive plains with an average height between 25 and 40 meters in the eastern region and between 50 and 65 m in the central region.

Figure 2. Physical-geographical characteristics



Source: Prepared by the authors from the Cartographic Database of Cuba at 1:25 000 scale

The municipalities under study are classified by experiencing the processes described in the introductory paragraph, both in their physical-geographical and socio-economic and territorial conditions, depressed in their levels of economic activity, with increasing exoduses of their population, reduction of cultivated area and therefore, food production, expansion of the area covered by Marabu (*Dichrostachys cinérea*) and a significant increase in the aging population and feminization of these spaces that face the consequences of an agricultural drought that has been going on for several decades, derived from the effects of climate change in these regions of the Center and East of the country.

This situation leads us to consider as a starting hypothesis:

The municipalities studied have a complex physical-geographical, socioeconomic and territorial problems and a high vulnerability to the effects of climate change.

Overall Objective

The objective of the research is to demonstrate that the areas under study experience the effects of climate change with great intensity, which are evident in the frequency and force of extreme weather events that affect them, the expansion of the agricultural area affected by drought, the reduction of cultivated lands, the expansion of the areas occupied by the Marabu, the exodus of the population in general, and in greater magnitude, the rural, first in search of better income and then as a survival mechanism.

These factors, together with the low rates of forest cover reported in the territories and the scarce presence of isolated trees in the rural scenario, predict a decrease in rainfall, and a more arid climate, an environment in which invasive plant species such as Marabu can be reproduced more easily, affecting the resilience capacity of these territories and the communities present in the AIP.

The implementation of projects aimed at mitigating the effects of the situation described in this research will contribute to reverting the deplorable physical-geographic, socioeconomic and territorial processes of the current scenario, recovering agricultural and livestock spaces, in order for those rural households currently more vulnerable to change climate change in AIPs, to become better adapted to the impacts through the rehabilitation of productive agroforestry landscapes, reversing the chain of processes that are now downward, as evidenced in the results of this study.

The modules to be implemented operate under sustainable systems that fulfill relevant functions in the scenario in which they are developed and that focus on ensuring greater resilience of vulnerable people, households and ecosystems.

II. METHODOLOGY

The application of representation tools, spatial and statistical analysis in GIS together with digital image processing techniques represents an important point of this work, in addition to the analysis of the official statistics of the Balance of Use and Tenure of the land developed by the National Center for Land Control of the Ministry of Agriculture (MINAG) and the National Office of Statistics and Information (ONEI) in all matters relating to the population, which were processed for the preparation of the tables and the examination of the population dynamics in its complexity for the territories studied. The methodology used is easily extrapolated to other territories that have the same problem and can serve as the basis for different investigations. The methodology used can be summarized in four stages:

(a) Cartographic representation and analysis of the statistical information contained in various

publications of the ONEI (Demographic Yearbooks of Cuba, Demographic series for different periods of time by place of residence and sex, studies of migrations and aging for several years, among others), of the MINAG (Balance of land use and tenure for several years prepared by the National Center for Land Control).

(b) Cartography of the state of Marabu in the areas of Project Intervention (AIP) from the digital image processing of the Sentinel satellite, February 2, 2019 and analysis of its special dynamics

(c) Analysis of the climatic variables studied (trajectory of hurricanes in the Atlantic Ocean basin) and agricultural drought maps of Cuba

(d) Analysis of the influence of climate change on the expansion of Marabu and population variations in the human settlements present in the AIP, with special emphasis on rural settlements (migration, aging and feminization of these spaces).

The main materials used were the following: national topographic maps of Cuba at 1:25 000 scale; Sentinel 2A satellite image of the year 2019, (with a spatial resolution of 10 x 10 m); map of agriculture prepared by the Soil and Fertilizer Directorate of MINAG for 2015, Balance of use and land tenure for several years of the National Center for Land Control of MINAG; Several ONEI Publications on population and its characteristics for several years, data of the Meteorological Service of the United States and other interesting data obtained through the consultation of documents of Cuban Institutions. For example, the System of Monitoring and Early Warning of the Agricultural Drought executed by the Center for Agricultural Meteorology of INSMET. The drought maps were taken from Centella A, B. Lapinel, O. Solano, R. Vázquez, C. Fonseca, V. Cutié, R. Baéz, S. González, J. Sille, P. Rosario and L. Duarte (2006). The meteorological and agricultural drought in the Republic of Cuba and the Dominican Republic. Volume I, 172 pp.

III. DISTRIBUTION OF THE POPULATION IN THE AIP

The analyzed municipalities are located in the Central Region, towards the central and northern part of the island. Those grouped in the Eastern region, are located in southern and eastern parts of the country, positions that place them in different physio geographic frames and under the differentiated effect of meteorological and climatological phenomena that affect them over time.

An evaluation of selected demographic indicators for the territories under study and their variation over time constitutes evidence of the processes of various nature events that have occurred in recent years and that largely derive from the effect of processes and physio geographic phenomena linked to climate change, which highlights the agricultural drought that for several decades and with increasing trend is present in these territories.

In 2009, the total population of the studied area (Central and Eastern regions), which comprises the seven municipalities analyzed and related in Appendix 2.2.3, reached 248,994 inhabitants; of them, 127,605 men and 121 389 women, for a masculinity index of 1 051 men for every 1 000 women. The urban population represents 62.2% and the rural population 37.8%. The population over 60 years old represented 17.68% of the total population, 17.64% of males and 17.22% of females; the urban population of 60 years and over was 60.73% and the rural population of 39.27%; presented a masculinity index of 1 047 men for every 1 000 women (Appendix 2.2.1).

In 2017, approximately eight years later, the total population of the seven municipalities analyzed was 240 939 inhabitants, 8 055 inhabitants less; structured in 123 317 men (51%) and 118 252 women (49%) reported an approximate decrease of 4,288 men and 3,137 women. There is evidence of abandonment by the population of the studied territories where the woman is the most affected,

reporting a masculinity index of 1 043 men for every thousand women, 8 fewer men for every 1 000 women. The analysis of gender shows that the most unfavorable situation in these territories is suffered by women, given the abandonment of a greater number of men in search of greater and better opportunities for work and life. A feminization process of the studied rural spaces is underway.

The 2017 analysis for the population of 60 years and older shows a growth of 5.9 thousand inhabitants within the population of 60 years and older, emphasizing that this population group increases in urban spaces by 6369 inhabitants and decreases 448 in rural areas, which attests to the presence of a significant migration of this age group towards urban spaces. Demographic aging is occurring on the territories studied (17.68% in 2009 and 20.73% in 2017). The situation described makes it difficult to replace the labor force and its development in the short and medium term in all the municipalities analyzed, with particular emphasis on rural areas. Likewise, an evident feminization is reported in the aging process of the whole territory, with a percentage growth of the urban population and an index of masculinity that decreases for this population group of 60 years and older, reaching a value of 999 men for each a thousand women.

III.1. Distribution of the Population in the AIP – Central Region

The analysis for 2009 of the municipalities of the Central region showed a total of 127,864 inhabitants; 65 379 men and 62 485 women, for a masculinity index of 1 046 men per 1 000 women. The urban population represents 67.04% and the rural population 32.96%. The population aged 60 and over represented 20%; the urban population aged 60 years and over 19.88% and the rural population 20.13%. In 2017.

Approximately eight years later, the population of the four municipalities analyzed was 120,757 inhabitants, 7,107 less inhabitants; Structured in 61 235 men (4 144 fewer than in 2009) and 59 522 women (2 963 fewer). There is evidence of an abandonment by the population of the studied territories, urban rural migration (exodus of the rural population), by which women are the most affected, with a variation in the masculinity index that decreases by 17 men per thousand women (1 029). Gender analysis shows that the most unfavorable situation in this region affects women, given the abandonment of men in search of greater and better opportunities for work and life, while women, in particular aged 60 years and older, increase their number. A process of feminization of rural spaces in the municipalities of the Central region is underway (Appendix 2.2.2, Tables 2 and 3).

Table 2. Selected indicators of the population of the municipalities of the AIP in the Center region, year 2009.

Municipality	Population					Index masculinity (men for every 1000 women)	Percentage	
	Total	Male	Female	Urban	Rural		urban	rural
Los Arabos	24 829	12 701	12 128	13 869	10 960	1 047	55,86	44,14
Population ≥60	4 665	2 410	2 255	2 629	2 036	1 069	56,36	43,64
%	18,79	18,97	18,59	18,96	18,58			
Corralillo	27 554	14 043	13 511	19 441	8 113	1 039	70,56	29,44
Population ≥60	5 582	2 855	2 727	3 851	1 731	1 047	68,99	31,01
%	20,26	20,33	20,18	19,81	21,34			
Quemado de Güines	22 474	11 630	10 844	14 211	8 263	1 072	63,23	36,77

Population ≥60	4 670	2 378	2 292	2 767	1 903	1 038	59,25	40,75
%	20,78	20,45	21,14	19,47	23,03			
Santo Domingo	53 007	27 005	26 002	38 201	14 806	1 039	72,07	27,93
Population ≥60	10 659	5 352	5 307	7 451	3 208	1 008	69,90	30,10
%	20,11	19,82	20,41	19,50	21,67			
Central Region	127 864	65 379	62 485	85 722	42 142	1 046	67,04	32,96
Population ≥60	25 576	12 995	12 581	16 698	8 878	1 033	65,29	34,71
%	20,00	19,88	20,13	19,48	21,07			

Source: ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2012) Demographic series 2000-2010. Magnetic support.

When this analysis is carried out for the population aged 60 and over, there is a growth of 2.5 thousand inhabitants in the population aged 60 and over, highlighting that this population group increases in urban spaces by 886 inhabitants and 1,638 in the rural areas. As for all the territory studied, they are facing demographic aging in these municipalities, which affects their sustainable development. Likewise, a feminization is reported in the evident aging process of rural spaces, with a percentage growth of the urban population, a decrease in the rural population and an index of masculinity that increases for this population group of 60 years and over until reaching a value of 976 men per thousand women.

Table 3. Selected indicators of the population of the municipalities of the AIP in the Central region, year 2017.

Name	Population					Index masculinity (men for every 1000 women)	Percentage	
	Total	Male	Female	Urban	Rural		urban	rural
Los Arabos	24 119	12 257	11 862	14 650	9 469	1 033	60,74	39,26
Population ≥60	5 290	2 683	2 607	3 352	1 938	1 029	63,36	36,64
%	21,93	21,89	21,98	22,88	20,47			
Corralillo	25 834	13 117	12 717	19 039	6 795	1 031	73,70	26,30
Population ≥60	6 031	2 973	3 058	4 401	1 630	972	72,97	27,03
%	23,35	22,67	24,05	23,12	23,99			
Quemado de Güines	21 359	10 942	10 417	13 906	7 453	1 050	65,11	34,89
Population ≥60	5 217	2 597	2 620	3 295	1 922	991	63,16	36,84
%	24,43	23,73	25,15	23,69	25,79			
Santo Domingo	49 445	24 919	24 526	35 905	13 540	1 016	72,62	27,38
Population ≥60	11 562	5 628	5 934	8 351	3 211	948	72,23	27,77
%	23,38	22,59	24,19	23,26	23,71			
Central Region	120 757	61 235	59 522	83 500	37 257	1 029	69,15	30,85
Population ≥60	28 100	13 881	14 219	19 399	8 701	976	69,04	30,96
%	23,27	22,67	23,89	23,23	23,35			

Source: ONEI (2017). The aging of the population 2017. Havana

III.2. Distribution of the Population in the AIP – Eastern Region

The population of the municipalities of the Eastern region for 2009 reached 121 130 inhabitants, of which 62 226 are men and 58 904 women, for a masculinity index of 1 056 men for every 1 000 women. The urban population represents 57% and rural 43%. The population aged 60 and over represented 15.23%; the urban population of 60 years and more 14.51% and the rural population 16.18%. In 2017, approximately eight years later, the population of the three municipalities analyzed was 120 182 inhabitants, 948 inhabitants less; in its structure, 62,082 men and 58,730 women, an estimated decrease of 144 men and 174 women was reported. There is evidence of abandonment by the population of the studied territories where women are the most affected, with a variation in the value of the masculinity index that increases by approximately one man per thousand women (Appendix 2.2.2, Tables 4 and 5).

Table 4. Selected indicators of the population of the municipalities of the AIP in the East region, year 2009.

Municipality	Population					Index masculinity (men for every 1000 women)	Percentage	
	Total	Male	Female	Urban	Rural		urban	rural
Jobabo	47 580	24 608	22 972	18 299	29 281	1 071	38,46	61,54
Population ≥60	7 330	3 924	3 406	2 453	4 877	1 152	33,47	66,53
%	15,41	15,95	14,83	13,41	16,66			
Colombia	32 779	16 750	16 029	22 532	10 247	1 045	68,74	31,26
Population ≥60	5 044	2 531	2 513	3 504	1 540	1 007	69,47	30,53
%	15,39	15,11	15,68	15,55	15,03			
Amancio Rodríguez	40 771	20 868	19 903	28 335	12 436	1 048	69,50	30,50
Population ≥60	6 069	3 062	3 007	4 079	1 990	1 018	67,21	32,79
%	14,89	14,67	15,11	14,40	16,00			
Eastern Region	121 130	62 226	58 904	69 166	51 964	1 056	57	43
Population ≥60	18 443	9517	8 926	10 036	8 407	1 066	54,42	45,58
%	15,23	15,29	15,15	14,51	16,18			

Source: ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2012) Demographic series 2000-2010. Magnetic support.

When this analysis is carried out for the population aged 60 and over, a growth of 3.4 thousand inhabitants is observed, highlighting that this population group increases in urban spaces by 3,668 inhabitants and decreases by 271 in rural areas, as a result of the urban rural migration that is reported. As for all the territory studied, there is an aging demographic of these municipalities, which affects their sustainable development. Likewise, an evident feminization is reported in the aging process of rural spaces, with a percentage growth of the urban population, a decrease in the rural population and a masculinity index that increases for this population group of 60 years and over.

Table 5. Selected indicators of the population of the municipalities of the Eastern region, year 2017.

Municipality	Population					Index masculinity (men for every 1000 women)	Percentage	
	Total	Male	Female	Urban	Rural		urban	rural
Jobabo	47 350	24 503	22 847	18 012	29 338	1 072	38,04	61,96
Population ≥60	8 394	4 368	4 026	3 788	4 606	1 085	45,13	54,87
%	17,73	17,83	17,62	21,03	15,70			
Colombia	32 185	16 747	16 068	22 564	10 251	1 042	70,11	31,85
Population ≥60	6 342	3 224	3 118	4 666	1 676	1 034	73,57	26,43
%	19,70	19,25	19,41	20,68	16,35			
Amancio Rodríguez	40 647	20 832	19 815	28 360	12 287	1 051	69,77	30,23
Population ≥60	7 104	3 487	3 617	5 250	1 854	964	73,90	26,10
%	17,48	16,74	18,25	18,51	15,09			
Eastern Region	120 182	62 082	58 730	68 936	51 876	1 057	57,36	43,16
Population ≥60	21 840	11 079	10 761	13 704	8 136	1 030	62,75	37,25
%	18,17	17,85	18,32	19,88	15,68			

Source ONEI (2017). The aging of the population 2017. Havana

Due to the importance of this population aging process and its high level of manifestation in both regions (Central and Eastern), its behavior will be analyzed in the following section for the period 2009-2017.

III.3. Distribution of the population 60 years and over (Central and Eastern Regions)

The observed variation 2009-2017 shows that the population aged 60 years and older of all seven municipalities studied, increases by 5,921 inhabitants, the urban in 6 369 and the rural decreases by 448 inhabitants. For the population of the municipalities of the Central region, these values represented an increase in the total population of 2 524 inhabitants, of the urban population in 2,701 and a decrease in the rural population of 177 inhabitants; for the Eastern region the variation of the total population was of a growth of 3 397 inhabitants, of such, 3668 urban while the rural diminishes by 271 inhabitants. In all the AIP, the total and urban population aged 60 and over increases, with a decrease in the population in rural areas, a population that moves to urban spaces; the masculinity index shows the process of feminization that is underway in these territories, together with the aging of its population (Appendix 2.2.3, Table 6).

Table 6. Variation of the indicators analyzed for the population aged 60 and over. 2009-2017

Municipality	Variation Population 60 and over 2009-2017				
	Total Population	Male	Female	Urban	Rural
Central Region	2 524	886	1638	2701	-177
Los Arabos	625	273	352	723	-98
Corralillo	449	118	331	550	-101
Quemado de Güines	547	219	328	528	19
Santo Domingo	903	276	627	900	3
Eastern Region	3 397	1 562	1835	3668	-271
Jobabo	1 064	444	620	1335	-271
Colombia	1 298	693	605	1162	136
Amancio	1 035	425	610	1171	-136
Total	5 921	2 448	3473	6369	-448

Source: Prepared from the preceding tables

IV. DYNAMICS OF THE POPULATION AND THE CULTIVATED AREAS IN THE AIP

The studied territories display a complex dynamic in their demographic indicators, (aspect analyzed in the previous section). A similar situation occurs with the cultivated area. In the period 1995-2015 a marked tendency of decline was reported of the cultivated area that reached 36 216 ha. in the municipalities of the Central region, and 51 982 ha. in the municipalities of the East region, making a total of 88 198 ha. Not irrelevant results, considering that the population of these two regions depends on food supplies from other regions of the country and imports them from abroad.

When analyzed by municipality, the greatest drop off in this indicator was observed in the Corralillo municipality of the Central Region, as well as in Jobabo of the East region (Table 7).

Table 7. Variations in the cultivated area 1995-2015 (ha)

Municipalities	1995	2005	2007	2012	2015	1995-2015
Central Region	124 982	98 254	87 094	99 036	88 766	-36 216
Los Arabos	25 126	16 997	15 699	15 473	17 441	-7 685
Corralillo	36 236	26 433	24 061	21 431	19 212	-17 025
Quemado de Güines	20 827	19 459	17 785	15 872	15 841	-4 986
Santo Domingo	42 791	35 363	29 547	38 497	36 271	-6 520
Eastern Region	101 483	67 737	57 668	72 894	49 501	-51 982
Jobabo	39 846	26 589	21 311	29 195	13 035	-26 811
Colombia	23 715	17 336	17 250	16 405	17 804	-5 911
Amancio	37 921	23 811	19 107	27 293	18 661	-19 260
Total	226 465	165 991	144 763	171 930	138 267	-88 198

Note: Decimal values have been approximated to the unit.

Source: Prepared by the authors based on the Balance of Use and Land Tenure of the MINAG (several years).

At the same time, there is a notable decrease in the population within the studied area of approximately 19634 inhabitants between 1995 and 2015. The population of the Central region decreases in the same period by 8,745 inhabitants and the Eastern region by 10889 inhabitants. In the first one, the Santo Domingo municipality stands out for its decrease in the demographic amount with a loss of 3,735 inhabitants; in the Eastern region, the greatest reduction in population is reported at the Jobabo municipality with 5,825 (Table 8).

Table 8. Population dynamics, years 1995-2015

Municipalities	1995	2005	2007	2012	2015	1995-2015
Central Region	131 757	129 364	128 249	131 068	123 012	-8 745
Los Arabos	27 160	25 475	25 144	24 787	24 416	-2 744
Corralillo	27 077	27 747	27 202	26 843	26 393	-684
Quemado de Güines	23 271	22 532	22 507	28 425	21 689	-1 582
Santo Domingo	54 249	53 610	53 396	51 013	50 514	-3 735
Eastern Region	126 351	123 358	122 159	116 420	115 462	-10 889
Jobabo	50 036	49 157	48 415	44 851	44 211	-5 825
Colombia	32 680	32 887	32 740	32 612	32 537	-143

Amancio	43 635	41 314	41 004	38 957	38 714	-4 921
Total	258 108	252 722	250 408	247 488	238 474	-19 634

Source: ONEI (several years). Demographic yearbook of Cuba. Havana; ONEI (2005). Demographic series 1982-2002. Center for demographic studies. T I. Havana; ONEI (2008). Demographic series 1982-2002). Center for demographic studies. T II. Havana.

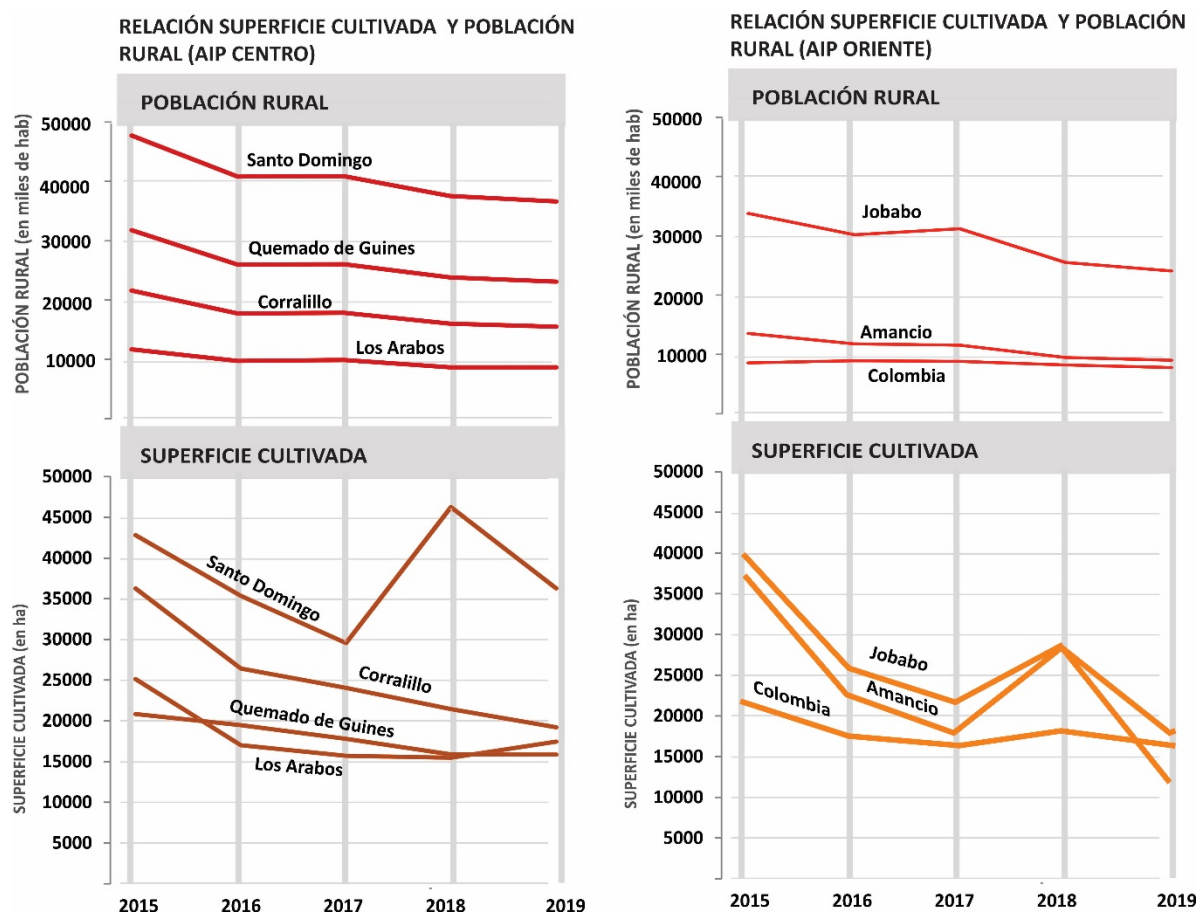
The behavioral analysis of the rural population reveals that the demographic loss reaches more than 23 thousand inhabitants between 1995 and 2015. The rural population of the Central region decreases in equal period by 11175 inhabitants and the Eastern region by 12779 inhabitants. In the first, the municipalities Corralillo and Los Arabos, with 3097 and 3044 inhabitants, respectively, stand out due to their demographic decline; in the eastern region the greatest reduction in population is reported at the Jobabo municipality, with 8251 inhabitants (Table 9).

Table 9. Rural Population Dynamics. Years 1995-2015

Municipalities	1995	2005	2007	2012	2015	1995-2015
Central Region	48 902	41 939	41 995	38 636	37 727	-11 175
Los Arabos	12 602	10 672	10 837	9 568	9 558	-3 044
Corralillo	10 005	8 042	7 976	7 409	6 908	-3 097
Quemado de Güines	10 221	8 260	8 271	7 870	7 626	-2 595
Santo Domingo	16 074	14 965	14 911	13 789	13 635	-2 439
Eastern Region	56 004	51 770	52 347	45 193	43 225	-12 779
Jobabo	31 593	28 543	29 403	24 542	23 342	-8 251
Colombia	10 099	10 405	10 300	9 784	9 412	-687
Amancio	14 312	12 822	12 644	10 867	10 471	-3 841
Total	104 906	93 709	94 342	83 829	80 952	-23 954

Source: ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2005). Demographic series 1982-2002. Center for demographic studies. T I. Havana; ONEI (2008).

Graph 1. Evolution of the cultivated area and the rural population (AIP Central and EAST Region) in the period 1995-2015.



Source: Prepared by the authors from: ONE (several years). Demographic yearbook of Cuba. Havana; ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2005). Demographic series 1982-2002. Center for demographic studies. T I. Havana; ONEI (2008). Demographic series 1982-2002). Center for demographic studies. Balance of Land of the MINAG (several years).

The per capita analysis of the cultivated area per inhabitant is strongly influenced by the decrease in population and its reported aging within the two regions and municipalities of the studied area, in a context where processes and physical-geographic phenomena (meteorological and climatic) linked together to climate change, which highlights the agricultural drought that has been present in these territories for several decades, the loss of agro productivity of soils, the frequency of hurricanes and the expansion of Marabu, the latter favored by the set of factors mentioned above and that influences the decrease in values of the cultivated area. This indicator decreases in the region by 0.298 has cultivated per inhabitant, 0.227 in the Central region and 0.384 in the Eastern region. The Corralillo municipality stands out with a reduction of 0.610 has cultivated per inhabitant and Amancio with 0.387 (Table 10).

Table 10. Variations Per capita of cultivated area per inhabitant, 1995-2015 (ha/inhabitant).

Municipalities	1995	2005	2007	2012	2015	1995-2015
Central Region	0,949	0,760	0,679	0,756	0,722	-0,227
Los Arabos	0,925	0,667	0,624	0,624	0,714	-0,211
Corralillo	1,338	0,953	0,885	0,798	0,728	-0,610
Quemado de Güines	0,895	0,864	0,790	0,558	0,730	-0,165
Santo Domingo	0,789	0,660	0,553	0,907	0,718	-0,071
Eastern Region	0,803	0,549	0,472	0,540	0,429	-0,374
Jobabo	0,796	0,541	0,440	0,651	0,295	-0,502
Colombia	0,726	0,527	0,527	0,196	0,547	-0,178
Amancio	0,869	0,576	0,466	0,701	0,482	-0,387
Total	0,877	0,657	0,578	0,654	0,580	-0,298

Source: Prepared by the authors from the preceding tables.

When this analysis is carried out considering only the rural population, the tendency to reduce the value of this indicator is similar. A loss of 0.451 ha of cultivated area per rural inhabitant is reported; for the Central region this value is minus 0.203 and for the Eastern region minus 0.667. With the largest reductions in the municipalities of Corralillo and Amancio (Table 11 and Illustration 2).

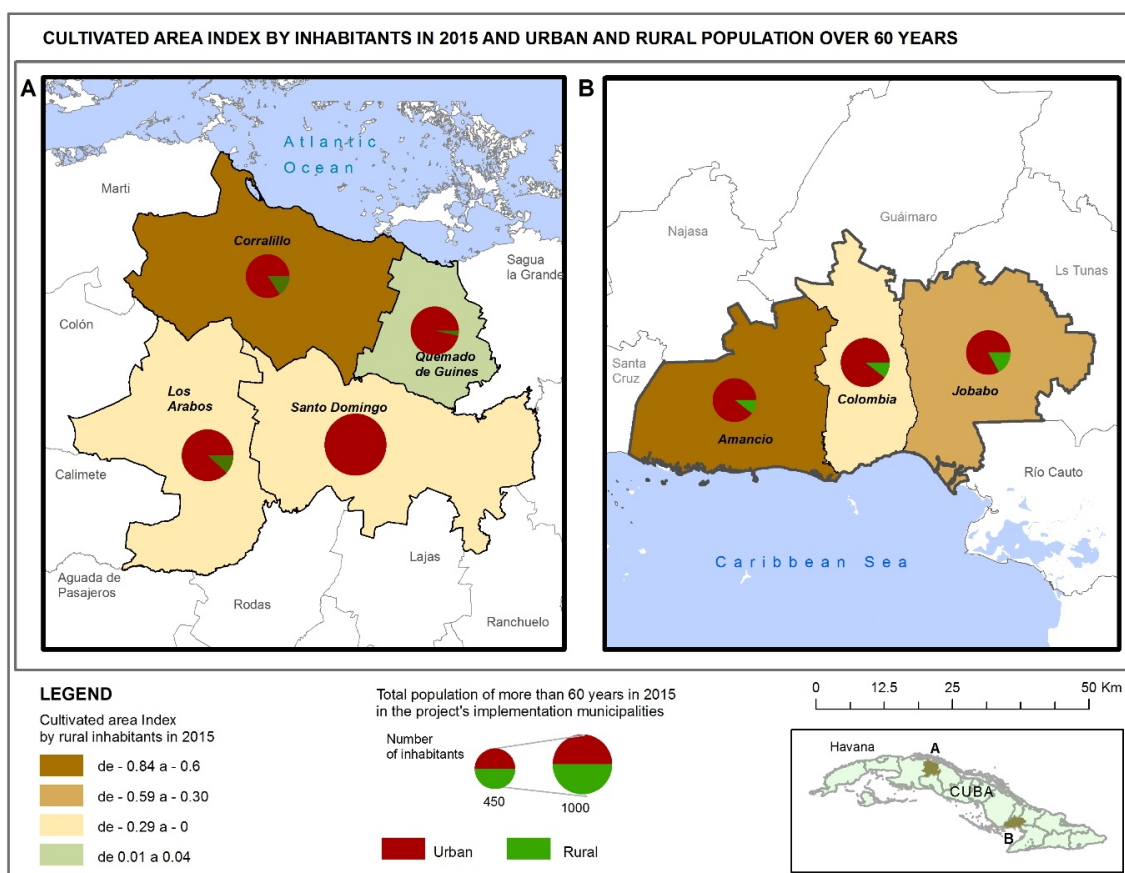
Table 11. Variations per Capita of cultivated rural area per rural inhabitant, years 1995-2015 (ha/rural inhabitant).

Municipality	1995	2005	2007	2012	2015	1995-2015
Central Region	2,556	2,343	2,074	2,563	2,353	-0,203
Los Arabos	1,994	1,593	1,449	1,617	1,825	-0,169
Corralillo	3,622	3,287	3,017	2,893	2,781	-0,841
Quemado de Güines	2,038	2,356	2,150	2,017	2,077	0,040
Santo Domingo	2,662	2,363	1,982	3,355	2,660	-0,002
Eastern Region	1,812	1,308	1,102	1,392	1,145	-0,667
Jobabo	1,261	0,932	0,725	1,190	0,558	-0,703
Colombia	2,348	1,666	1,675	0,655	1,892	-0,457
Amancio	2,650	1,857	1,511	2,512	1,782	-0,867
Total	2,159	1,771	1,534	1,932	1,708	-0,451

Source: Prepared by the authors from preceding tables.

The analysis in figure 3 shows a differentiated behavior of the surface area cultivated per capita per rural inhabitant, with values that represent a per capita loss of 0.84 to 0.6 ha in the Corralillo municipalities in the Central region and Amancio in the East region; a decline in the range from 0.5 to 0.30 ha of cultivated area per capita in the municipality of Jobabo; from 0.29 to 0.01 in the municipalities of Los Arabos, Santo Domingo and Colombia and below that value in Quemado de Güines. It is important to highlight the weight of the population aged 60 and over in the rural areas of the AIP and, in particular, as mentioned above, their tendency to migrate to urban spaces (see Table 6).

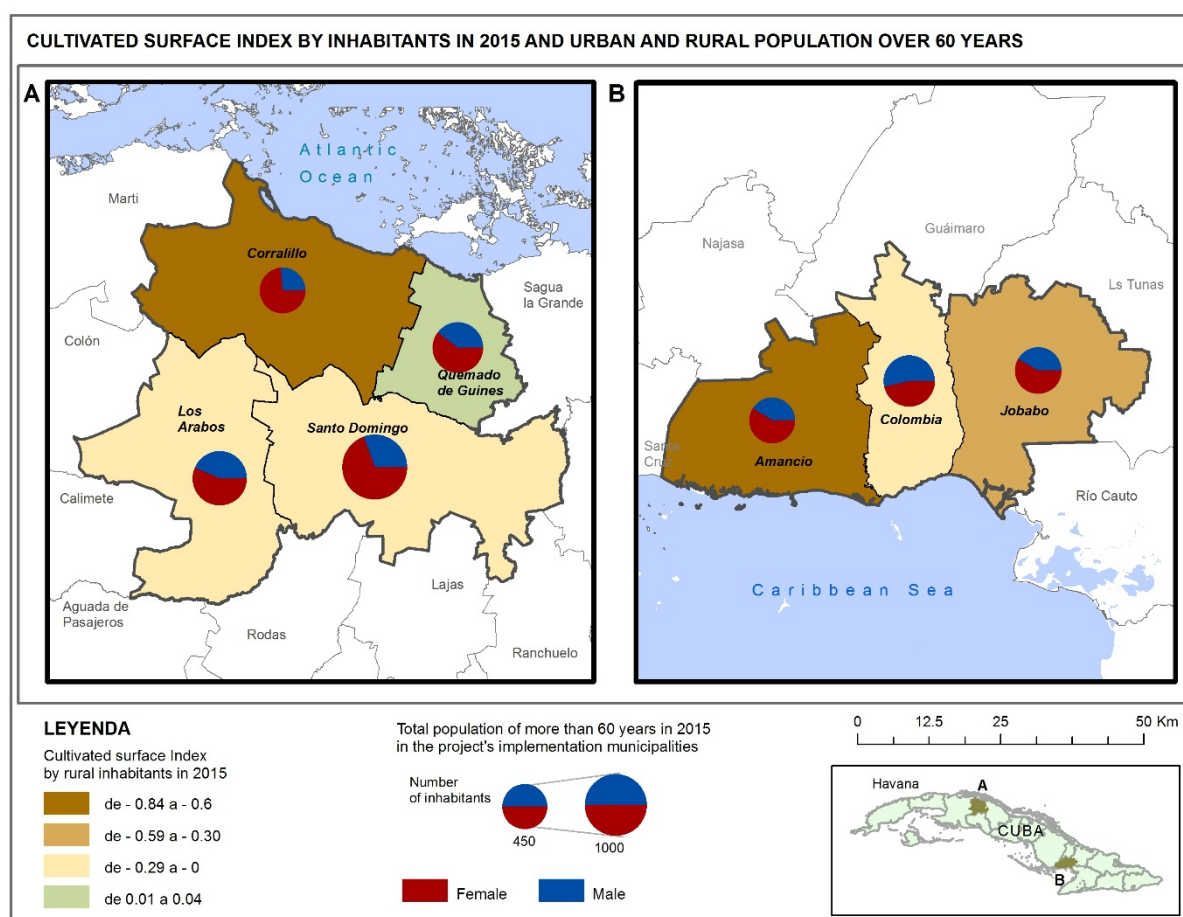
Figure 3. Variation of the index of cultivated area per inhabitant in 2016 - urban and rural population over 60 years.



Source: Prepared by the authors from: ONE (several years). Demographic yearbook of Cuba. Havana; ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2005). Demographic series 1982-2002. Center for demographic studies. T I. Havana; ONEI (2008). Demographic series 1982-2002). Center for demographic studies. T II. Havana. Balance of use and land tenure of the MINAG (several years).

Figure 4 incorporates the gender issue into the analysis of the variation of the per capita index of area cultivated in the AIP. The demographic processes, as highlighted in previous sections, show an increase in the participation of women, which points to an ongoing process of feminization of the population of these municipalities. The masculinity index varies in this age group of 60 years and over, being 1 047 men for every 1000 women in 2009 to 999 in 2017 (see Table 6, Appendix 2.2.3).

Figure 4. Variation of the index of the cultivated land per inhabitant in 2016, and female and male population aged 60 years and over.



Source: Prepared by the authors from: ONE (several years). Demographic yearbook of Cuba. Havana; ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2005). Demographic series 1982-2002. Center for demographic studies. T I. Havana; ONEI (2008). Demographic series 1982-2002). Center for demographic studies. T II. Havana. Balance of use and land tenure of the MINAG (several years).

AIPs display a considerable loss of cultivated area as well as population residing in these territories. The negative trend is present in all the calculated values of the indicators constructed from the ratio of cultivated area and the total rural population of the municipalities. Processes associated with the increase of droughts, resulting in the exodus of the rural population and the abandonment of land by smallholder farmers in their different organizational forms; the frequency of extreme weather events, the proliferation of Marabu as an invasive plant that spreads rapidly in arid environments and whose control is difficult and expensive for the smallholder farmer, are associated with the climatic variability that is observed today in those territories, the adjacent municipalities as well as in other zones of the country (Table 12).

Table 12. Summary of the variation in selected indicators, years 1995-2015

Municipality/Region	Variation 1995-2015		Variation, Cultivated Land Per Capita 1995-2015	
	Cultivated Land (ha)	Population Total (Inhabitants)	In relation to total population	In relation to rural population
Central Region	-36 216	-8 745	-0,227	-0,203
Los Arabos	-7 685	-2 744	-0,211	-0,169
Corralillo	-17 025	-684	-0,610	-0,841
Quemado de Güines	-4 986	-1 582	-0,165	0,040
Santo Domingo	-6 520	-3 735	-0,071	-0,002
Eastern Region	-51 982	-10 889	-0,374	-0,667
Jobabo	-26 811	-5 825	-0,502	-0,703
Colombia	-5 911	-143	-0,178	-0,457
Amancio	-19 260	-4 921	-0,387	-0,867
Total	-88 198	-19 634	-0,298	-0,451

Source: prepared from preceding tables.

V. THE EXPANSION OF MARABU 2012-2019 AND ITS INFLUENCE IN THE DYNAMICS OF THE POPULATION

V.1. Population Dynamics within the AIP affected my Marabu

The municipalities involved in the territory of implementation of the project reveal, as a common feature, a decline in the total population between 2012 and 2017, a process previously mentioned. It has been assumed for these calculations that the population decline responds to emigration to other municipalities, provinces or outside the country. Other indicators that influence these values are not analyzed since these municipalities show natural growth and fertility rates above the national average, which makes the influence of the migratory factor on the obtained values more evident (ONEI, several years. Cuba).

For neighboring or border municipalities, with the exception of Jagüey Grande in Matanzas, which is experiencing significant growth associated with the development of various economic projects related to the citrus agroindustry and other agricultural and livestock products, and the municipality of Las Tunas, head of that province, a condition that transforms it into a population-receiving territory, behavior similar to the capital cities of the remaining provinces. The rest of the municipalities have negative migration rates (Table 13).

This set of municipalities where the project is planned to be implemented, as well as in the adjacent municipalities, stand out for their high negative migratory balance rates of more than 4 per thousand inhabitants: Santa Cruz del Sur, Guáimaro, Cifuentes and Jobabo; with negative rates between 3 and 4 per thousand inhabitants, the municipalities of Santo Domingo, Quemado de Güines, Najasa and Corralillo; with negative rates between 2 and 3 the municipalities Amancio, Calimete, Marti, Sagua La Grande, Los Arabos and Ranchuelo.

Table13. Dynamics and distribution of the population of the municipalities of the AIP and surroundings. Years 2012-2017.

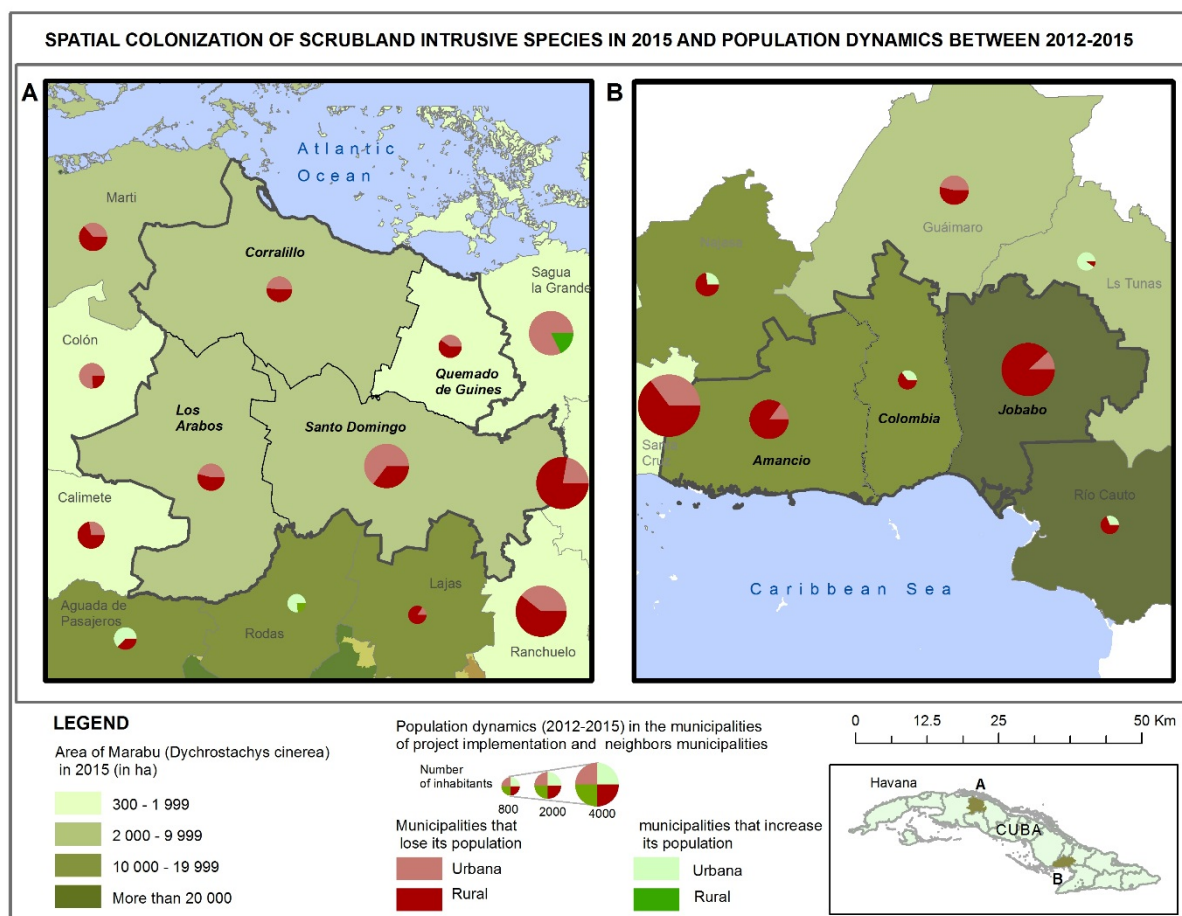
Municipality	Province	2012	2015	2017	Migratory balance rate 2012-2017 (Per thousand inhabitants)
Los Arabos	Matanzas	24 787	24 416	24 119	-2,77
Marti	Matanzas	22 786	22 507	22 236	-2,47
Colón	Matanzas	70 248	70 350	69 881	-0,53
Perico	Matanzas	31 191	31 042	30 774	-1,36
Jagüey Grande	Matanzas	59 722	60 284	60 391	1,11
Calimete	Matanzas	28 751	28 499	28 100	-2,32
Corralillo	Villa Clara	26 843	26 393	25 834	-3,91
Quemado de Güines	Villa Clara	22 089	21 689	21 359	-3,42
Sagua La Grande	Villa Clara	53 077	52 516	51 687	-2,69
Cifuentes	Villa Clara	28 425	27 835	27 323	-4,03
Santo Domingo	Villa Clara	51 013	50 514	49 445	-3,17
Ranchuelo	Villa Clara	54 889	54 244	53 329	-2,93
Aguada de Pasajeros	Cienfuegos	32 159	32 249	32 098	-0,19
Rodas	Cienfuegos	34 376	34 139	33 848	-1,56
Lajas	Cienfuegos	21 999	22 037	21 826	-0,79
Guáimaro	Camagüey	39 118	38 276	37 551	-4,17
Najasa	Camagüey	15 816	15 579	15 260	-3,64
Santa Cruz del Sur	Camagüey	45 710	44 762	43 229	-5,74
Las Tunas	Las Tunas	202 105	207 648	210 412	3,95
Jobabo	Las Tunas	44 851	44 211	43 123	-4,01
Colombia	Las Tunas	32612	32 537	32 186	-1,32
Amancio	Las Tunas	38957	38714	38111	-2,22
Río Cauto	Granma	47189	47381	46804	-0,82

Note: The municipalities in bold are part of the project implementation area; the rest are municipalities bordering these.

Source: ONEI (2012). National Nomenclature of Human Settlements of the Population and Housing Census of 2012. Havana; ONEI (2018). National Statistical Information System (SIEN), of demography 2017.

An assessment of the demographic situation of these municipalities based on the migratory condition that predominates in this group shows that independent of registering positive rates of natural growth, as well as of fertility (ONEI, 2017), the related internal conditions, among others factors, with processes and physio geographic phenomena linked to climate change, among them the increase of drought, the loss of agricultural productivity of the soils and the expansion of invasive plants, such as Marabu, turn them into municipalities emitting population, which leads to a negative growth and population exodus (Figure 5).

Figure 5. Area covered by shrubs of Marabu in 2015 and dynamics of the population according to place of residence in the period 2012-2015 in the AIP



Source: Prepared by the authors from: ONE (several years). Demographic yearbook of Cuba. Havana; ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2005). Demographic series 1982-2002. Center for demographic studies. T I. Havana; ONEI (2008). Demographic series 1982-2002). Center for demographic studies. T II. Havana. Balance of use and land tenure of the MINAG (several years).

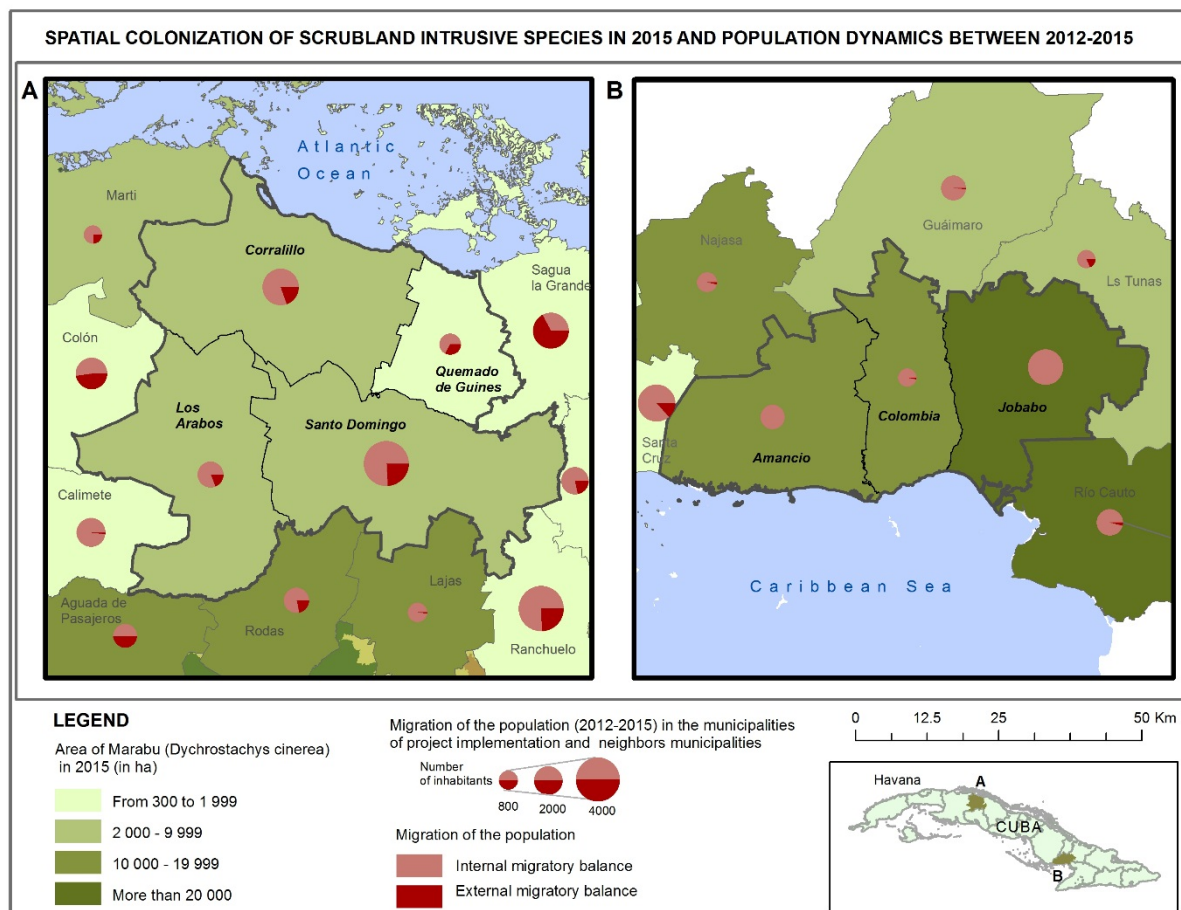
Figure 5 shows the area occupied by Marabu shrubs in the municipalities of the AIP and neighboring municipalities of the Central region, with values ranging from 300 – 1 999 ha in Colón, Calimete, Quemado de Güines, Sagua La Grande and Ranchuelo up to a range that boasts values of more than 20,000 ha in the southern municipalities of Aguada de Pasajeros, Rodas and Lajas. This confirms the thesis that the expansion of the coverage of Marabu goes beyond the municipalities linked to the project and makes the propagation of the shrubs a process that exceeds the limits of the municipalities analyzed, exposing the importance of these effects on the bottom of cultivated lands. For the Eastern region, the domain of Marabu shrubs covers ranges exceeding 10 000 ha, with a maximum coverage in the municipality of Jobabo and the adjacent municipalities. Río Cauto in the province of Granma. The analysis of the quantitative information for both regions makes this an evident fact that dominates the population decline, both for urban and rural areas of all the municipalities studied.

Figure 6 The area occupied by Marabu shrubs in the municipalities of the AIP and neighboring areas for 2015, and the migration process 2012-2015 reported in those territories show that all Municipalities, both those included in the AIP and the adjacent ones, experience emigration, internally from rural to urban areas and externally outside their limits (IPF, 2012. National study of

internal migration 1976-2010, ONEI, 2016. Statistical yearbook by provinces and municipalities, Ed. 2018). Havana).

Values of migratory balance rate are negative in all cases (see Table 13).

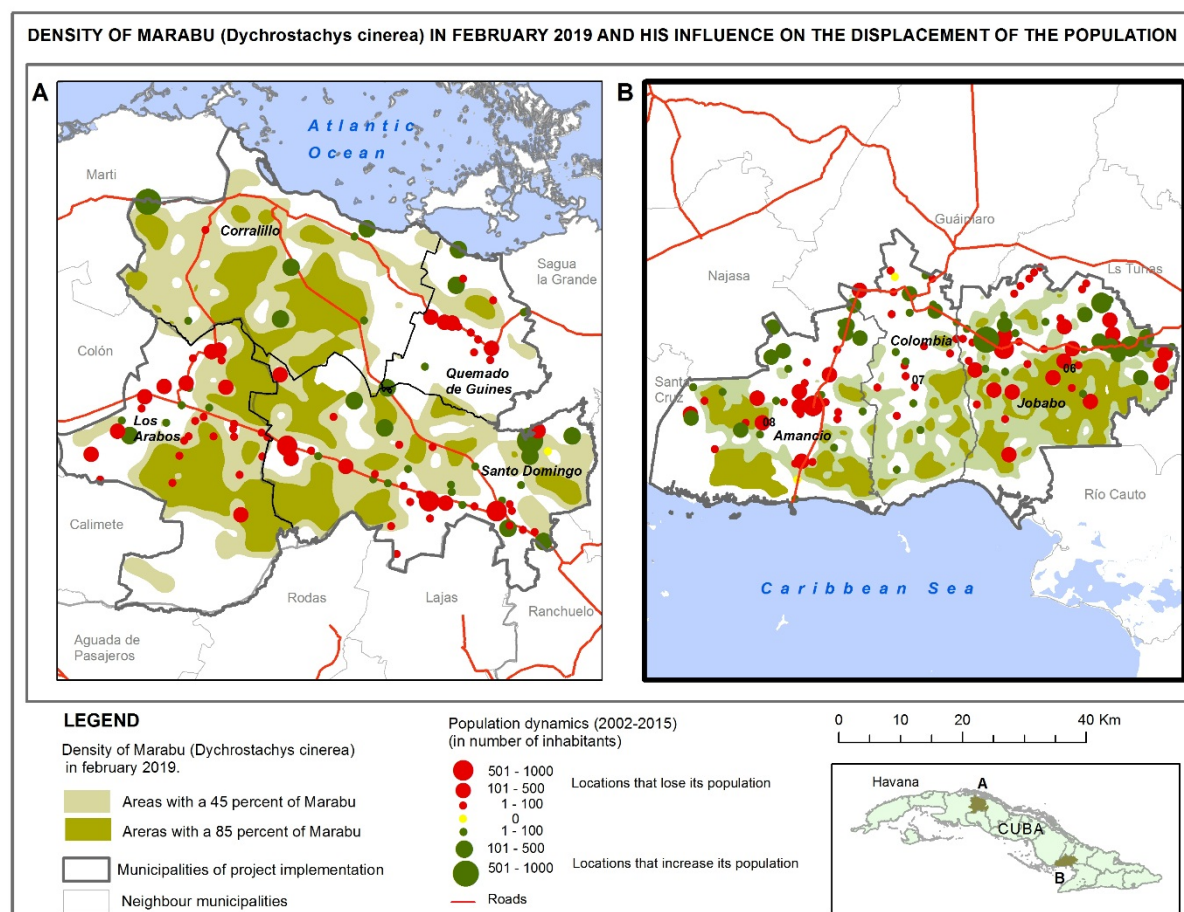
Figure 6. Area covered by Marabu between 2015 and 2019 and the migratory balance rate of the population by location 2012-2015.



Source: Prepared by the authors with inputs from: ONE (several years). Demographic yearbook of Cuba. Havana; ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2005). Demographic series 1982-2002. Center for demographic studies. T I. Havana; ONEI (2008). Demographic series 1982-2002). Center for demographic studies. T II. Havana. Balance of use and land tenure of the MINAG (several years).

From the study of satellite images for 2019, figure 6 shows very important points of the territory with high densities of Marabu shrubs, forming a kind of north to south corridor in the Central region that covers a large part of the total surface of the municipalities Corralillo, Los Arabos and Santo Domingo, where the coverage densities of Marabu, with values of 45% and up to 85% predominate in the territory. In the Eastern region there is a corridor of Marabu areas with 45% density, along the entire central and southern part of the three municipalities and reaching the vicinity of the coastal area. Although the localities whose population declined in the region between the years 2002-2015 predominate, a small number of them report little significant increases (Table 13 and Figure 7).

Figure 7. Shrub density of Marabu and variation of population by locality 2002-2015



Source: Prepared by the authors based on images of the Sentinel 2a satellite (February 2019) and the Demographic Yearbook of Cuba. Havana; ONEI (several years).

V.2. Dynamics of Marabu Shrubs for the period 2015-2019

Figure 7 shows a marked relationship between the areas whose coverage of Marabu grows or remains in the course of the years 2015-2019, with small decreases in the eastern end of the Corralillo municipality, the southern portion of Los Arabos and small plots in the Quemado de Güines and Santo Domingo municipalities of the Centro region. In the Eastern region a wide distribution of areas covered with shrubs is detected, that extend from the central part of the Amancio, Colombia and Jobabo municipalities that extends and increases in density towards the coast. However, the common denominator in terms of the migration balance rate by localities for both regions and their municipalities is negative (Table 14 and Figure 8).

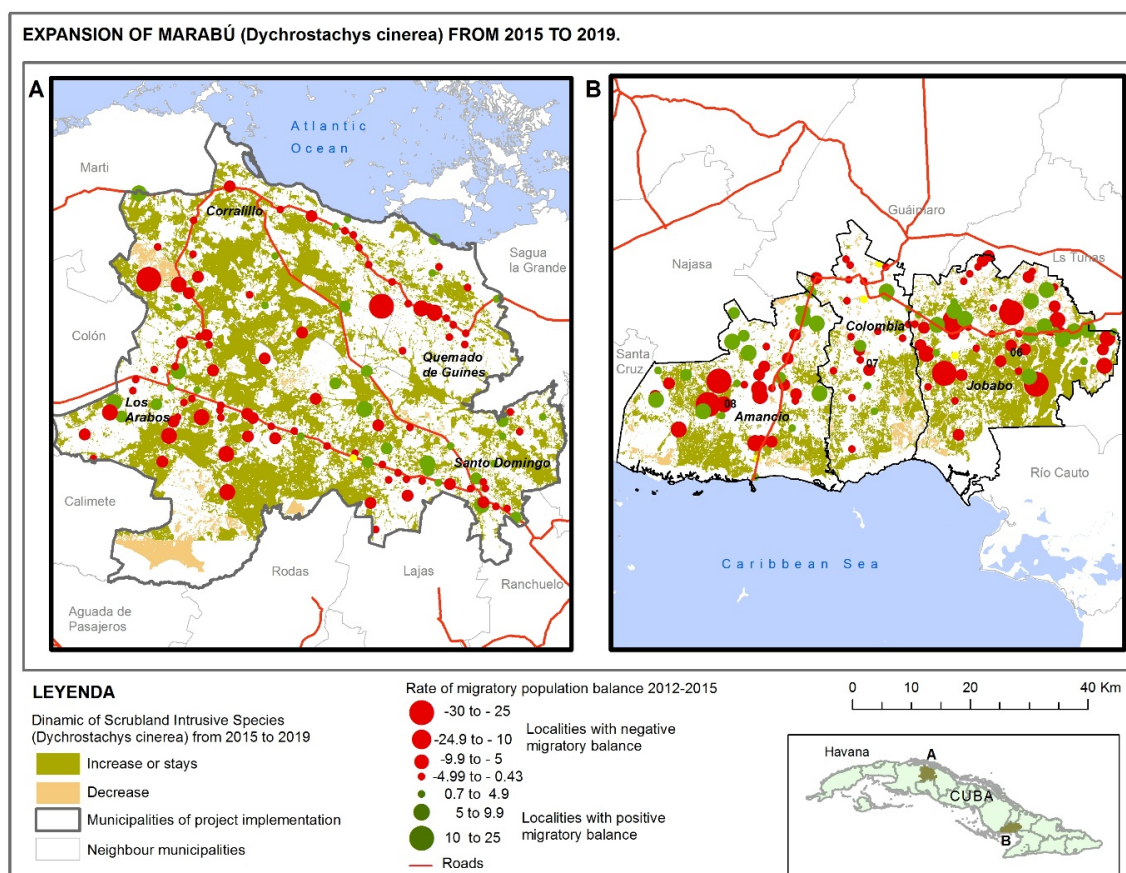
The behavioral study of the area occupied by Marabu shrubs and its dynamics between 2015 and 2019, from the interpretation of satellite images for 2019, shows a percentage growth of 31,14 for the AIP within the Central region, with higher percentage values of growth in the municipalities of Corralillo and Santo Domingo; for the AIPs of the Eastern region, a percentage growth of 22,25, with higher percentages of growth in the Jobabo municipality of 27.66 (Table 14).

Table 14. Covered area of Marabu in each municipality in the years 2015 and 2019.

MUNICIPALITY	Total Area (Km ²)	Marabu infested areas 2015 (%)	Marabu infested areas 2019 (%)
Central Region	2 815,86	10,07	40,40
Los Arabos	757,61	12,01	35,93
Santo Domingo	885,10	10,51	24,24
Quemado de Güines	333,26	0,63	5,49
Corralillo	839,89	10,60	31,50
Eastern Region	2 298,77	25,69	31,44
Jobabo	888,48	39,89	35,93
Colombia	561,33	13,40	24,24
Amancio	848,95	19,14	31,50
Total	5 114.63	17,09	71,9

Source: Prepared by the authors based on the Balance of Use and Land Tenure of the MINAG (several years). Images from the Sentinel 2a satellite (February 2019).

Figure 8. Variation in the area occupied by Marabu shrubs in the AIP and migration status of the localities.



Source: Prepared by the authors based on images of the Sentinel 2a satellite (February 2019) and the Demographic Yearbook of Cuba. Havana; ONEI (several years).

VI. IDLE LANDS AND NATURAL PASTURES, AND THEIR CORRESPONDENCE WITH THE EXPANSION OF MARABU SHRUBS

The analysis of the distribution of lands covered with natural pastures and other lands that are considered idle, according to the MINAG declaration for 2015 in its Land Use Balance, evidences for the municipalities of the Central region, that by 2015 they occupied approximately 55% of the total area of the region, with a maximum value of 60% in Los Arabos of the total municipal area and a minimum of 42% in Quemado de Güines. In this analysis, the lands declared as covered with natural pastures with a relatively high level of Marabu shrub infestation are considered, which is confirmed from the satellite image analysis of 2019 and the map of agriculture prepared by the Directorate of Soils and fertilizers from MINAG in 2015 (Table 15).

Table 15. Covered surface of natural pastures and declared idle lands in the municipalities of the Central region, year 2016

Municipality	Total Area (km ²)	Natural Pastures (a)	Idle Lands (b)	Total (a + b)	% Lands of Municipal Surface		
		(km ²)			Of natural pastures (c)	Idle (d)	Total (c + d)
Central Region	2 815,86	953	608	1561	33,84	21,59	55,44
Los Arabos	757,61	276	176	452	36,43	23,23	59,66
Corralillo	839,89	296	189	484	35,24	22,50	57,63
Quemado de Güines	333,26	92	47	140	27,61	14,10	42,01
Santo Domingo	885,10	289	196	485	32,65	22,14	54,80

Source: Prepared from the Balance of land use, MINAG (2015).

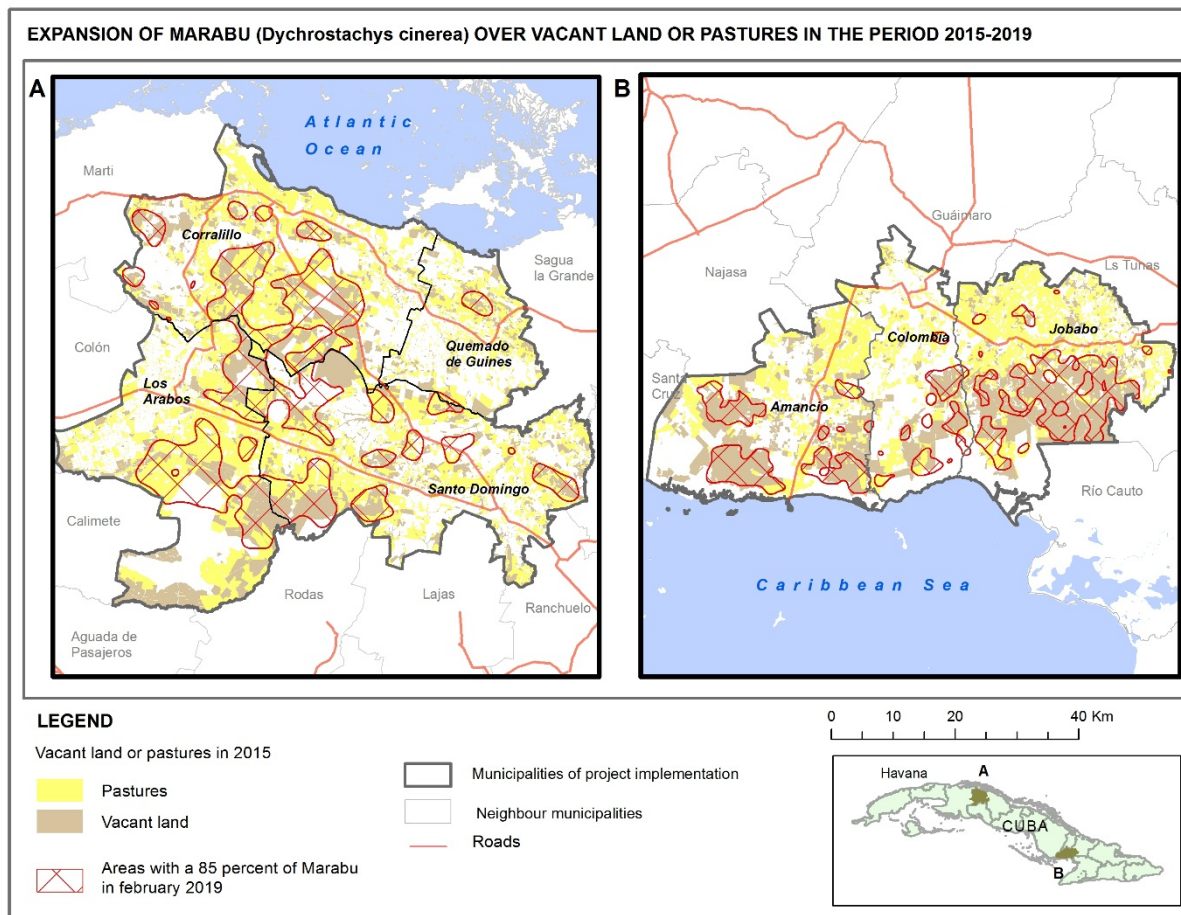
The distribution of the lands covered with natural pastures and other lands that are considered idle for the municipalities of the Eastern region occupied in 2015 approximately 55% of the total area of the region, with a maximum value of 65.48% of the surface total of the municipality in Jobabo, and a minimum of 38.45% in Colombia. In this analysis, the lands declared as covered with natural pastures with a relatively high level of Marabu scrub infestation are considered, which is confirmed from the satellite image analysis of 2019 and the map of agriculture prepared by the Directorate of Soils and fertilizers of the MINAG for 2015 (Table 16).

Table 16. Covered area of natural pastures and declared idle lands in the municipalities of the Eastern region, 2015

Municipality	Total Surface (Km ²)	Natural Pastures (a)	Idle Lands (b)	Total (a + b)	% Lands of Municipal Surface		
		(Km ²)			Of natural pastures (c)	Idle (d)	Total (c + d)
East Region	2 298,77	596	680	1 276	25,96	29,60	55,56
Colombia	561,33	117	98	215	20,85	17,60	38,45
Jobabo	888,48	281	300	581	31,71	33,77	65,48
Amancio	848,95	197	281	478	23,31	33,17	56,48

Source: Prepared by the authors based on the Balance of Use and Land Tenure of the MINAG (several years).

Figure 9. Expansion of the area occupied by Marabu shrubs in idle declared lands or with natural pastures between 2012 and 2019



Source: Prepared by the authors based on images from the Sentinel 2a satellite (February 2019). Balance of use and land tenure of the MINAG (several years).

In the values shown in tables 15 and 16 of the idle lands or with natural pastures between 2012 and 2019, its assessment for 2015 and the area covered with shrubs of Marabu in the year 2019 (figure 9), an extremely important situation is observed as an unfavorable loss of cultivated area, in a context where processes and physical-geographical phenomena (meteorological and climatic) linked to climate change are added, among which the agricultural drought that has been constant in these territories for several decades stands out. The loss of agro productivity of the soils, the frequency of hurricanes and the expansion of the Marabu, the latter favored by the set of factors previously mentioned and that influences the decrease in the values of cultivated area (see Table 10).

VII. LANDHOLDERS IN THE AIP AND THEIR RELATION WITH THE EXPANSION OF MARABU

VII.1 Landholders, cultivated area and Marabu covered area of in the period 2012-2015.

The analysis of the three indicators at the level of the territories studied for the year 2012 shows a non-uniform distribution, with a greater number of landholders in the Central region (53%), who own 61% of the cultivated area and 36% of the covered area of Marabu. Studied at the municipality scale, Santo Domingo stands out in the Central region, and Jobabo in the Eastern region with 24% and 22% of the landholders and 29% and 18% of the cultivated area respectively. When the area covered by Marabu is assessed, the municipalities of Amancio and Colombia report the highest values with 28% and 25% respectively. The ratio of hectares of cultivated area per hectare of Marabu covered area is 1.7 (Table 17).

Table 17. Landholders, cultivated area and Marabu covered area, year 2012

Municipality	Landholders	Cultivated Area	Area covered by Marabu
Central Region	9 865	99 036	34 317
Los Arabos	1 062	15 474	5 204
Corralillo	2 807	21 432	14 903
Quemado de Güines	1 452	15 873	777
Santo Domingo	4 544	46 258	13 433
Eastern Region	8 847	62 895	61 036
Jobabo	4 160	29 195	9 564
Colombia	1 504	6 406	24 312
Amancio	3 183	27 294	27 159
Total	18 712	161 930	95 352

Source: Prepared from the balance of use and land tenure, MINAG (2012).

In 2013, the share of landholders in the Central region (81%) increased in the total number of holders of the territory studied, where the municipality of Santo Domingo stands out with 45% of the total number of holders. The municipalities of Jobabo and Amancio reveal the highest percentage of cultivated area with 39% and 28% respectively. In terms of the areas covered by Marabu, the municipalities of Santo Domingo and Colombia stand out with 27 and 20% respectively. For every 1.7 hectares of cultivated area, one ha of Marabu is reported (Table 18).

Table 18. Landholders, cultivated area and Marabu covered area, year 2013

Municipality	Landholders	Cultivated Area	Area covered by Marabu
Central Region	11 812	25 218	88 356
Los Arabos	1 942	3 942	15 368
Corralillo	1 992	13 539	20 138
Quemado de Güines	1 355	935	13 090
Santo Domingo	6 523	6 802	39 759
Eastern Region	2 683	78 432	60 653
Jobabo	35	40 782	7 552
Colombia	1 628	8 257	29 186
Amancio	1 020	29 393	23 915
Total	14 495	103 649	149 008

Source: Prepared from the balance of use and land tenure, MINAG (2012).

The Central region maintained the highest participation in total holders (62%) in 2015; the municipalities of Santo Domingo and Jobabo stand out with 29 and 21% respectively. The Central region has 64% of the cultivated area of the territory studied while the Eastern region has 68% of the total area of existing Marabu in the entire territory studied. For each 1.58 hectare of cultivated area, one ha of Marabu is reported (Table 19)

Table 19. Landholders, cultivated area and Marabu covered area, year 2015

Municipality	Landholders	Cultivated area (ha)	Area covered by Marabu (ha)
Central Region	9 189	88 766	28 367
Los Arabos	2 056	17 441	9 104
Corralillo	1 603	19 212	9 751
Quemado de Güines	1 254	15 841	210
Santo Domingo	4 276	36 271	9 303
Eastern Region	5 751	49 501	59 054
Jobabo	3 186	13 035	35 286
Colombia	1 645	17 804	7 522
Amancio	920	18 661	16 246
Total	14 940	138 266	87 421

Source: Prepared from the balance of use and land tenure, MINAG (2015).

The 2012-2015 comparative analysis of the indicators considered shows a reduction of approximately 3.7 thousand landholders, with a greater reduction in the East region. At the municipality level, the decreases in the number of Amancio and Corralillo landholders stand out. The cultivated area decreases by 23,664 ha in the studied area, with the Jobabo municipality standing out with a loss of more than 16 thousand ha (Table 20 and 21).

Table 20. Variation in the values of landholders, cultivated area and Marabu covered area, years 2012-2015

Municipality	Landholders	Cultivated Area (ha)	Area covered by Marabu (ha)
Central Region	-676	-10 270	-5 950
Los Arabos	994	1 968	3 900
Corralillo	-1 204	-2 220	-5 153
Quemado de Güines	-198	-31	- 567
Santo Domingo	-268	-9 987	-4 130
Eastern Region	-3 096	-13 394	-1 981
Jobabo	-974	-16 160	25 721
Colombia	141	11 398	-16 790
Amancio	-2 263	-8 632	-10 913
Total	-3 772	-23 664	-7 930

Source: Prepared from the balance of use and land tenure, MINAG (several years).

Table 21. Variation in the values of indicators for landholders, cultivated area and Marabu covered area, years 2013-2015

Municipality	Landholders	Cultivated Area	Area covered by Marabu (ha)
Central Region	-2 623	63 549	-59 988
Los Arabos	114	13 499	-6 264
Corralillo	-389	5 673	-10 388
Quemado de Güines	-101	14 906	-12 880
Santo Domingo	-2 247	29 470	-30 457
Eastern Region	3 068	-28 932	-1 599
Jobabo	3 151	-27 747	27 733
Colombia	17	9 548	-21 664
Amancio	-100	-10 732	-7 669
Total	445	34 617	-61 587

Source: Prepared from the balance of use and land tenure, MINAG (several years).

VIII. EXTREME METEOREOLOGICAL PHENOMENA, CLIMATE CHANGE, AND THEIR INFLUENCE IN THE AIP

Climate change affects all regions of the world. In some regions, extreme weather events and floods are becoming more frequent, and in others heat waves and droughts are recorded. It is likely that its consequences will intensify in the coming decades.

The AIPs are located in a geographical area historically affected by hurricanes, in the Atlantic Ocean basin. In the last 15 years these destructive organisms have had a significant increase in their frequency and intensity, according to some experts we are in an active cycle, in addition to the possible effect caused by global warming as a result of climate change. The consensus among scientists is that ocean currents are responsible for the current increase in the number of hurricanes and their intensity in the Caribbean. The increase in 0.5 degrees of the average temperature of the waters in the whole planet is an addition to a natural tendency, but never the trigger. At present there are other hypotheses that relate this increase in cyclonic activity to global warming, meaning that recent studies suggest that global warming may have a much greater effect on the number and intensity of hurricanes than it was initially thought.

Global warming raises water temperatures in the oceans by converting them, together with hot air, into fuel for hurricanes, although there is still no conclusive evidence on whether the increase in activity is related to climate change, AIPs are under the influence area of the historical trajectory of hurricanes.

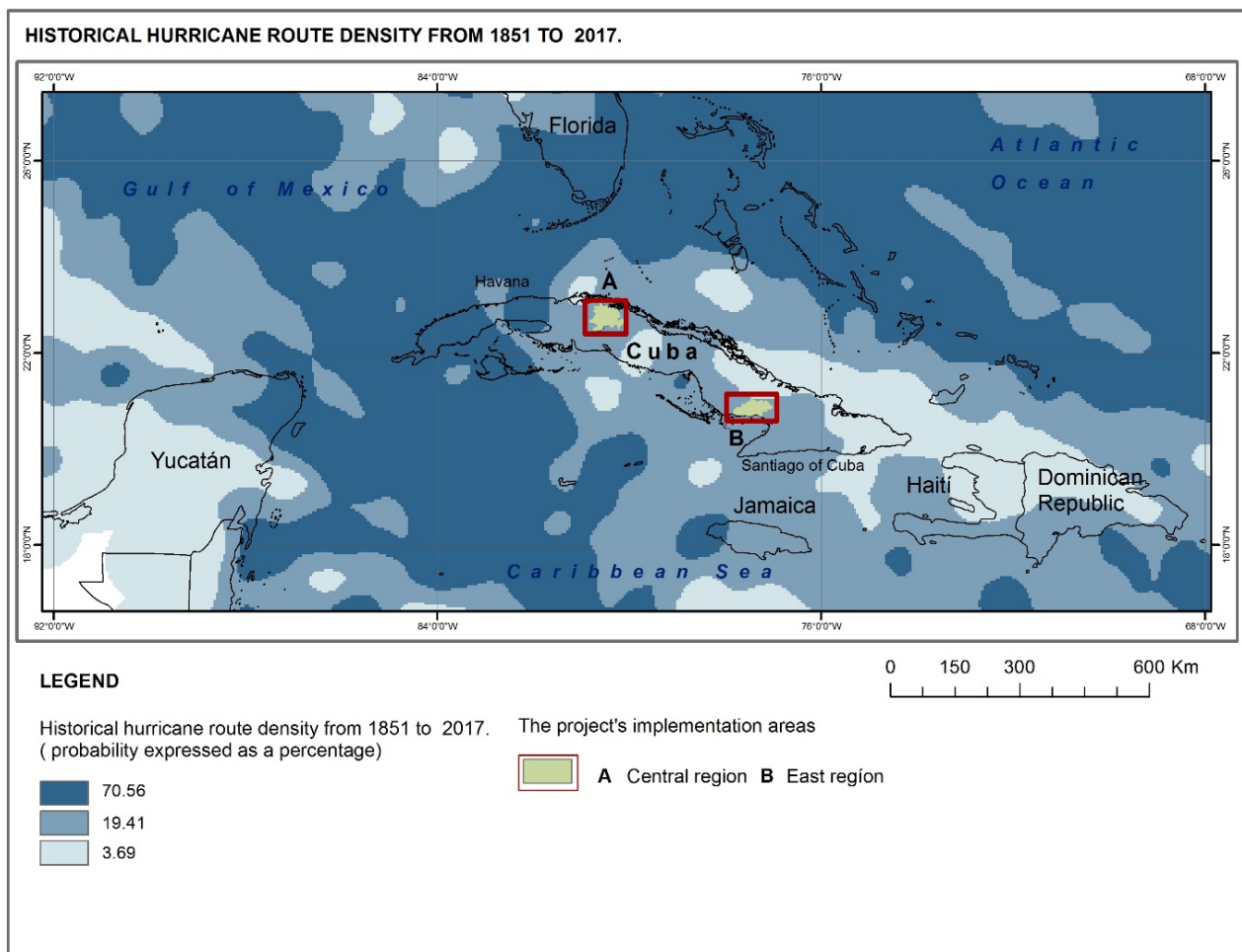
VIII.1 HURRICANES AND THEIR IMPACT IN THE AIP

Tropical cyclones and severe local storms are the extreme weather events that most affect the AIPs. Although the scourge of these events is more frequent towards the west-central region of the country (Figure 10), in the last 15 years we have been experiencing a very active period of hurricane activity in Cuba. Between 2005 and 2017, the country was affected by 11 hurricanes. In recent years, the

Central and Eastern regions of the country especially Las Tunas province, has been affected by 4 tropical organisms.

Figure 10 represents a density surface that visualizes the areas with the highest concentration in the historical trajectories of hurricanes from 1851 to 2017, expressing the probability values in percentages.

Figure 10. Historical trajectories of hurricanes between 1851 and 2017) for the hurricane season (June-November)



Source: Prepared by the authors based on data downloaded from: <https://www.nhc.noaa.gov/data/>

When analyzing the events that have affected Cuba from 2000 to date, the number of hurricanes that have impacted the island and the intensity recorded by these events is remarkable, table 22 summarizes some of the most important.

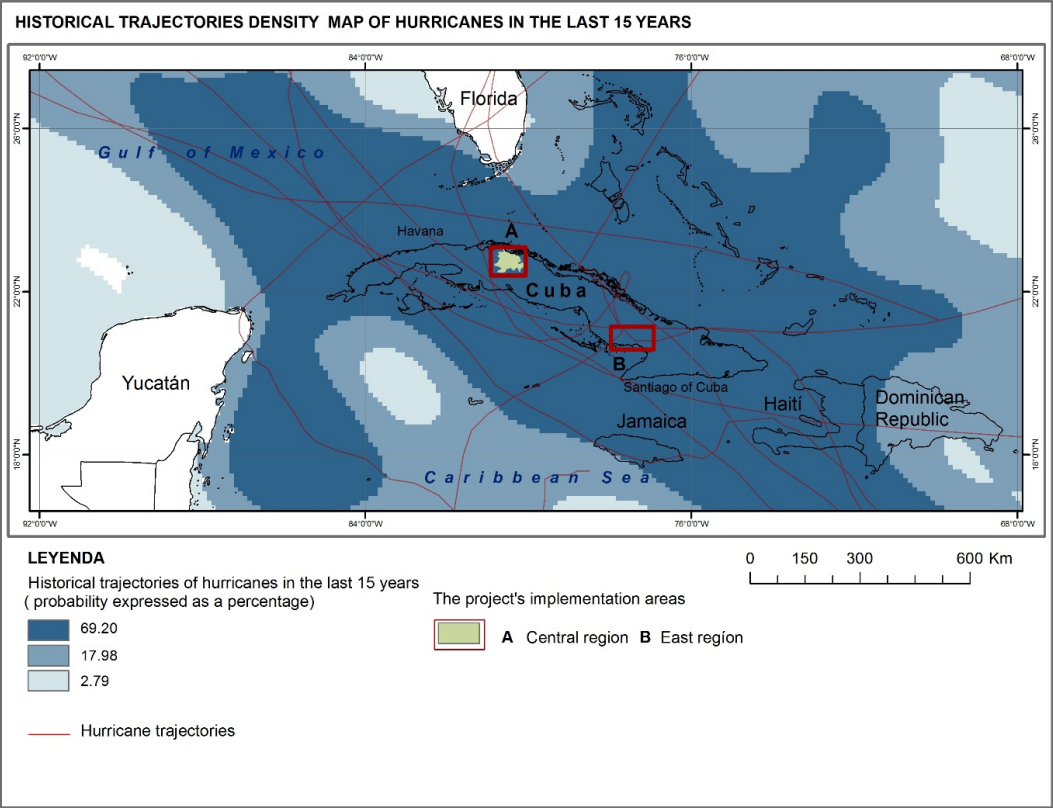
Table 22. Aspect ratio of hurricanes that affected Cuba in the 21st century

Hurricane	Year	Category	Affected Provinces
Michelle	2001	4	Isla de la Juventud, Matanzas, Cienfuegos and Villa Clara.
Isidore	2002	1	Pinar del Río
Lili	2002	2	Pinar del Río
Charley	2004	3	La Habana, Artemisa, Mayabeque
Ivan	2004	5	Santiago de Cuba, Granma, Cienfuegos,
Dennis	2005	4	Santiago de Cuba, Granma, Cienfuegos, Matanzas La Habana, Artemisa, Mayabeque
Wilma	2005	5	La Habana, Artemisa
Gustav	2008	4	Isla de la Juventud, Pinar del Río
Ike	2008	4	Isla de la Juventud, Pinar del Río
Paloma	2008	3	Camagüey and Las Tunas
Sandy	2012	3	Santiago de Cuba
Matthew	2016	4	Guantánamo
Irma	2017	5	North shore from Guantanamo to Artemisa

Source: Prepared by the authors with information from <http://www.insmet.cu>

In the model constructed from the trajectories followed by these organisms over the past 15 years, it is worth noting that not only the east is within the areas of greatest probability, but that these areas cover practically the entire island of Cuba and its adjacent seas, which would imply that the AIPs would be more exposed than in previous decades, although it is premature to affirm that the areas most likely in the trajectories of these organisms have moved further north and include practically the entire island of Cuba and not only to the east of Cuba, it is interesting to see the surfaces with higher concentrations taking into account the last 15 seasons (Figure 11).

Figure 11. Historical hurricane trajectories in the last 15 years - For the hurricane season months



Source: Prepared by the authors based on data downloaded from: <https://www.nhc.noaa.gov/data/>

VIII.2 PROTECTION OF THE COASTS BY MANGROVES IN THE AIP

The insular condition of Cuba, with two large islands and more than 1,600 islets or cays, makes mangroves a natural barrier of great importance to mitigate the negative effects of increased mean sea level, coastal flooding and strong winds caused by extreme hydrometeorological phenomena, such as hurricanes, and at the same time preserve their diversity of marine and terrestrial species.

With a length of coasts of 5 746 km on the big island, and an elongated and narrow configuration, practically all of the Cuban territory can be considered "coastal" and "marine". The AIPs located on the north central coast and south east coast have a considerable area in the coastal zone, despite being on different coasts they have very similar geomorphological and geological features, where the biogenic and cumulative marine and fluvial plains predominate with the presence of mangroves and coastal lagoons in most of its configuration.

The length of the coast occupied by these municipalities is 243.19 km, of which 69.31 km in the Central AIP region, and 173.88 km in the East region, which represent 4.2% of the coasts of Cuba and 1.98% and 5.75% of the north and south coasts in each case (Table 23), with an orientation of the coast predominantly between the north and northeast on the north central coast and towards the south and southwest at the south east coast (Chart 2)

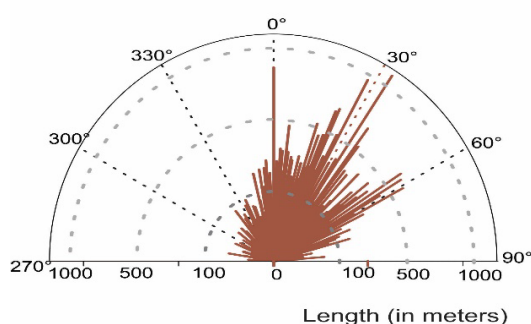
Table 23 - Coast length by municipality, protected by mangroves

MUNICIPALITY	Coast Length (Km2)	Coast protected by mangroves (Km2)	Coast protected by mangroves (%)	Mangrove surface in 2019 (Ha)
Central Region	69,31	57,19	82,51	2 014,86
Quemado de Güines	14,85	12,08	81,35	1 013,48
Corralillo	54,46	45,11	82,83	1 001,37
East Region	173,88	157,59	90,63	9 393,30
Jobabo	41,04	36,54	89,04	3 108,26
Colombia	16,1835	16,18	99,98	1 726,27
Amancio	116,65	104,87	89,90	4 558,78
Total	243,19	214,78	88,32	11 408,16

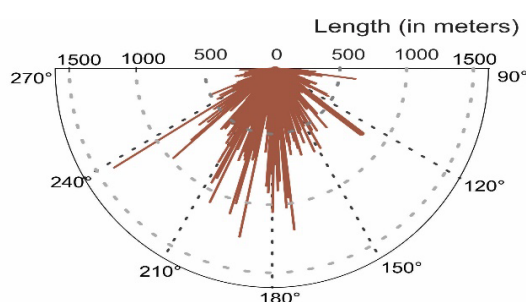
Source: Prepared by the authors based on images from the Sentinel 2a satellite of the month of February 2019.

Graphic 2. Coastal Orientation (in degrees)

AIP Central Region



AIP East Region



Source: Prepared by the authors based on the cartographic base of Cuba at scale 1:25 000

Evolution of the Mangrove Area

Mangrove forests highlight the vegetation formations present on both coasts. The stretches of coast with wide insular platform, as is the case of the territories studied, correspond generally with cumulative biogenic (mangrove) coasts.

The analysis of the data available in the statistics of the information system of the national cadaster of land use for the years 2003 and 2007, issued by the Directorate of Hydrography and Geodesy (MINFAR), in relation to the forest area for the Central region and in its structure, the participation of natural forests and the area covered by mangrove swamps and herbaceous marshes, is observed for the first of the considered years, amounting to 26 088 ha; of them, 11 264 occupied by natural forests and, from this category of use, mangroves and herbaceous marsh vegetation with 1 895 ha. These magnitudes vary for 2007, when the forest area totals 26 106 ha, with a decrease in the area occupied by natural forests of 366 ha and 43.6 ha in the mangroves, including the swamp grass vegetation (table 24).

In 2019, with the use of satellite images, based on its interpretation and analysis, the mangrove area was 2 014.86 ha, which represents an increase of approximately 120 ha in the Central region; 192 ha in the municipality of Corralillo, decrease of 48 ha in Quemado de Güines and 25 ha in Santo Domingo.

The data available for land use for the years 2003 and 2007 on the forest area for the East region, and the participation in its structure of the natural forests and the area covered with mangrove swamps and herbaceous marshes, amounts to 26 717 ha for the first of the considered years; Of these, 13,873 have been occupied by natural forests and, from this category of use, mangroves and herbaceous vegetation are mentioned with 5,540 ha. These magnitudes vary for 2007 and the forest area reaches 27 672 ha, with an increase in the area occupied by natural forests of 692 ha and a decrease of 506 ha of mangroves, including the vegetation of swamp shrubs (table 25).

Table 24. Central Region: land use according to selected use categories (ha).

Concept	Los Arabos	Corralillo	Quemado de Güines	Santo Domingo	Central Region
Year 2003					
Forest Area. Of which	11 805,35	6 701,15	1 667,99	5 913,59	26 088,08
Natural Forests. Of which	688,6	6 583,65	1 618,5	2 373,84	11 264,59
• Mangrove and swamp scrub	0	808,81	1 061,86	24,57	1 895,24
Year 2007					
Forest Area. Of which	12 057,83	6 681,22	1 551,92	5 815,63	26 106,6
Natural Forests. Of which	687,69	6 563,72	1 473,51	2 173,57	10 898,49
• Mangrove and swamp scrub	0	784,25	1 094,84	17,54	1 851,63
Variation 2003-2007					
Forest Area. Of which	252,48	-19,93	-116,07	-97,96	18,52
Natural Forests. Of which	-0,91	-19,93	-144,99	-200,27	-366,1
• Mangrove and swamp scrub	0	-24,56	-12,02	-7,03	-43,61
Year 2019					
Mangrove (ha)	0	1 001,37	1 013,48	0	2 014,86
Mangrove variation 2003-2019					
Mangrove	0	192,56	-48,38	-24,57	119,61

Note: The sum of what was declared as mangrove and herbaceous swamp vegetation in the same category are considered in the calculations for 2003 to 2007

Source: Directorate of Hydrography and Geodesy, Ministry of the Revolutionary Armed Forces (MINFAR).

Table 25. East Region: land use according to selected use categories (ha).

Concept	Jobabo	Colombia	Amancio	East Region
Year 2003				
Forest Area. Of which	10 938,3	3 608,3	12 170,8	26 717,4
Natural Forests. Of which	6 417,9	2 656,34	4 799,39	13 873,63
• Mangrove and swamp scrub	11 10,07	2 307,35	2 122,46	5 539,88
Year 2007				
Forest Area. Of which	11 015,28	3 999,55	12 657,85	27 672,68
Natural Forests. Of which	6 279,1	2 916,62	5 370,11	14 565,83
• Mangrove and swamp scrub	1 067,52	2 304,71	1 661,29	5 033,52
Variation 2003-2007				
Forest Area. Of which	76,98	391,25	487,05	955,28
Natural Forests. Of which	-138,8	260,28	570,72	692,2
• Mangrove and swamp scrub	-42,55	-2,64	-461,17	-506,36
Year 2019				
Mangrove (ha)	3 108,26	1 726,27	4 558,78	11 408,16
Mangrove variation 2003-2019				
Mangrove	1 998,19	-581,08	2 436,32	3 853,42

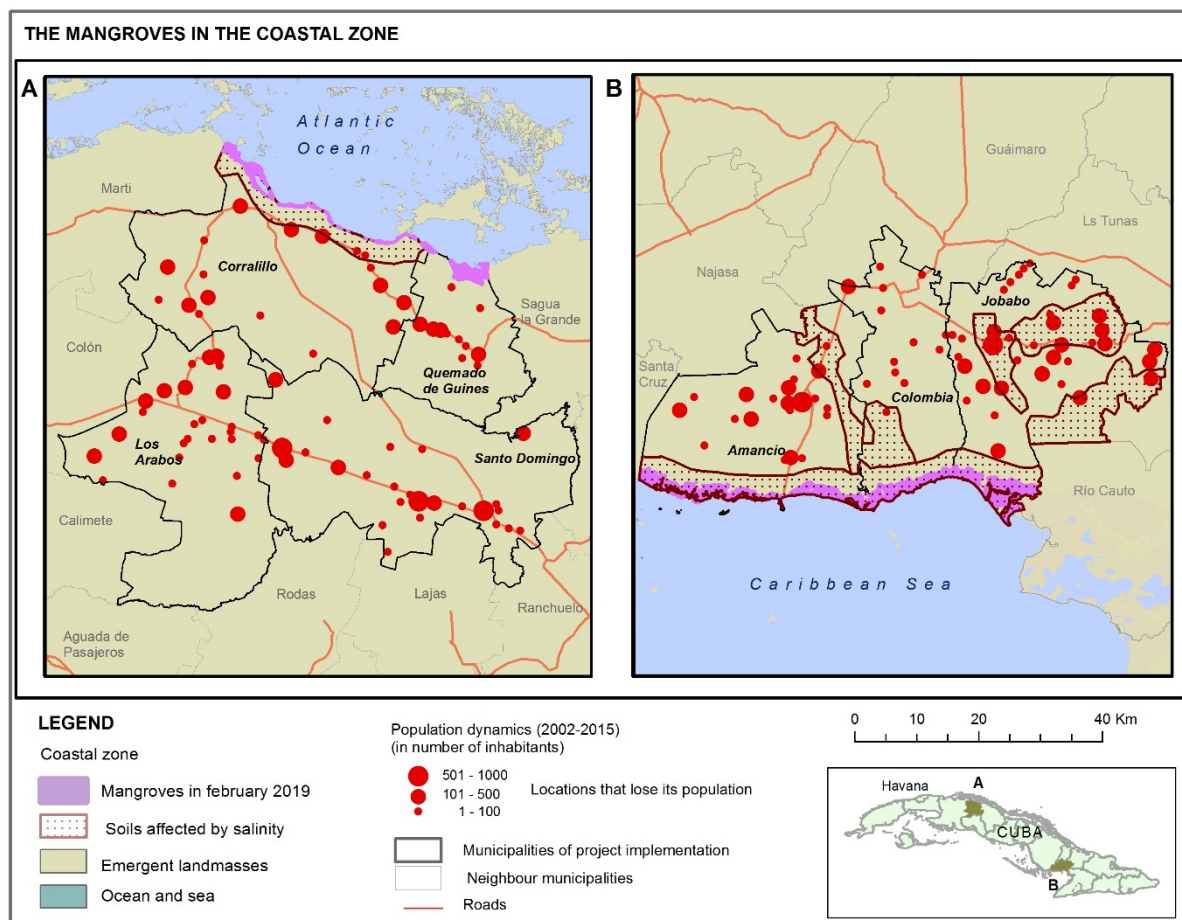
Note: The sum of what was declared as mangrove and swamp vegetation in the same category are considered in the calculations for 2003 to 2007.

Source: Directorate of Hydrography and Geodesy, Ministry of the Revolutionary Armed Forces (MINFAR).

With the use of satellite images, it is observed that in 2019 the mangrove area reached 11,408 ha, which represents an increase of approximately 3 853 ha in the East region, 1 998 ha in the municipality of Jobabo, 2 436 ha in Amancio and a decrease of 581 ha in Colombia. Due to the variability observed in the behavior of the figures for the municipalities that make up the AIPs in both regions, it can be inferred that there is no investment plan to protect the area occupied by mangroves and/or increase it when impacts on its coverage indicator are detected.

There is presence of mangroves in both coasts, in near 80% or more of the coasts of both regions, with a greater representation in the south east coast of the municipalities of Jobabo, Amancio and Colombia; however, the spatial analysis of its distribution for the year 2019 mapped from the digital processing of the satellite image for the month of February (Figure 12 and Figure 3) show that its extension from land to place is very variable with a more favorable situation in the eastern region.

Figure 12. Surface occupied by the mangroves in the coastal areas of the AIP



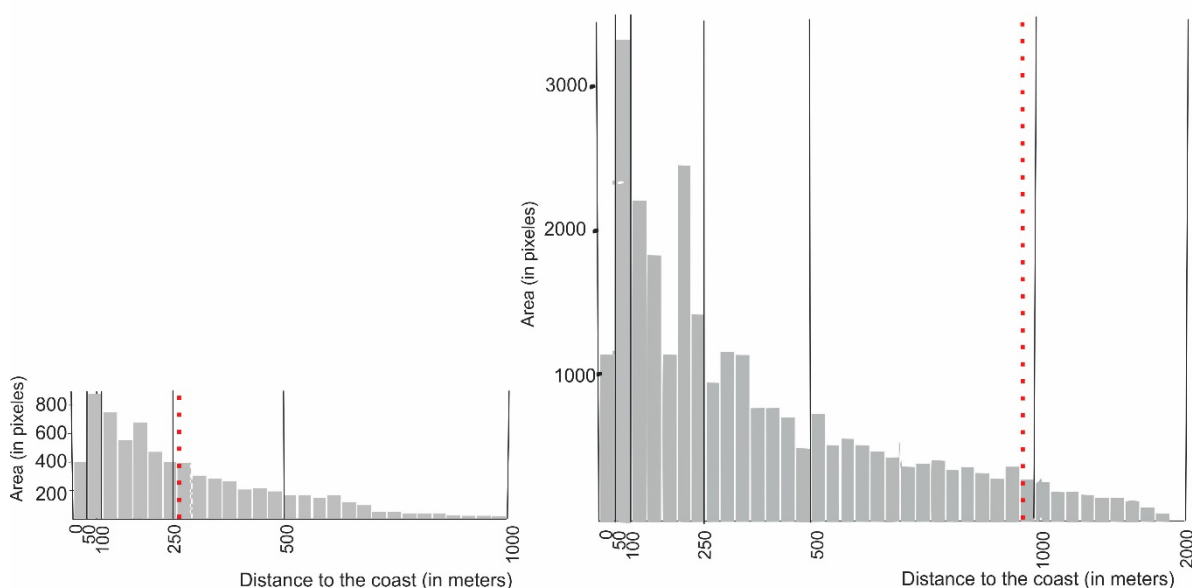
Source: Prepared by the authors based on images of the Sentinel 2a satellite (February 2019) and the Demographic Yearbook of Cuba. Havana; ONEI (several years), and data from CITMA

In most of the two AIPs, the distance between the coastline and the interior limit of the mangrove forest is 50 to 100 meters, and only in very specific areas, especially in the municipality of Jobabo, does the mangrove forest exceed 500 m earth inside. Figure 3 shows these values through the frequency histogram where the great difference between both regions is evidenced. In the municipalities of the AIP of the central region, the mangroves are reduced to small spots on the north coast of the municipalities of Quemado de Güines and Corralillo, in the latter much more degraded and occupying a smaller area, which leaves much of the north coast unprotected against the impact of hurricanes. In a general sense, these ecosystems are degraded on both coasts, mainly due to the effects caused by hurricanes, invasive plant species and man-made affectations throughout the last years.

Graph 3. Distance between the coastline and the interior boundary of the mangrove (in meters)

AIP Central Region

AIP East Region



■ ■ ■ Average distance from the coast to the interior boundary of the Mangrove (in meters)

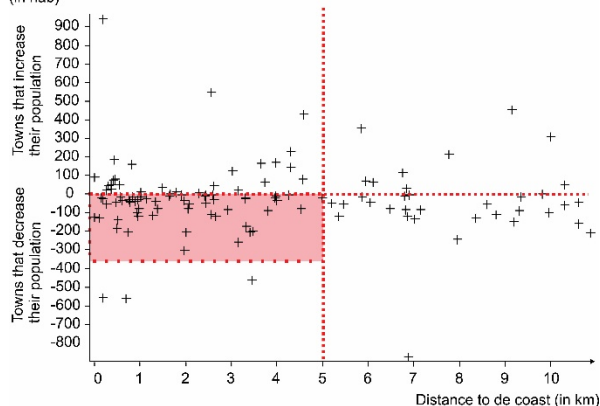
Source: Prepared by the authors based on images from the Sentinel 2a satellite (February 2019).

On the other hand, the analysis of the spatial distribution of the population in the coasts of both regions showed that most of the population localities near the coast are those experiencing negative variations in population, with important losses in their absolute values of total population in a sustained manner from year 2002 to date, (Chart 4), shows the exodus rise in the last 5 years.

Graph 4. Relation between the variation of the population (period 2002-2017) and proximity to the coast.

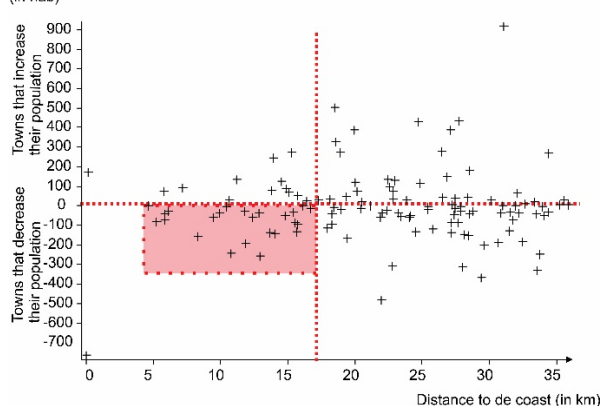
AIP Central Region

Variation of the population (in hab)



AIP East Region

Variation of the population (in hab)



Source: Prepared by the authors based on images of the Sentinel 2a satellite (February 2019) and the Demographic Yearbook of Cuba. Havana; ONEI (several years).

The distribution of the mangrove areas in the studied AIP in relation to the presence of officially established protected areas in these territories shows some coincidence for the Central region in the Corralillo municipality (8.5%), while for the East region, this coincidence is observed in the

municipality of Colombia in 48% and in Amancio 34%, an aspect that must be considered in the location of the modules to be developed (Table 26).

Table 26. Distribution of mangrove areas in relation to the presence of protected areas in the studied AIP, 2019

Central Region				
Concept	Los Arabos	Corralillo	Santo Domingo	Quemado de Güines
Total mangrove areas in the municipality (includes mangroves in protected areas)	0	1 001,37	0	1 013,48
Mangrove area outside protected areas	0	915,66	0	0
East Region				
Concept	Jobabo	Colombia	Amancio	
Total mangrove areas in the municipality (includes mangroves in protected areas)	3 108,26	1 726,27	4 558,78	
Mangrove area outside protected areas	0			

Source: Prepared by the authors based on images from the Sentinel 2a satellite (February 2019)

VIII.3 DROUGHT AND ITS IMPACT ON THE AIP

The variation in the amount of population of the human settlements of the AIP that are shown in figures 6 and 7 is the expression of what happens in these territories affected by an agricultural drought that oscillate in three ranges that start from 42 to 50 days and culminate between 61 to 80 days a year on average, taking into account more than 50 years of observations. Table 27 highlights the relationship between the agricultural drought and the Marabu expansion in 2019, with figures for Marabu coverage reaching 62 km² approximately in the municipalities of the central region and 476 km² in the East region.

Table 27. Relationship between the agricultural drought and the expansion of Marabu, year 2019

Days per year with agricultural drought (%)	Area occupied by Marabu in 2019	
	AIP in Las Villas	AIP in Las Tunas
From 42 to 50	143, 20 km ² (21.58%)	-
From 51 to 60	497, 65 km ² (75.01%)	232, 27 km ² (48.78%)
From 61 to 80	22, 60 km ² (3.41%)	243, 81 km ² (51.21%)

Source: Prepared by the authors from the processing of the Sentinel 2a image and information on the agricultural drought in Cuba: Centella A, B. Lapinel, O. Solano, R. Vázquez, C. Fonseca, V. Cutié, R. Baéz, S. Gonzalez, J. Sille, P. Rosario and L. Duarte (2006)

Table 28 highlights the correlation between agricultural drought and settlements that decrease their population between 2012 and 2015. In the municipalities of the Central region the number of localities that lose population is 84 for a total population that moves towards other territories equal to 102 356 inhabitants; in the AIP of the East region, the displacement of population to other territories reaches 64 041 inhabitants and 71 is the number of human settlements whose populations decrease.

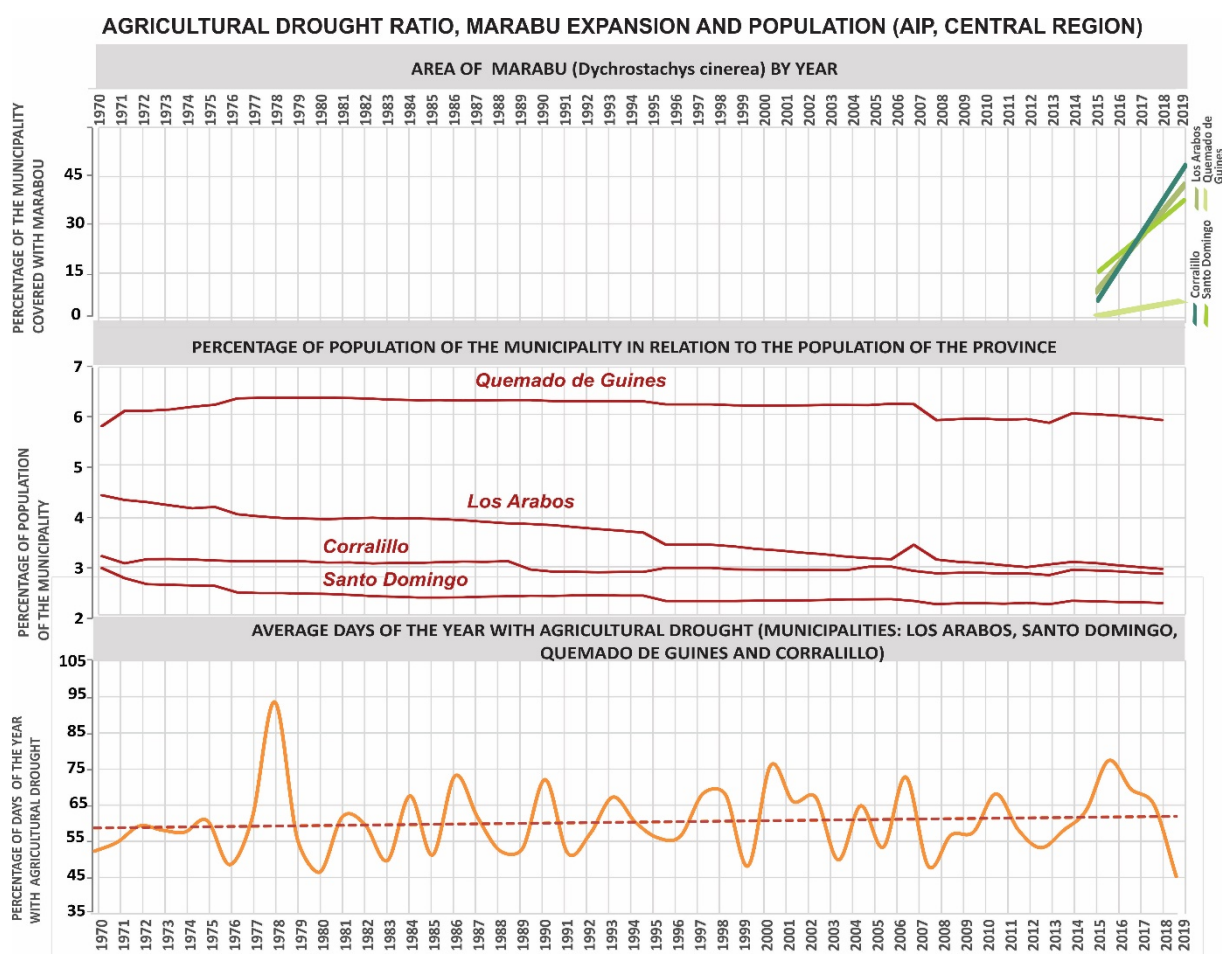
Table 28. Correlation between the agricultural drought, and the localities that lose population, Years 2002-2015

Days per year with agricultural drought (%)	Settlements that lose population (2002-2015)			
	AIP in Las Villas		AIP in Las Tunas	
	Number of localities	Decrease in population (inhab.)	Number of localities	Decrease in population (inhab.)
From 42 to 50	25	29 119	-	-
From 51 to 60	51	61 734	44	35 190
From 61 to 80	8	11 503	27	28 851

Source: Prepared by the authors based on the processing of the Sentinel 2^a image and Cuba's Demographic Yearbooks.

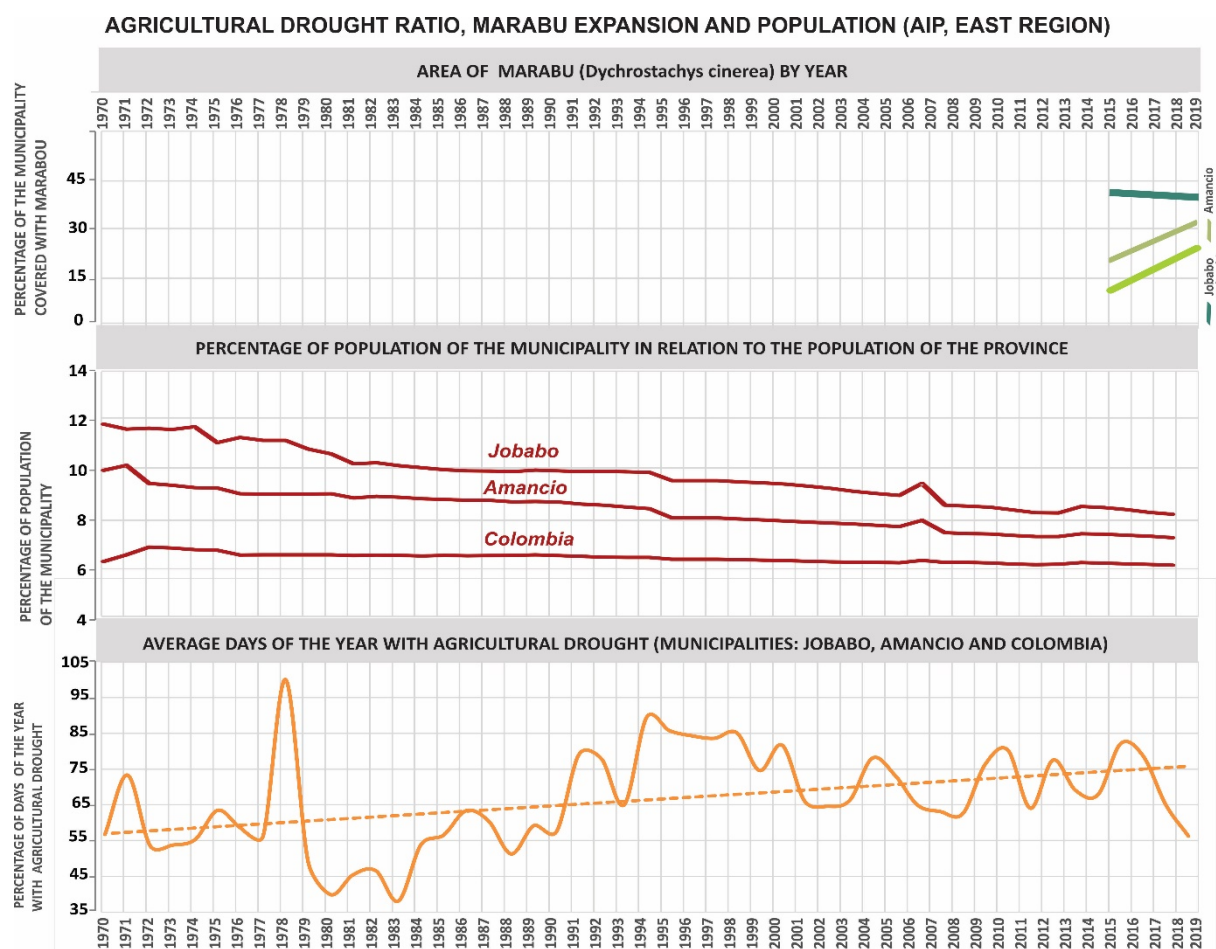
Graphs 5 and 6 reflect the growing trend of agricultural drought in the AIP with a more growing trend in the east region, data calculated from records that begin in 1951 and continue until 2018. In both zones, drought processes have favored the expansion of Marabu and the variation in the amount of population in human settlements.

Graph 5. Drought and its impact on the expansion of Marabu, and the variation of the population in the human settlements (AIP Central Region)



Source: Prepared by the authors from the processing of the Sentinel 2a image, Cuba's Demographic Yearbooks and agricultural drought information in: Centella A, B. Lapinel, O. Solano, R. Vázquez, C. Fonseca, V. Cutié, R. Baz, S. Gonzalez, J. Sille, P. Rosario and L. Duarte (2006). The meteorological and agricultural drought in the Republic of Cuba and the Dominican Republic. Volume I, 172 pp,

Graph 6. Drought and its impact on the expansion of the Marabu and the variation of population in the human settlements (AIP East Region).



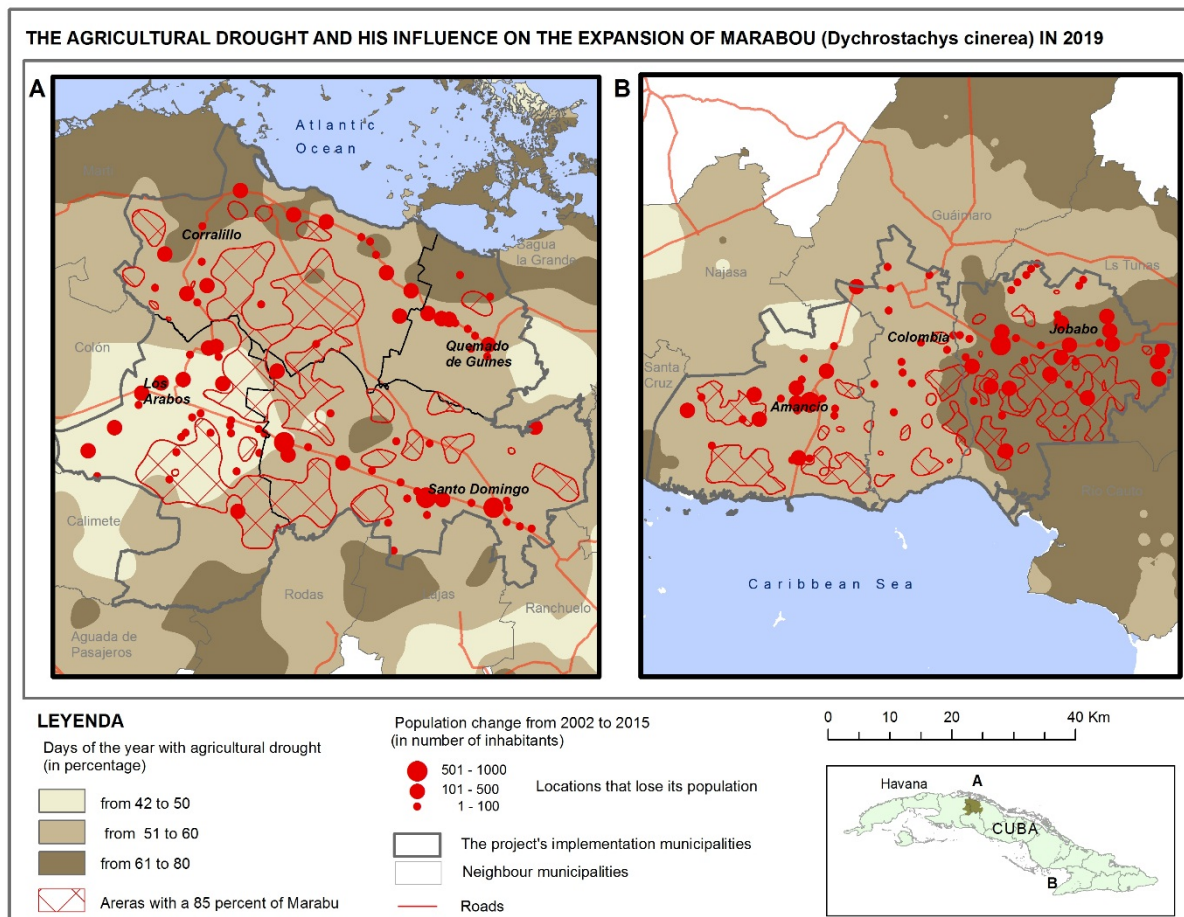
Source: Prepared by the authors from the processing of the Sentinel 2a image, Cuba's Demographic Yearbooks and agricultural drought information in: Centella A, B. Lapinel, O. Solano, R. Vázquez, C. Fonseca, V. Cutié, R. Baz, S. Gonzalez, J. Sille, P. Rosario and L. Duarte (2006). The meteorological and agricultural drought in the Republic of Cuba and the Dominican Republic. Volume I, 172 pp.,

As evidenced in this section, population of the human settlements in the municipalities implementing the project, both in the Central and East regions, which have been affected by agricultural drought for more than three decades, report a tendency towards a decrease in their population between the years 1970 and 2019 (Figures 6, 7 and Figure 11).

By way of example and from the statistics prepared by the ONEI, it is indicated that between 2012 and 2017 only five human settlements of Los Arabos municipality gained numbers in population, the remaining urban and rural decreased, including the dispersed population; in Coralillo and Quemado de Güines also only five settlements, the rest decreased in number of population. In Santo Domingo 15 human settlements increased their population, the remaining 30 settlements decreased, which shows that in this region of just over 80 settlements, only about 25 increased, although in unrepresentative magnitudes.

In the municipalities of the East region population declined in nearly 100 settlements, while an increase was reported in approximately 60 settlements. If we go back in the analysis of the years 2002 and 2012 it is observed that only the capitals of the municipalities Los Arabos, Corralillo, Jobabo, Colombia and Amancio increased their population. The remaining two municipal capitals (Quemado de Güines and Santo Domingo) lost population. This fact confirms the existence of an important migration to the municipal capitals and the loss of population in rural areas and small urban settlements (ONEI, 2007, 2012, 2017, figures 4, 5, 6 and 13).

Figure 13. Drought and its impact on the expansion of Marabu and the variation in the amount of population in human settlements



Source: Prepared by the authors from the processing of the Sentinel 2a image, Cuba's Demographic Yearbooks and agricultural drought information in: Centella A, B. Lapinel, O. Solano, R. Vázquez, C. Fonseca, V. Cutié, R. Baz, S. Gonzalez, J. Sille, P. Rosario and L. Duarte (2006). The meteorological and agricultural drought in the Republic of Cuba and the Dominican Republic. Volume I, 172 pp.,

IX. WATER DISTRIBUTION, RESERVE AND CURRENT DIFFICULTIES

Population of the municipalities with aqueduct service (AIP Central region)

In this section a brief incursion is made to the population in its various categories, according to place of residence with aqueduct service, which does not mean that this service works on a regular basis, either with permanent frequency or just for days scheduled for pumping water.

The reliable information available comes from the 2002 and 2012 population and housing censuses, so the analysis will be carried out from these two sources. Firstly, the population that has aqueduct service is valued in absolute numbers obtained from the 2012 census. It is then broken down according to place of residence. For the Central region 55% of the resident population has this service (68 575 inhabitants out of a total resident population of 124 732 inhabitants), with maximum percentage values in the municipality of Corralillo (20,750 inhabitants, representing 77% of its population) and becomes lower in Quemado de Güines, 15%, equivalent to 3 247 inhabitants. This service favored the urban population that had greater infrastructure for it and strongly drops off in rural areas, except in the Quemado de Güines municipality, where according to census information, the resident rural population has a greater water supply service (Table 29).

Table 29. Central Region: population with aqueduct service according to place of residence, 2012

Municipality	Total Population	With Aqueduct Service (one)				
		Municipality	Urban Area	Rural Area	Rural concentrated	Rural dispersed
Los Arabos	24 787	18 714	14 215	4 526	4 171	348
Corralillo	26 843	20 750	16 530	4 178	3 345	814
Quemado de Güines	22 089	3 247	640	2 605	2 563	37
Santo Domingo	51 013	25 864	21 515	4 344	4 181	155
Total	124 732	68 575	52 900	15 653	14 260	1 354

Source: ONEI. Population and housing censuses, 2012

The East region displays a less favorable situation in this indicator of population with aqueduct service than the Central region, with a percentage of 44% (51 296 inhabitants) of its total population with access to it. The Amancio municipality displays the highest percentage values (68% equivalent to 26 323 inhabitants); the municipality least favored with the provision of this service is Colombia with only 22% of its population (7 229 inhabitants). Just like in the Central region, this service favors the urban population that has more infrastructure for it and strongly drops off in rural areas (Table 30).

Table 30. East region: population with aqueduct service according to place of residence, 2012

Municipality	Total Population	With Aqueduct Service (one)				
		Municipality	Urban area	Rural area	Rural concentrated	Rural disperse
Jobabo	44 851	17 744	11 800	6 455	6 221	620
Colombia	32 612	7 229	3 803	1 233	1 266	129
Amancio	38 957	26 323	21 516	6 118	5 353	424

Total	116 420	51 296	37 119	13 806	12 840	1 173
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Source: ONEI. Population and housing censuses, 2012

In Los Arabos municipality, the percentage of the population that benefits from aqueduct service for water supply dropped off from 77% to 18% between 2002 and 2012, according to the population and housing censuses conducted for both years (ONEI, 2002, 2012); the percentage of the urban population that have access to this service for the period analyzed decreased from 99.6 to 22.2, for a reduction in the coverage, which represents 77% of the urban population; for the rural population the variation is reported from 58.1% to 10% with access to aqueduct service (Table 31).

The coverage of the service in Corralillo municipality increased by 2.7% in the intercensal period, varying from 74.6 to 77.3%; in the urban area it decreased by 2.6%. The coverage of this service in 2012 was 83.7%; the rural population with access varies from 44.2% to 58.9%, while the concentrated rural is 62.6% and the disperse one 46.5%.

Table 31. Central Region: percentages of population with access to water by aqueduct, 2002 and 2012 (%)

Municipality	Years	2002	2012	Variation
Los Arabos	Total municipal	77,7	18	-59,7
	Urban area	99,6	22,2	-77,4
	Rural area	56,2	11,3	-44,9
	Concentrated	58,1	10	-48,1
	Disperse	38,6	0	-38,6
Corralillo	Total municipal	74,6	77,3	2,7
	Urban area	86,3	83,7	-2,6
	Rural area	44,2	58,9	14,7
	Concentrated	50,3	62,6	12,3
	Disperse	31,9	46,5	14,6
Quemado de Güines	Total municipal	45,8	14,7	-31,1
	Urban area	51,5	4,5	-47
	Rural area	35,6	33,1	-2,5
	Concentrated	46,7	44,9	-1,8
	Disperse	14,5	1,7	-12,8
Santo Domingo	Total municipal	62,3	50,7	-11,6
	Urban area	70,1	57,8	-12,3
	Rural area	42,1	31,5	-10,6
	Concentrated	55,1	38,5	-16,6
	Disperse	20,2	5,3	-14,9

Source: ONEI. Population and housing censuses, 2002 and 2012

The extent of the aqueduct service experienced a strong drop off in the Quemado de Güines municipality, where the percentage of the population served went from 45.8 in 2002 to 14.7% in 2012, a reduction concentrated in the urban spaces that went from 51.5 to 4.5% of the population with access to this service. The percentages in the rural population served vary from 46.7 to 44.9%; while only 1.7% of the dispersed population have this service.

The population of Santo Domingo with access to water service by aqueduct decreased by 11.6% in the intercensal period; the urban population with access is reduced to 57.8% for a loss percentage of 12.3; the rural one decreases to 31.5 with a percentage reduction of 10.6. The dispersed rural population only reaches 5.3% of its total.

Population of the municipalities with access to aqueduct service (AIP East Region)

The percentage of the population that has access to aqueduct service for water supply increases from 22% to 39.56% in the 2002-2012 intercensal period for the Jobabo municipality; the percentage of the urban population that has this service for the period analyzed almost doubles, reaching a coverage of 58% of the population residing in urban spaces; this service expands in rural areas to 26% of the population, 32% in the concentrated rural population and decreases to 12% in the rural dispersed (Table 32).

Table 32. Eastern Region: percentages of population with access to water by aqueduct, 2002 and 2012 (%)

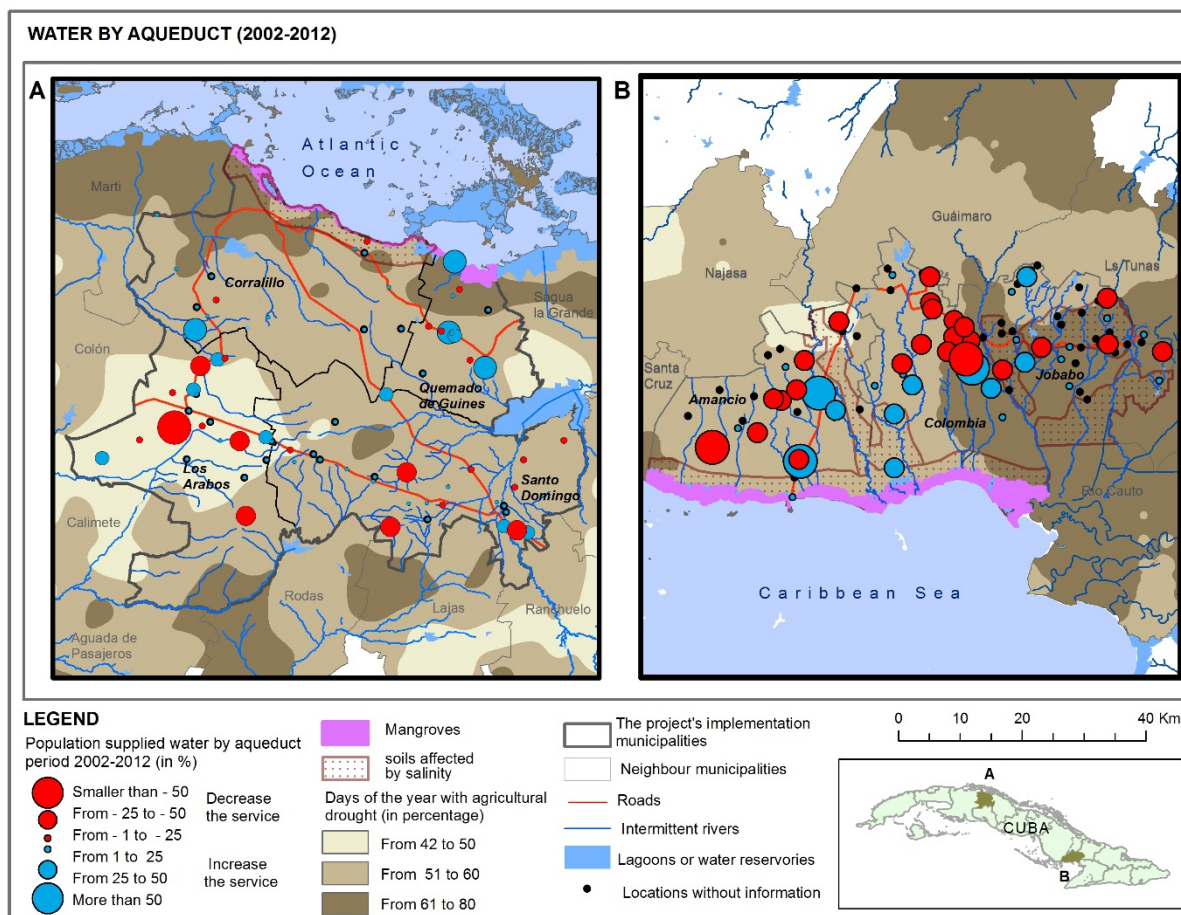
Municipality	Years	2002	2012	Variation
Jobabo	Total municipal	22	39,56	17,56
	Urban area	25,4	58,10	32,70
	Rural area	19,7	26,30	6,60
	Concentrated	28,7	32,00	3,30
	Disperse	15,3	12,15	-3,15
Colombia	Total municipal	48,8	22,17	-26,63
	Urban area	31,8	16,66	-15,14
	Rural area	37,8	12,60	-25,20
	Concentrated	50,1	18,00	-32,10
	Disperse	8,5	4,70	-3,80
Amancio	Total municipal	62,2	67,57	5,37
	Amancio (urban)	72,6	76,60	4,00
	Guayabal (urban)	90,9	92,97	2,07
	Rural concentrated	49,2	64,30	15,10
	Disperse	12,70	16,68	3,98

Source: ONEI. Population and housing censuses, 2002 and 2012

The coverage of this service in the municipality of Colombia decreases sharply in the intercensal period, varying from 48.8% to 22.17%; for the urban area, the percentage of the population served decreases to represent 16% of the total residents in these spaces; the rural population with access varies from 37.8% to 12.6%. While the rural population maintains this same decreasing tendency whereby only 12.6% had this service in 2012; the concentrated rural population and the dispersed one also diminishes the percentage of population with access to aqueduct service.

The population of the Amancio municipality with access to water service by aqueduct increased by 5.37% in the intercensal period, and reaches a coverage of 67.57% of the total municipality; the urban population with access does so by 4% in the municipal capital, by 2% in the second urban settlement of the municipality; the rural population increases and reaches 64% coverage, while the dispersed rural population also increases and comes to represent approximately 17% of the total dispersed population.

Figure 14. Situation of the water supply to the population residing in the localities of the AIP



Source: Prepared by the authors from the image processing Sentinel 2a, Census of population and housing, 2002 and 2012 and information of the agricultural drought in: Centella A, B. Lapinel, O. Solano, R. Vázquez, C. Fonseca, V. Cutié, R. Baz, S. Gonzalez, J. Sille, P. Rosario and L. Duarte (2006). The meteorological and agricultural drought in the Republic of Cuba and the Dominican Republic. Volume I, 172 pp.,

The effects of climate change in the AIP, which are evident by the frequency and intensity of the extreme weather events that affect them, the increase of the area affected by agricultural drought, together with the low rates of forest cover reported in the territories, as well as the reduction of rainfall and a more arid climate, threaten the state of surface and underground basins, and the availability of water resources for water supply to communities inhabiting the AIP. As shown in Figure 14, there are a significant number of human settlements whose population aqueduct services decreased.

From the analysis of the territorial statistical yearbooks for 2016 (ONEI) for the province and municipalities of Las Tunas (it is not done for the AIP of the Central region because it does not contain this information in the indicated statistical source), it is evident that half of the population of the municipality of Colombia (71.6%) lacks home connection and public service for water supply, therefore must seek this resource up to distances of 300 meters from their place of residence; in the Jobabo municipality, this percentage is 45.4 and in Amancio it is 11.7%, nevertheless, this figure increases to 66.5% (Table 33) for the rural population of the municipality.

Table 33. Eastern Region: indicators of drinking water coverage, 2016 (%)

INDICATOR	% Population according to type of potable water coverage		
	Jobabo	Colombia	Amancio
Total Population	100	100	100
• Home connection	23,4	17,4	21,8
• Public service	31,2	11,0	66,5
• Easy access	45,4	71,6	11,7
Urban Population	100	100	100
• Home connection	31,4	11,3	47,4
• Public service	28,4	13,4	19,9
• Easy access	40,2	75,4	32,7
Rural Population	100	99,9	100
• Home connection	17,2	31,8	21,8
• Public service	33,4	5,4	11,7
• Easy access	49,4	62,7	66,5

Notes: Easy access: it requires searching for water up to distances of 300 meters.

Source: ONEI (2016). Statistical yearbook of Cuba by territories. Havana.

X. CONCLUSIONS

1. Research shows abandonment by the population of the AIP and a significant process of population aging, more noticeable in rural areas, with a percentage growth of the urban population as a result of rural-urban migration. The exodus of the rural population of the AIP reached more than 23 thousand inhabitants between 1995 and 2015.
2. A process of feminization of the rural spaces of the AIPs is also under way, where women present the most unfavorable situation, given the abandonment of a greater number of men in search of better opportunities for work and life.
3. An assessment of the demographic situation of the AIPs and the adjacent municipalities, based on the migratory status that predominates in this group, reveal that regardless of registering positive rates of natural growth, as well as of fertility, which could imply the possibility of replacing the labor force, the reduction of the arable land that influences the lack of employment in agricultural and agro industrial sectors, force the population to leave the AIPs, which leads to negative growth rates and population exodus.
4. The AIPs report a considerable loss of cultivated area, given in a context where processes and physical-geographic phenomena (meteorological and climatic) linked to climate change are added, highlighting the agricultural drought that has been present for several decades in these territories. The loss of agro productivity of soils, the frequency of hurricanes and the expansion of Marabu, the latter favored by the set of factors aforementioned and which influences the decline in numbers of cultivated area.
5. The behavioral study of the area occupied by Marabu shrubs and its dynamics between 2015 and 2019, from the processing of satellite images for 2019, shows that a percentage growth of 31 is reported for the AIP of the Central region. 14% and 22.25% for the AIP of the East region, highlighting the municipalities of Jobabo, Amancio, Corralillo and Los Arabos, with about a third of their area covered by Marabu. The analysis of the distribution of lands covered with natural pastures and other lands that are considered up to 2015, show values close to 55% of the total area in both regions. These high values are a consequence, among other factors, of the increase in the agricultural drought reported for these territories, with a more pronounced growth in the East region.
6. The related analysis for 2012-2015 of the number of landholders, cultivated area and covered area of Marabu, shows a reduction of approximately 3.7 thousand landholders, with a greater reduction in the AIP of the Eastern region.
7. The analysis of the historical trajectories of hurricanes in the last 15 years represented through the density surfaces shows a greater exposure of the AIP to the impact of these tropical organisms that could become more intense and destructive in the context of the change climate.
8. The reduction on the amount of population in more than 85% of the human settlements of the AIP is, to a large extent, a result of what happens in these territories affected by an agricultural drought in ranges that start from 42 to 50 days and reach to between an average

of 61 to 80 days per year, plus the expansion of Marabu in the last four years, with values reaching 662 km² in the AIP of the Central Region and 476 km² in the East region by 2019.

9. The annual percentage of the area affected by agricultural drought as an average in the AIP shows a growing trend, calculated from records that began in 1951 and extended to 2018, a phenomenon that greatly influences the population of the human settlements that have been affected for more than three decades by agricultural droughts and the expansion of Marabu, and where population decline is reported in most of the rural, urban and dispersed populations.
10. The effects of climate change on the studied AIP that are manifested in the frequency and intensity of extreme weather events, the expansion of the area affected by the agricultural drought, together with the low rates of forest cover reported in the territories, the decrease in rainfall and a more arid climate, threaten the state of surface and underground basins, and the availability of water resources for the supply of water to the population of human settlements, with a significant number of these localities where there is a decline of the population benefiting from water by aqueduct.

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Appendix 2.2.1. Selected indicators of the population of the municipalities of the Central region, years 2009 and 2017

Municipality	Population					Masculinity Index (Men per 1000 women)	Percentage	
	Total	Male	Female	Urban	Rural		Urban	Rural
YEAR 2009								
Los Arabos	24 829	12 701	12 128	13 869	10 960	1 047	55,86	44,14
Population ≥60	4 665	2 410	2 255	2 629	2 036	1 069	56,36	43,64
%	18,79	18,97	18,59	18,96	18,58			
Corralillo	27 554	14 043	13 511	19 441	8 113	1 039	70,56	29,44
Population ≥60	5 582	2 855	2 727	3 851	1 731	1 047	68,99	31,01
%	20,26	20,33	20,18	19,81	21,34			
Quemado de Güines	22 474	11 630	10 844	14 211	8 263	1 072	63,23	36,77
Population ≥60	4 670	2 378	2 292	2 767	1 903	1 038	59,25	40,75
%	20,78	20,45	21,14	19,47	23,03			
Santo Domingo	53 007	27 005	26 002	38 201	14 806	1 039	72,07	27,93
Population ≥60	10 659	5 352	5 307	7 451	3 208	1 008	69,90	30,10
%	20,11	19,82	20,41	19,50	21,67			
CENTRAL REGION	127 864	65 379	62 485	85 722	42 142	1 046	67,04	32,96
Population ≥60	25 576	12 995	12 581	16 698	8 878	1 033	65,29	34,71
%	20,00	19,88	20,13	19,48	21,07			
YEAR 2017								
Los Arabos	24 119	12 257	11 862	14 650	9 469	1 033	60,74	39,26
Population ≥60	5 290	2 683	2 607	3 352	1 938	1 029	63,36	36,64
%	21,93	21,89	21,98	22,88	20,47			
Corralillo	25 834	13 117	12 717	19 039	6 795	1 031	73,70	26,30
Population ≥60	6 031	2 973	3 058	4 401	1 630	972	72,97	27,03
%	23,35	22,67	24,05	23,12	23,99			
Quemado de Güines	21 359	10 942	10 417	13 906	7 453	1 050	65,11	34,89
Population ≥60	5 217	2 597	2 620	3 295	1 922	991	63,16	36,84
%	24,43	23,73	25,15	23,69	25,79			
Santo Domingo	49 445	24 919	24 526	35 905	13 540	1 016	72,62	27,38
Population ≥60	11 562	5 628	5 934	8 351	3 211	948	72,23	27,77
%	23,38	22,59	24,19	23,26	23,71			
CENTRAL REGION	120 757	61 235	59 522	83 500	37 257	1 029	69,15	30,85
Population ≥60	28 100	13 881	14 219	19 399	8 701	976	69,04	30,96
%	23,27	22,67	23,89	23,23	23,35			

Source: ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2012) Demographic series 2000-2010. Magnetic support; ONEI (2017). The aging of the population 2017, Havana

Appendix 2.2.2 Selected indicators of the population of the municipalities of the East region, years 2009 and 2017.

Municipality	Population					Masculinity Index (Men per 1000 women)	Percentage	
	Total	Male	Female	Urban	Rural		Urban	Rural
YEAR 2009								
Jobabo	47 580	24 608	22 972	18 299	29 281	1 071	38,46	61,54
Population ≥60	7 330	3 924	3 406	2 453	4 877	1 152	33,47	66,53
%	15,41	15,95	14,83	13,41	16,66			
Colombia	32 779	16 750	16 029	22 532	10 247	1 045	68,74	31,26
Population ≥60	5 044	2 531	2 513	3 504	1 540	1 007	69,47	30,53
%	15,39	15,11	15,68	15,55	15,03			
Amancio Rodríguez	40 771	20 868	19 903	28 335	12 436	1 048	69,50	30,50
Population ≥60	6 069	3 062	3 007	4 079	1 990	1 018	67,21	32,79
%	14,89	14,67	15,11	14,40	16,00			
EAST REGION	121 130	62 226	58 904	69 166	51 964	1 056	57	43
Population ≥60	18 443	9517	8 926	10 036	8 407	1 066	54,42	45,58
%	15,23	15,29	15,15	14,51	16,18			
YEAR 2017								
Jobabo	47 350	24 503	22 847	18 012	29 338	1 072	38,04	61,96
Population ≥60	8 394	4 368	4 026	3 788	4 606	1 085	45,13	54,87
%	17,73	17,83	17,62	21,03	15,70			
Colombia	32 185	16 747	16 068	22 564	10 251	1 042	70,11	31,85
Population ≥60	6 342	3 224	3 118	4 666	1 676	1 034	73,57	26,43
%	19,70	19,25	19,41	20,68	16,35			
Amancio Rodríguez	40 647	20 832	19 815	28 360	12 287	1 051	69,77	30,23
Population ≥60	7 104	3 487	3 617	5 250	1 854	964	73,90	26,10
%	17,48	16,74	18,25	18,51	15,09			
EAST REGION	120 182	62 082	58 730	68 936	51 876	1 057	57,36	43,16
Population ≥60	21 840	11 079	10 761	13 704	8 136	1 030	62,75	37,25
%	18,17	17,85	18,32	19,88	15,68			

Source: ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2012) Demographic series 2000-2010. Magnetic support; ONEI (2017). The aging of the population 2017. Havana

Appendix 2.2.3. Summary of selected indicators of the population of the municipalities of the AIP, years 2009 and 2017

Municipality	Population					Masculinity Index (Men per 1000 women)	Percentage	
	Total	Male	Female	Urban	Rural		Urban	Rural
YEAR 2009								
Total	248994	127605	121389	154888	94106	1051	62,21	37,79
Population ≥60	44019	22512	21507	26734	17285	1047	60,73	39,27
%	17,68	17,64	17,72	17,26	18,37			
YEAR 2017								
Total	240939	123317	118252	152436	89133	1043	63,27	36,73
Population ≥60	49940	24960	24980	33103	16837	999	66,29	33,71
%	20,73	20,24	21,12	21,72	18,89			

Source: ONEI (several years). Demographic yearbook of Cuba. Havana; ONE (2012) Demographic series 2000-2010. Magnetic support; ONEI (2017). The aging of the population 2017. Havana