

Analysis of the Spatiotemporal Distribution of Variables that Affect the Water Deficit in Manabí

Análisis de la distribución espaciotemporal de variables que inciden en el déficit hídrico en Manabí

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ABSTRACT: The results of a study focused on addressing information gaps related to water deficit for irrigation purposes in different areas and times of the year in Manabí are presented. The objective of the research was to analyze the spatial and temporal distribution of the most influential variables in the water deficit for irrigation purposes. The study was conducted thru a descriptive, analytical, and deductive investigation based on data collected and processed by INAMHI at 20 meteorological stations with a minimum history of 13 years. Based on the calculation of effective precipitation, reference crop evapotranspiration, and monthly water deficit at each station, thematic maps were generated to visualize spatial patterns, as well as temporal ones, in the province. The results showed considerable variations of these variables between the north-south zones. The lowest levels of effective precipitation and the highest water deficits were observed in the southern zone of Manabí, while the northern zones showed higher effective precipitation with a lower water deficit. The evapotranspiration of the reference crop was high throughout the province, but it intensifies in the south, where the water demand far exceeds the water availability. The final results highlight the importance of implementing investment strategies, along with the management of water resources for agriculture based on studies of this nature that respond to the specific conditions of each area.

Keywords: Effective precipitation, evapotranspiration, water deficit maps.

RESUMEN: Se muestran los resultados de un estudio enfocado a resolver vacíos de información relacionados con el déficit hídrico con fines de riego en diferentes zonas y épocas del año en Manabí. El objetivo de la investigación fue analizar la distribución espacial y temporal de las variables más influyentes en el déficit hídrico con fines de riego. El estudio se realizó mediante una investigación descriptiva, analítica y deductiva a partir de los datos recopilados y procesados por el INAMHI en 20 estaciones meteorológicas con un historial mínimo de 13 años. A partir del cálculo de la precipitación efectiva, la evapotranspiración del cultivo de referencia y el déficit hídrico mensual en cada estación, se generaron mapas temáticos que permiten visualizar los patrones espaciales, además de temporales en la provincia. Los resultados mostraron variaciones considerables de estas variables entre las zonas norte-sur. Los niveles de precipitación efectiva más bajos y mayores déficits hídricos se presentaron en la zona sur de Manabí, mientras que en las zonas del norte se evidenciaron precipitaciones efectivas superiores con un menor déficit hídrico. La evapotranspiración del cultivo de referencia fue alta en toda la provincia, pero se intensifica en el sur, donde la demanda hídrica supera ampliamente la disponibilidad de agua. Los resultados finales evidencian la importancia de implementar estrategias de inversión, junto con la gestión de recursos hídricos para la agricultura basadas en estudios de esta índole que respondan a las condiciones específicas de cada zona.

Palabras clave: Precipitación efectiva, evapotranspiración, déficit hídrico, mapas.

INTRODUCTION

In Ecuador, Manabí has the largest percentage of agricultural land (1,894,000 ha), followed by Guayas, Loja, Los Ríos, and Esmeraldas, being of vital importance to the Manabí economy (Instituto Nacional de Estadística y Censos, 2021). Moreover, the climate has become unpredictable, causing changes in humidity, fog, temperatures, and rainfall, where constant variations in the amount, intensity, and temporal pattern of precipitation are observed (Su *et al.*, 2023). Therefore, the accuracy of

rainfall information is crucial for agronomy, hydrology, and meteorology (Ara, Lewis y Ostendorf, 2018).

The distribution of water in irrigation systems requires technical and equitable planning, so that water resources are utilized efficiently and timely, and do not result in losses in agricultural production and quality (Zekele *et al.*, 2023). The analysis of precipitation behavior and its spatial and temporal variability constitutes an essential aspect for understanding current and future climatic processes (Liu *et al.*, 2022).

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Table 1. Weather Stations in Manabí

Código	Descripción	Tipo	Zona Hidro.	Latitud	Longitud	Altitud (m)	Instit. Propiet.
M0447	24 De mayo (Jaboncillo)	PV	130	1° 16' 44" S	80° 25' 6" W	115	INAMHI
M1234	Yil-Unesum	CO	120	1° 20' 49" S	80° 32' 23" W	378	INAMHI
M1241	Atascoso	PV	0	1° 4' 21" S	80° 0' 32" W	497	INAMHI
M1074	Ayampe	PV	120	1° 41' 0" S	80° 47' 0" W	0	EX-C.R.M
M1217	Bahía De Caráquez-Puce	CO	100	0° 39' 34" S	80° 23' 51" W	12	INAMHI
M1251	Banchal	PV	-	1° 38' 37" S	80° 29' 13" W	149	INAMHI
M1077	Bella Flor	PV	110	1° 5' 0" S	80° 7' 0" W	0	EX-C.R.M
M1088	Botadero (Río Briceño)	PV	90	0° 32' 0" S	80° 16' 0" W	0	EX-C.R.M
M0163	Boyacá	PV	100	0° 34' 15" S	80° 10' 41" W	70	INAMHI
M0450	Camarones-Manabí	PV	120	1° 7' 46" S	80° 46' 38" W	197	INAMHI
M0171	Camposano #2	CO	130	1° 35' 34" S	80° 24' 4" W	156	INAMHI
M1233	Cantagallo-Granja Unesum	CP	120	1° 17' 13" S	80° 43' 44" W	64	INAMHI
M0162	Chone-U. Católica	CP	100	0° 39' 51" S	80° 2' 11" W	36	INAMHI
M0453	Chorrillos	PV	110	1° 3' 15" S	80° 41' 20" W	226	INAMHI
M0458	Colimes De Paján	PV	130	1° 34' 42" S	80° 30' 21" W	200	INAMHI
M1079	Convento	PV	90	0° 16' 0" S	80° 2' 0" W	0	EX-C.R.M
M1205	Cuaque Pedernales	PV	60	0° 26' 0" N	80° 3' 0" W	0	EX-C.R.M
M0451	El Anegado	PV	120	1° 28' 46" S	80° 32' 19" W	398	INAMHI
M0160	El Carmen	CO	130	0° 15' 35" S	79° 25' 37" W	260	INAMHI
M1230	Español-Mfl-Calçeta	CP	100	0° 49' 23" S	80° 11' 1" W	15	INAMHI
M1076	Guajabe	PV	110	1° 6' 0" S	80° 10' 0" W	0	EX-C.R.M
M0589	Guale	PV	130	1° 37' 32" S	80° 14' 9" W	40	EX-CEDEGE
M1078	Guale Ayampe	PV	120	1° 41' 0" S	80° 44' 0" W	0	EX-C.R.M
M0167	Jama	CO	90	0° 11' 49" S	80° 15' 53" W	46	INAMHI
M0455	Joa-Jipijapa	PV	120	1° 21' 45" S	80° 35' 40" W	260	INAMHI
M0169	Julcuy	CO	130	1° 28' 48" S	80° 37' 56" W	263	INAMHI
M0462	Junín	PV	100	0° 56' 4" S	80° 12' 30" W	20	INAMHI
M1089	La Azucena	PV	60	1° 4' 0" S	79° 59' 0" W	0	EX-C.R.M
M1081	La Colombia (Ayampe)	PV	120	1° 40' 0" S	80° 40' 0" W	0	EX-C.R.M
M0448	La Laguna	PV	110	1° 9' 10" S	80° 37' 27" W	235	INAMHI
M1208	La Teodomira	CP	110	1° 9' 51" S	80° 23' 24" W	60	INAMHI
M0047	Manta-Inocar	CO	120	0° 56' 3" S	80° 44' 2" W	3	-
M0166	Olmedo-Manabí	CO	130	1° 23' 41" S	80° 12' 25" W	50	INAMHI
M0623	Palmeras Unidas (Palmar)	PV	130	0° 15' 53" S	79° 35' 48" W	460	EX-CEDEGE
M0005	Portoviejo-Utm	AP	110	1° 2' 15" S	80° 27' 35" W	46	INAMHI
M1080	Poza Honda	CP	110	1° 7' 0" S	80° 12' 0" W	0	EX-C.R.M
M0457	Puerto Cayo	PV	120	1° 20' 58" S	80° 44' 11" W	6	INAMHI
M0464	Río Chamotete-Jesús María	PV	110	1° 2' 12" S	80° 13' 58" W	128	INAMHI
M0454	Río Chico En Alajuela	PV	110	1° 3' 16" S	80° 17' 33" W	118	INAMHI
M1091	Río Grye (Chone)	PV	100	0° 40' 0" S	79° 59' 0" W	0	EX-C.R.M
M1105	Río Grye Inamhi	PV	100	0° 43' 52" S	79° 56' 44" W	124	INAMHI
M1104	Río Santo	PV	100	0° 34' 7" S	80° 0' 2" W	75	INAMHI
M0165	Rocafuerte	CO	110	0° 55' 21" S	80° 26' 55" W	20	INAMHI
M0446	San Isidro-Manabí	PV	90	0° 22' 34" S	80° 11' 1" W	138	INAMHI
M1090	San Miguel	PV	110	1° 2' 0" S	80° 5' 0" W	0	EX-C.R.M
M0459	San Pablo-Manabí	PV	120	1° 34' 44" S	80° 35' 30" W	465	INAMHI
M1092	Sancán-Crm	PV	120	1° 15' 0" S	80° 35' 0" W	0	EX-C.R.M
M0449	Sancán-Inamhi	PV	110	1° 15' 29" S	80° 35' 12" W	255	INAMHI
M0452	Zapote	PV	100	0° 56' 18" S	80° 3' 20" W	79	INAMHI

Table 2. Meteorological Precipitation Data

No.	Código Nuevo	Descripción	Año 75% prob.	Ene	Feb	Mar	Abr	May	Jun	Jul	Ago	Sep	Oct	Nov	Dic	Precipitación Anual (mm)
1	M0005	Portoviejo-Utm	2011	63.10	122.40	20.30	69.40	0.30	42.50	4.50	0.00	0.10	1.30	0.00	31.30	355.20
2	M0162	Chone-U. Católica	2005	119.00	189.80	105.50	319.00	4.70	1.40	0.80	0.20	1.50	2.50	1.10	57.40	802.90
3	M0165	Roca fuerte	2011	25.80	112.00	29.50	73.80	0.00	6.40	0.50	0.00	1.00	0.00	0.00	5.30	254.30
4	M0166	Olmedo-Manabí	2005	21.20	340.40	383.40	426.40	3.00	0.00	0.00	0.00	0.00	1.00	0.00	37.00	1212.40
5	M0167	Jama	1996	30.40	167.20	127.40	56.60	8.70	0.10	6.70	0.00	0.20	0.00	0.00	0.00	397.30
6	M0169	Julcuy	2005	8.30	83.40	86.00	101.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.70	284.90
7	M0171	Camposano #2	2003	171.40	289.80	109.00	141.00	231.70	0.00	0.00	1.60	0.00	1.60	0.00	2.30	948.40
8	M0447	24 de mayo (Jaboncillo)	2004	87.20	182.50	263.50	72.70	111.70	5.80	7.90	0.20	4.30	4.00	0.80	0.00	740.60
9	M0448	La Laguna	1990	63.10	52.40	24.60	15.00	0.00	1.50	8.00	16.80	2.60	3.70	8.20	4.90	200.80
10	M0449	Sancán-Inamhi	2007	28.30	16.10	49.90	115.50	9.40	0.20	5.40	1.30	0.00	0.00	0.30	18.50	244.90
11	M0450	Camarones-Manabí	2009	81.40	55.10	11.50	5.00	7.50	2.30	0.80	3.60	2.42	4.40	3.70	0.00	177.72
12	M0451	El Anegado	1997	20.40	42.50	52.10	49.00	54.40	48.20	19.90	11.50	25.00	20.80	101.60	152.90	598.30
13	M0453	Chorrillos	1993	18.70	166.40	53.20	13.80	7.30	5.70	4.70	4.20	6.10	5.90	3.90	2.00	291.90
14	M0454	Río Chico En Alajuela	1991	136.20	113.70	144.60	98.40	50.20	0.00	0.00	0.00	0.00	0.00	0.00	23.50	566.60
15	M0455	Joa-Jipijapa	2005	0.00	84.70	63.40	59.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.40	223.40
16	M0457	Puerto Cayo	2011	54.40	71.00	0.00	28.00	2.40	8.50	18.20	12.30	1.00	8.90	0.00	17.20	221.90
17	M0458	Colimes de Paján	1990	106.40	173.00	197.20	196.00	39.70	47.00	1.60	0.00	0.00	0.30	0.00	60.50	821.70
18	M0459	San Pablo-Manabí	2010	167.70	179.00	232.20	182.80	42.00	5.90	11.00	2.00	0.80	0.40	14.80	101.90	940.50
19	M0462	Junín	2000	127.70	208.70	158.30	106.28	39.88	18.30	0.00	0.00	0.00	0.00	0.00	26.50	685.66
20	M0464	Río Chamotete-Jesús María	1991	136.60	141.50	272.50	130.10	68.70	31.50	0.00	2.30	0.90	0.00	14.40	21.90	820.40

Table 3. Meteorological Data on Evapotranspiration

Código	Descrip.	Año 25% prob.	Este	Norte	Ene	Feb	Mar	Abr	May	Jun	Jul	Ago	Sep	Oct	Nov	Dic	Anual (mm)
M0005	Portoviejo-Utm	2011	560110.5	9885319.8	146.8	125.5	149.5	149.2	145.7	127.2	133.7	145.7	142.0	146.0	141.9	139.8	1692.9
M0162	Chone-U. Católica	2005	607223.7	9926579.1	129.4	117.2	140.7	133.3	125.3	110.5	115.2	120.3	134.8	129.2	128.7	126.4	1510.9

Analysis of the Thematic Maps of Effective Precipitation

In [Figure 3](#), the monthly and annual ranges of effective precipitation are shown, allowing for the observation of rainfall variations throughout the year, with the aim of analyzing its temporal distribution, as seen below.

Mensual Precipitación (mm)	Anual Precipitación (mm)
0,00-10,00	161,8-293
11,00-50,00	293,1-379,1
51,00-62,00	379,2-444,7
63,00-90,00	444,8-512,3
91,00-167,00	512,4-684,5

Figure 3. Monthly and Annual Precipitation Ranges

In [Figure 4](#), the monthly distribution of effective precipitation in Manabí is observed, where the heaviest rains are recorded between January and April in the north and center, especially at the Chone (M0162), Pichincha (M0164), Flavio Alfaro (M0160), Santa Ana (M0166), and Paján (M0448) stations, with values exceeding 100 mm/month. In [Figure 5](#), the annual map confirms this trend, showing lower precipitation in coastal areas such as Manta (M0452), Montecristi (M0450), and Jaramijó (M0454), where the influence of the ocean reduces humidity

This table shows the spatial analysis of effective precipitation throughout the year, highlighting areas with the highest and lowest rainfall availability ([Table 4](#)).

Analysis of Thematic Maps of Reference Crop Evapotranspiration

In [Figure 6](#), the monthly and annual ranges of evapotranspiration for the reference crop are presented,

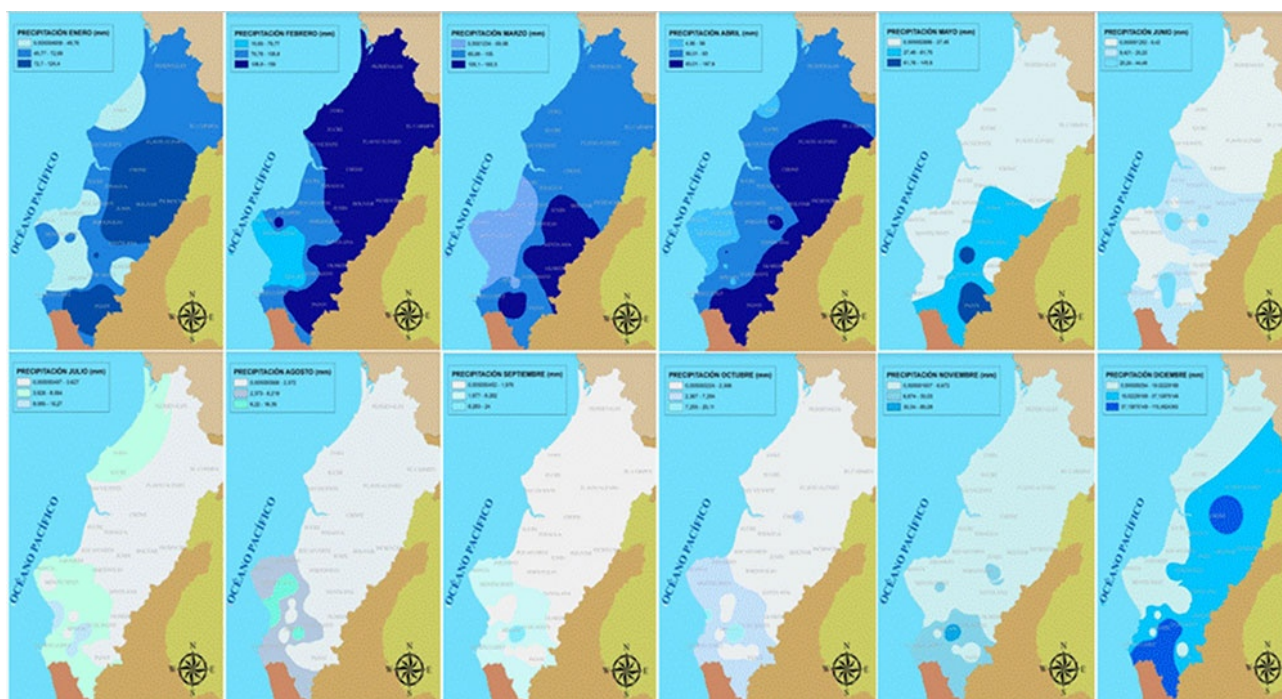


Figure 4. Spatial Distribution of Effective Precipitation in Manabí by Month

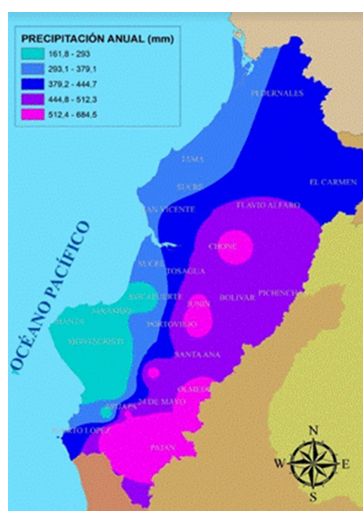


Figure 5. Spatial Distribution of Annual Effective Precipitation in Manabí

showing the variations in water demand throughout the year, identifying the periods of greatest and least water loss, which are essential for the efficient management of water resources in the study area.

In Figure 7, the monthly distribution of reference crop evapotranspiration is observed, showing higher values in the south of Manabí, mainly in Portoviejo (M0005), Santa Ana (M0166), Paján (M0448), and Jipijapa (M0455), with peaks of up to 154 mm/month between May and June. In Figure 8, the annual behavior shows that the highest rates are concentrated in Montecristi (M0450), Portoviejo (M0005), and Jipijapa (M0455), while the north, represented by Chone-U. Católica (M0162) and Flavio Alfaro (M0160), maintains lower values due to its higher humidity.

Table 5 presents the spatial analysis of reference crop evapotranspiration (ET_o) throughout the year, highlighting the areas with the highest and lowest irrigation demands.

Analysis of the Thematic Maps of Water Deficit

In Figure 9 indicates the monthly and annual ranges of water deficit, allowing the identification of periods when the irrigation demand exceeds availability, as observed below.

In Figure 10, the monthly distribution of water deficit is observed, with higher values in the south and coastal area Montecristi (M0450), Rocafuerte (M0165), Portoviejo (M0005), and Manta (M0452), reaching up to 146 mm, especially during the dry months. In Figure 11, the annual map reflects the same pattern, showing that the north, with stations like Chone (M0162), Paján (M0448), and Flavio Alfaro (M0160), maintains a more stable water balance throughout the year.

The spatial analysis of water deficit throughout the year is observed in Table 6, highlighting areas with the greatest irrigation scarcity and those with better availability.

Monthly temporal trend of the variables affecting water deficit in Manabí

A clear difference was observed in the distribution of rainfall, evapotranspiration, and water deficit at the Manabí stations. The central and southern areas, such as Portoviejo-UTM (M0005) and 24 de mayo (M0447), had more rain, while the coastal areas, such as Jama (M0167) and Montecristi (M0450), recorded less. In the south, Puerto Cayo (M0457) and Joa-Jipijapa (M0455) showed higher evapotranspiration, and the water deficit was stronger in Rocafuerte (M0165) and Montecristi (M0450).

Table 4. Spatial Analysis of Effective Precipitation

Periodo	Análisis
January-February	The highest precipitation was recorded in Chone, Pichincha, Bolívar, Junín, Flavio Alfaro, and Santa Ana, with values between ~72 and 120 mm/month. In contrast, coastal areas such as Manta, Montecristi, Jama, and Rocafuerte recorded the lowest values (<70 mm/month).
March-April	A contrasting distribution was maintained: Santa Ana, Olmedo, and Paján reached over 100 mm/month, while Manta, Montecristi, and Jaramijó recorded minimal precipitation (~5-65 mm/month).
May-June	A marked decrease in rainfall was evident throughout the province. Only Paján exceeded 100 mm/month, while most stations recorded values below 40 mm/month.
July-August	Precipitation was very low (<25 mm/month), with northern areas almost without any recorded rainfall.
September-October	The scarcity continued, with values below 24 mm/month, with light rains concentrated in the south.
November-December	An increase was observed in the south, especially in Puerto López, Paján, and 24 de mayo, reaching up to 115 mm/month.
Annual	The highest precipitation was concentrated in Flavio Alfaro, Chone, Pichincha, Santa Ana, and Paján; the lowest in Manta, Montecristi, and Jaramijó.

Mensual		Anual	
Precipitación (mm)	Color	Precipitación (mm)	Color
110-116		1.510,9-1.542,3	
117-127		1.542,31-1.576,56	
128-135		1.576,57-1.622,95	
136-140		1.622,96-1.660,78	
141-145		1.660,79-1.692,9	

Figure 6. Monthly and Annual Reference Crop Evapotranspiration Range

In contrast, the north, with Flavio Alfaro (M0160) and Junín (M0163), maintained more balanced conditions.

Figure 12 shows a comparative analysis of effective precipitation, reference crop evapotranspiration, and water deficit at the Manabí stations. It is observed that the southern and coastal areas have lower water availability due to high evapotranspiration and low precipitation, while the north maintains a more stable and favorable balance.

DISCUSSION

The results obtained for effective precipitation show that in Manabí there is a clear spatial difference in water availability, with higher values observed between January and April in the northern and central areas, where stations

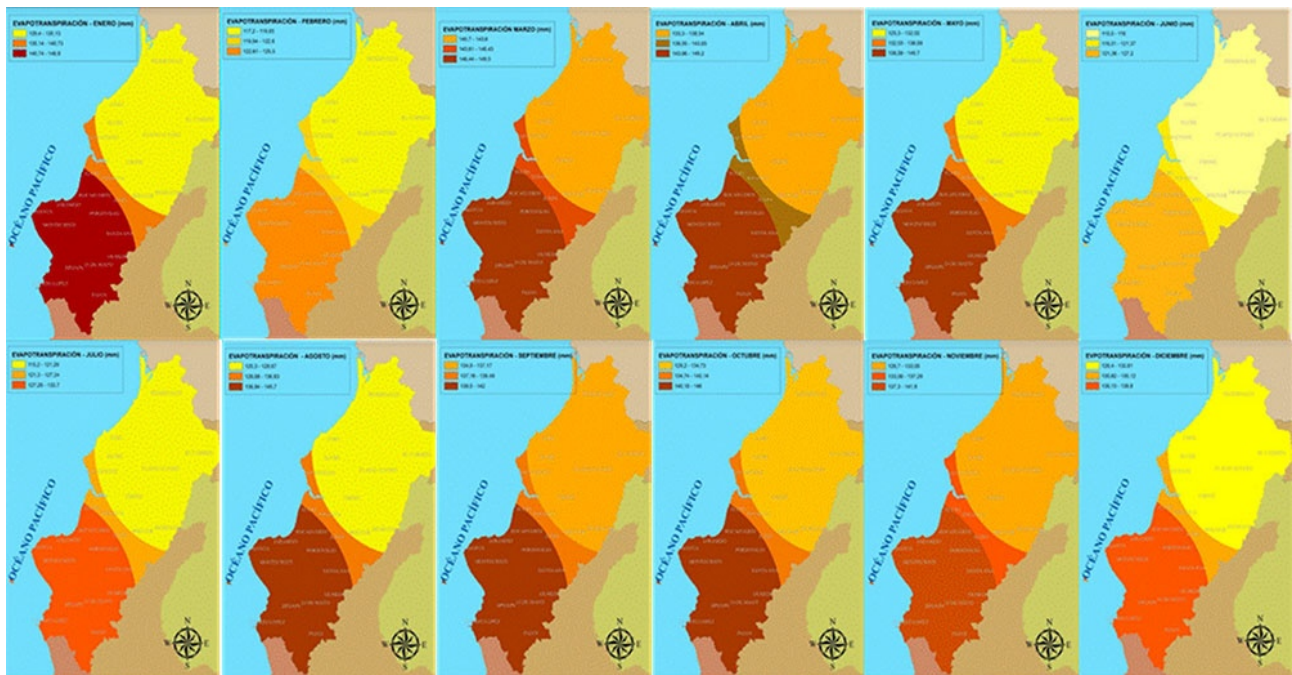


Figure 7. Spatial Distribution of Reference Crop Evapotranspiration in Manabí by Month

like Chone, Flavio Alfaro, and Santa Ana exceeded 100 mm/month, while coastal areas like Manta and Montecristi recorded values below 70 mm/month and even minimums close to 5 mm/month during the dry months. This behavior coincides with what was described by Pérez y Domínguez (2019), who reported that in Manabí the annual precipitation shows strong contrasts between humid inland areas and drier coastal sectors, which conditioned the need for supplemental irrigation. Similarly, Filgueiras *et al.*, (2019) they demonstrated that in tropical agricultural systems, the spatial variability of rainfall can generate significant productive differences within the same region. Nieto C. *et al.*, (2018) they also found in the Ecuadorian Sierra that areas with higher natural precipitation show less dependence on artificial irrigation, a situation comparable to the north of Manabí, where the water balance was more favorable. These results confirm that the irregular distribution of rainfall is one of the main factors explaining the provincial agricultural heterogeneity.

Regarding the evapotranspiration of the reference crop (ET_o), the obtained values show a higher water demand in the south of Manabí, reaching peaks close to 154 mm/month between May and June in stations like Portoviejo and Jipijapa, while the north presented lower values around 119-132 mm/month. Similar results were reported by Ashraf *et al.*, (2023) in Punjab, where evapotranspiration ranged between 120 and 160 mm/month, directly associated with the increase in temperature and solar radiation. Zheng *et al.*, (2022) they also identified comparable spatial variations, indicating that areas with lower atmospheric humidity experience greater water losses due to evapotranspiration. At the national level. Ortiz y Chile (2020) they estimated ET_o values close to 140 mm/month in the Tumbaco valley, a range very close to those obtained in this study, which supports the consistency of the results. From a productive standpoint, Abanum, Olalekan y Aremu (2023) demonstrated that crops like cocoa increase their irrigation requirements when evapotranspiration exceeds 130 mm/month, a situation observed in much of southern Manabí. Likewise, Dhaloiya *et al.*, (2022) they highlight that geospatial analysis allows for the identification of critical water demand areas, which aligns with the spatial patterns evidenced in the generated maps.



Figure 8. Spatial Distribution of Annual Reference Crop Evapotranspiration in Manabí.

Mensual		Anual	
Precipitación (mm)	Color	Precipitación (mm)	Color
-13-41		973,5-1.111	
-33-15		1.112-1.181	
14-43		1.182-1.262	
22-67		1.263-1.382	
67-91		1.383-1.531	
85-150			

Figure 9. Monthly and Annual Water Deficit Range

Table 5. Spatial Analysis of Reference Crop Evapotranspiration (ET_o)

Period	Analysis
January-February	The highest rates were recorded in the southern zone (Portoviejo, Santa Ana, Paján) with up to ~146 mm/month, while the northern zone showed lower values (~119 mm/month).
March-April	The trend persisted with high values in the south (~149 mm/month) and lower in the north.
May-June	The peak was reached (~154 mm/month) in Portoviejo, Olmedo, and Jipijapa, slightly decreasing toward the north (~132 mm/month). July-August Evapotranspiration remained high in the south (127-145 mm/month) and moderate in the north.
July-August	Evapotranspiration remained high in the south (127-145 mm/month) and moderate in the north.
September-October	The values stabilized with maxima in the south (~146 mm/month) and minima in the north (~129 mm/month).
November-December	Rates of up to 140 mm/month were observed in the south and 126 mm/month in the north
Annual	The highest rates were concentrated in Montecristi, Portoviejo, and Jipijapa; the lowest in the northern area.

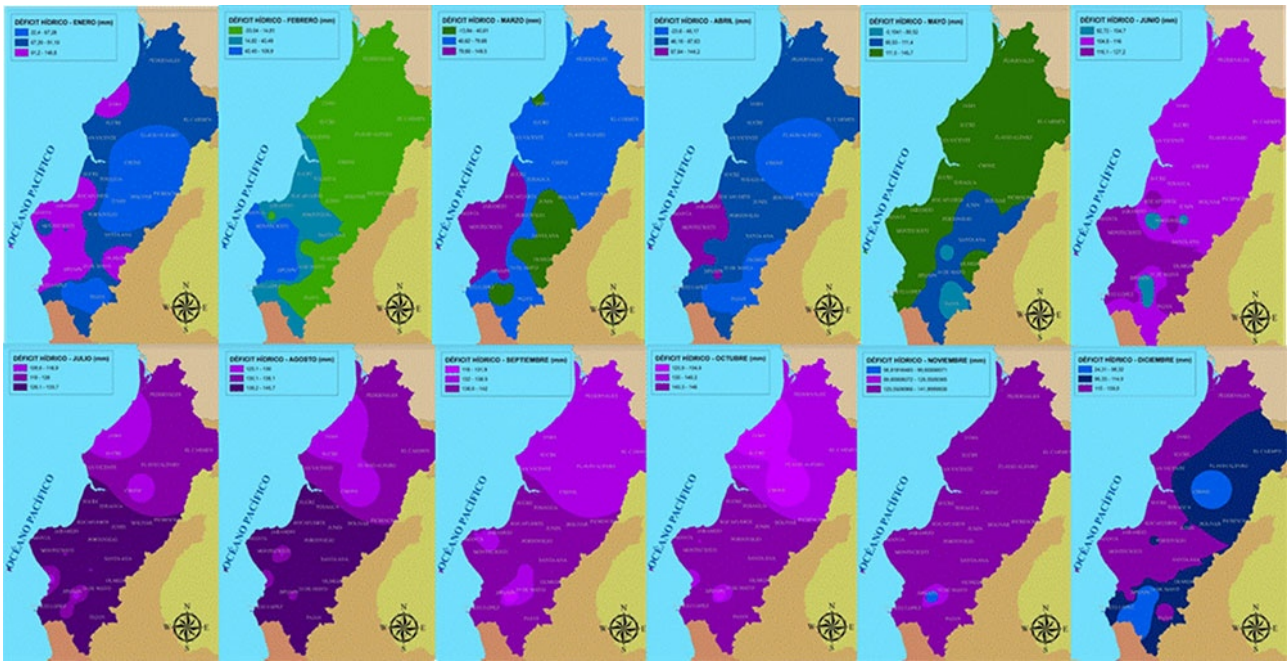


Figure 10. Spatial Distribution of Water Deficit in Manabí by Month



Figure 11. Spatial Distribution of Annual Water Deficit in Manabí

Regarding the water deficit, the results indicate that the most critical conditions are concentrated in the southern coastal zone, where stations like Montecristi, Rocafuerte, and Manta reached values close to 146 mm, while the north showed much lower deficits, around 22 mm, and

even almost neutral balances in Paján. These values reflect a direct combination of low precipitation and high evapotranspiration. *Inzunza et al., (2018)* they reported that deficits exceeding 120 mm cause significant reductions in corn yield, which allows for inferring possible productive impacts in the drier areas of Manabí. Similarly, *Ohikhen* (2023) observed that during prolonged dry seasons, the use of regulated irrigation allowed for the compensation of similar deficits, improving the efficient use of water in tropical crops. *Katerji et al., (2023)* they also warn that persistent water deficits can promote soil degradation processes and increased salinity, especially in coastal regions, a condition that coincides with the areas identified in this study.

This comparison with previous studies confirms that the identified spatial pattern corresponds to well-documented regional climatic processes and highlights the need for differentiated water management strategies according to local water availability.

CONCLUSIONS

It was determined that the spatial and temporal analysis of the variables associated with water deficit in the province of Manabí reveals significant contrasts between the different areas of the territory. The southern region presents the lowest values of effective precipitation and the highest deficits, reflecting a high water demand, while the northern stations, such as Flavio Alfaro (M0160) and Junín (M0163), show more favorable conditions with higher precipitation and positive balances. The concentration of rainfall in the months of February and March, coupled with high and constant evapotranspiration, shows that water scarcity intensifies between June and November, with demand far exceeding natural supply.

Table 6. Análisis Espacial del Déficit Hídrico

Period	Analysis
January-February	The deficit was higher in the south (Montecristi, Rocafuerte, Manta), reaching up to 146 mm, while in the north (Chone, Flavio Alfaro) the values were lower (~22 mm).
March-April	The south recorded pronounced deficits (~144 mm), while the north showed lower values (-23 mm).
May-June	There was a general increase in the deficit, reaching 127 mm in most stations, except for Paján (-0.10 mm).
July-August	High deficits persisted in the south (~145 mm), with lower values in the north.
September-October	The same trend continued, with deficits of up to 146 mm in the southern zone.
November-December	High values continued (~139-142 mm), with Chone and Jipijapa being the stations with the least deficit.
Annual	The highest deficit was concentrated in the southern coastal area (Montecristi, Rocafuerte, Portoviejo), while the lowest values were observed in Chone and Paján.



Figure 12. Monthly temporal trend of the variables evaluated in Manabí by weather station

These results confirm that the semi-arid climate of Manabí generates a structural water deficit that requires technical and sustained planning to ensure the efficient use of the resource and the stability of agricultural systems, and highlight the need to strengthen water resource management and conservation strategies in Manabí, promoting sustainable agricultural practices, efficient water use, and the implementation of adaptation measures in response to climate variability.

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