The International Journal of Engineering and Science (IJES)
|| Volume || 8 || Issue || 10 Series I || Pages || PP 22-34 || 2019 ||
ISSN (e): 2319 – 1813 ISSN (p): 23-19 – 1805

Precipitation forecast model for hydrological units using artificial neural networks (ANN).

Victor Rogelio Tirado Picado
Afiliation: Fundation Green Blue Planet

--ABSTRACT--
Duringhiscareer he has done importantwork as a consultantengineer and researcher in differentprojectsofhydraulic and environmentalengineering, it has beenpartofexaminers in differentmonographs Civil Engineering. He iscurrently Director ofConstructionDepartmentoftheFacultyofScience and Engineering UNAN-Managua. Doctor ofSciencegraduate, majoring Civil Engineering, withfilterdesignwork as processwaterpurification in smallcommunities in Atlantic International University. He has publishedprestigiousengineeringworksofnationalinterest, amongwhichresearchpapers, essays and books stand out.

Keywords: *Artificial Neural Networks, Precipitation, hydrogeologicalunit, waterstations.*

Date of Submission: 30-09-2019 Date of acceptance: 15-10-2019

I. SUMMARY

One of the main environmental concerns of different sectors of Nicaragua, including the current government, is focused on the possible effects of global climatechange and howitaffectsthe country.

Water is the most important for most human activities, but especially for natural ecosystems in the country, with which we live and nourish us natural resource. Often, water is a scarce commodity, especially when the effect of the child makes its ravages, clearly being denoted as a limiting resource in natural resources and activitiessuch as agriculture and industry.

Sometimes, abundanceorinadequate water distribution can be derived flood risk situations that affects the urban environment and human activity. Therefore, the study of rainfall in the context of global climate change is crucial for a coherent territorial planning with environmental conservation and proper for regional and local socio-economicactivitiesofour country.

However, climatemodels show significant systematic errors in projecting precipitation. The low spatial resolution of global, regional and national models causes the projections underestimate the significantspatialvariabilitygivingsmoothedvalues; ie extreme precipitationoftenunderestimate and overestimatethenumberofdayswithprecipitation.

Therefore, beforeusingthe products of precipitation models, it is necessary to correct the systematic error using data from meteorological observatories. However, rainfall is very irregular variable in its spatial and temporal distribution, so far the behavior of other physical variables such as temperature, pressure etc. For example, the probability distribution of the temperature approaches a normal or Gaussian distribution with mean valueroughlycenteredabout a curve issymmetrical.

However, the most likely value of daily precipitation is "zero", so that the peak probability distribution stands at around that value, causing the probability curve is completely asymmetric; a priori no negativerainfall, and lowdistributiontailgentlyfor positive rainfall.

From the physical point of view, it is possible to take evaporation as a kind of negative precipitation. For example, a cloud convective process, there may be simultaneouslyprecipitation and evaporation (virga); thusprecipitationreachingthegroundis the balance between what falls from the cloud and what becomes evaporate before reaching the ground. If we extend this phenomenon for precipitation in general, we can extend the domain ofmathematicalprobabilityfunctionsto try to complete the curves.

Nevertheless, the probability curves remain asymmetrical; the ends of evaporation are well below the extremes of precipitation. Therefore, it is necessary to seek new probability distributions, and new proposals for predictive models that can adequatelycorrectmodel and precipitationclimateprojections.

II. INTRODUCTION

In Nicaragua differenthydrographicunitsit presents in times of heavy rain most vulnerable sectors (also called critical points); therefore endanger the lives of the citizens living in places of high insecurity flood. Likewise always leave a lot of damage to the road infrastructure, which results in loss of life, economic losses regional and national levels, as well as losses in agricultural production. Currently, the lack of predictive models in Nicaragua and especially for different UH, not generate accurate forecasts; on the other hand, deprivation of predictions minimizes the chances of preventingdamage and lossesduetothreatsbyprecipitation.

Accordingtotheabove, in this paper, a forecasting model for rainfall events that manifests itself in units Hoyas basins, combining different variables to process information data through Artificial Neural Networks (ANN) is proposed and that certainly contribute to maximizing likely, emphasizing the comprehensive risk management and climatechange, toassist in preventingdamage and disasters.

III. METHODOLOGY

3.1 Kind of investigation

Basedontheproposedobjectivesandproblemsolve,thisworkwasconsidered as anexplorativeresearchtype, research,analyticalandapplied;sincetheanalysisofprecipitationproposingcriteriaforforescastingusingmathematical methods and standardizingthebehaviorof artificial neural networksitwasstudied.

2.1. Execution time

The research was conducted over a period of three and half months, distributed as follows: general data of the base stations were collected over a period of two weeks; we investigated the characteristics of the areas under study over a period of two weeks; Data analysis was performed on a four-week period; and finally the research paper was drafted over a period of six weeks.

2.2. Sources and technical data collection

Primary sources:

- Areas of study, study site visit.
- Engineers experts in the field, INETER for gathering information.

Secondary sources:

- Library of the National University of Engineering (UNI), to review and collect information from books on forecasts.
- Library of the National Autonomous University of Nicaragua, Managua (UNAN-Managua).
- Nicaraguan Institute of Territorial Studies (INETER).
- Internet, visiting websites with basic information on hydrological modeling, criteria and standards.

2.3. Data collection instruments

Observation in situ: a visit was made in the stations belonging to the hydrographic unit mantagalpa largest river in the upper part. Then study the physical characteristics of the hydrological unit.

Interviews: droughts of custionarios structured in order to obtain divergence criteria for analsis precipitation data were made, and recognized as the planning and analysis thereof is determined.

Documentary analysis: a summary in which the main titles to be used in the revised bilbliografia to achieve a speed in locating issues when used in drafting the document presented was used. Also the identification of factors that infloyen in the forecast model was provided.

2.4. Data processing techniques

` The data obtained in the experimentation, for hydrological modeling using artificial neural networks were processed through tabulation in which the parameters in studies by assigning a numerical value to each, in order to classify the information is coded, enter the results and processing it through the Microsoft Excel program, the preparation of the report the program was used Microsoft Word.

The interview data and in situ observation, were processed by techniques abstracting and indexing of information for easy location and handling.

2.5. Data analysistechniques

Content analysis: a content analysis based on projected by abstracting and indexing data gives the variables through graphics and tables to determine the future values of the most relevant rainfall and compare it to the natural tendency is done.

IV. RESULTS AND DISCUSSION

- **Drainage Area of the Rio Grande de Matagalpa Hoya (Alta)**

It is the flat area including topographical divide, planimetric obtained form the plane, for this Subhoya Rio Grande de Matagalpa (High) is 5157.37 Km2. This area represents 28.17% of the entire basin area 55 Rio Grande de Matagalpa.

- **Perimeter subhoya**

It covers a length of 656.10 km

- **Length of the main river**

Rio Grande de Matagalpa (High) 354.7 km included in this subhoya

- **Compactness of Gravelius Index**

Relationship between perimeter and area of the basin, calculated with the equation:

$\text{Ic} = 0.28\frac{\text{P}}{\text{A}^{1/2}}$Equation 1

$$\text{Ic} = 0.28\ \frac{656.10}{5157.37^{1/2}} = 2.56$$

- **Drainage system**

It consists of the main river, Rio Grande de Matagalpa and its tributaries in the upper part of the basin.

- **Order watercourse**

It reflects the degree of branching or bifurcation of the Rio Grande de Matagalpa Subhoya (High), third order according to Figure 1.

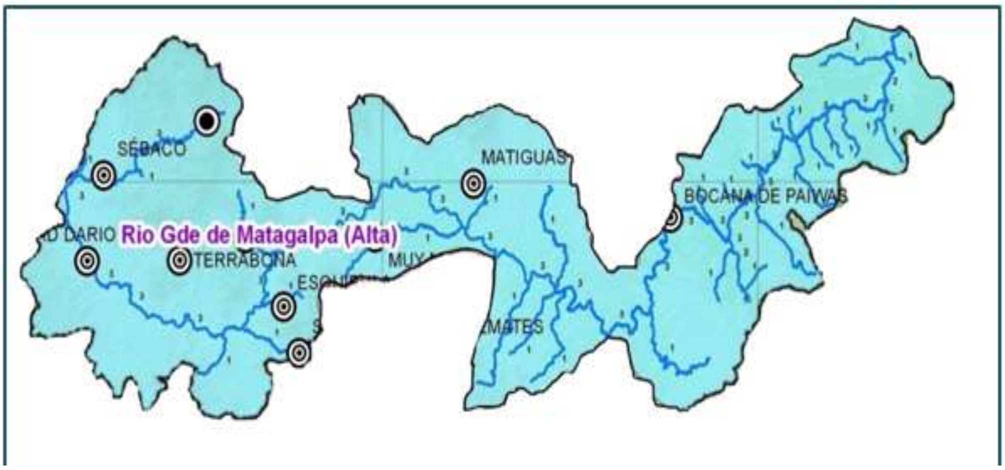

Figure 1: Map of order flows subhoya water, Rio Grande de Matagalpa (High)
Source: INETER. (N.d.). Order of the streams of the Rio Grande de Matagalpa subhoya (High).

- **Drainage density**

Relationship between the total length of the waterways of the subhoya and the total area, this gives an idea of the permeability of soil and vegetation, as among lower the higher density are these factors is obtained from from:

$\text{Dd} = \frac{\text{L}}{\text{A}}$Equation 2

$$\text{Dd} = \frac{\text{L}}{\text{A}} = \frac{951.35}{5157.37} = 0.18$$

- **Relief feature of Subhoya**

Average slope River:

$\mathbf{Ir} = \frac{\mathbf{HMr - Hmr}}{\mathbf{1000Lr}}$Equation 3

$$\text{Ir} = \frac{1500 - 100}{1000(354.7)} = 0.0039$$

Index pending Subhoya

$Sc = \frac{HMc - Hmc}{1000\ Lc}$ Equation 4

$$Sc = \frac{HMc - Hmc}{1000\ Lc} = \frac{1500 - 100}{1000 * 951.35} = 0.15\%$$

Hypsometric curve and frequency distribution

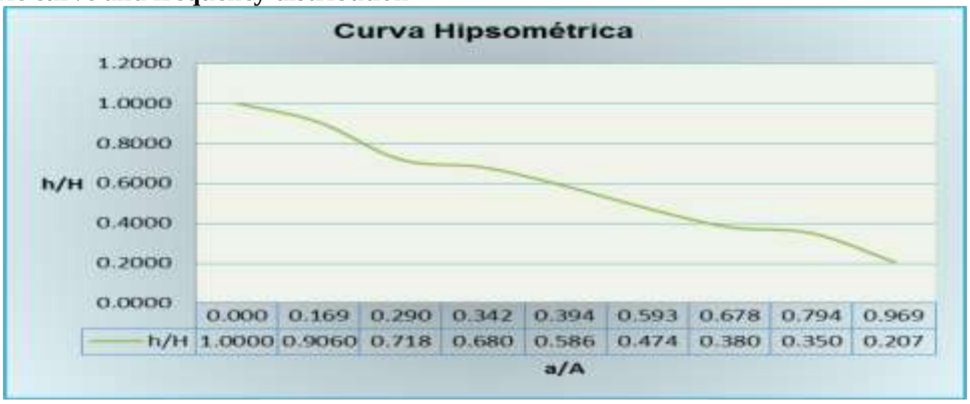

Figure 2: Figure Hypsometric, climb Rio Grande de Matagalpa.
Source: Made by myself. (2015). Hypsometric curve of the Rio Grande de Matagalpa top,Nicaragua subhoya.

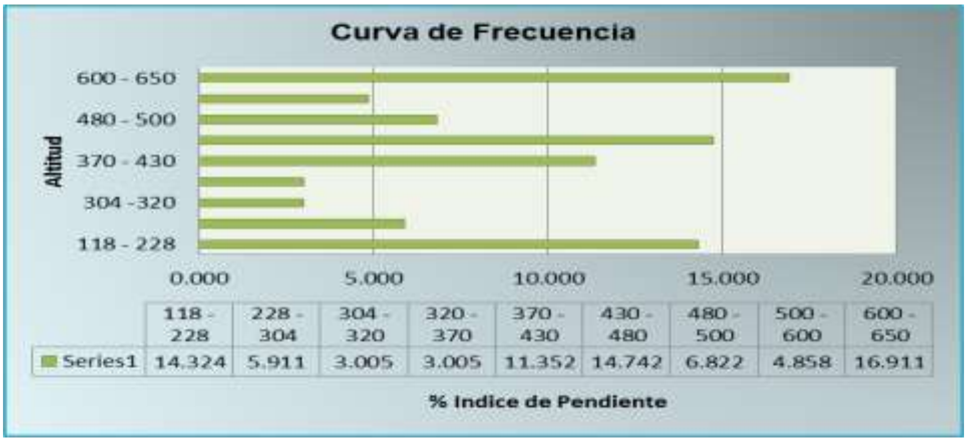

Figure 3: Frequency curve, climb Rio Grande de Matagalpa top.
Source: Prepared (2015). Subhoya frequency curve Rio Grande de Matagalpa top,Nicaragua.

- **Box equivalent**

According to (Monsalve, 1999) he states that it is an attempt to compare the influence of watershed characteristics on runoff.

The most important feature of this box is that it has equal distribution of heights that the hypsometric curve Subhoya study, building the rectangle from the area of the Subhoya for this case of 5157.37 km2 perimeter of 656.10 km, the longest side LM will be lower and side lm, these values being:

$LM = \frac{P + \sqrt{P^2 - 16(A)}}{4}$ Equation 5

$$L = \frac{656.10 + \sqrt{656.10^2 - 16(5157.37)}}{4} = 311.49km$$

$lm = \frac{P - \sqrt{P^2 - 16(A)}}{4}$ Equation 6

$$lm = \frac{656.10 - \sqrt{656.10^2 - 16(5157.37)}}{4} = 16.56km$$

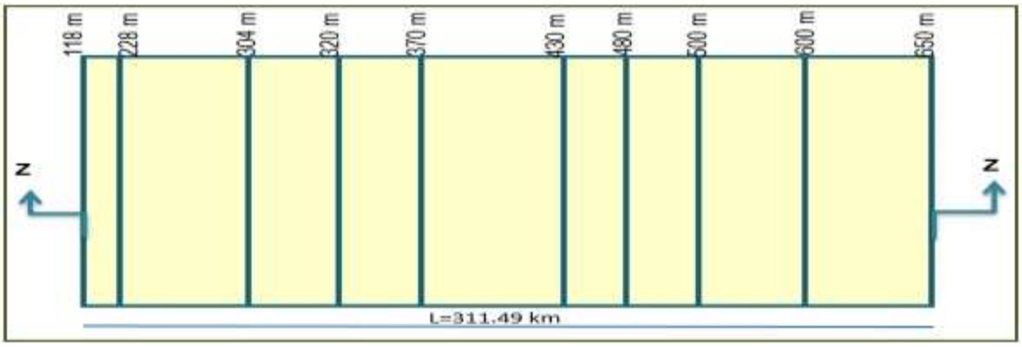

Figure 4: Equivalent Rectangle, climb Rio Grande de Matagalpa top.

Source: Made by myself. (2015). subhoya equivalent rectangle Rio Grande de Matagalpatop, Nicaragua.

Then precipitation data are presented Station Very Very / Very Very, which will be the season to build the model, the procedure is generalized for other stations belonging to the subhoya of Rio Grande de Matagalpa.

INSTITUTO NICARAGUENSE DE ESTUDIOS TERRITORIALES
DIRECCION GENERAL DE METEOROLOGIA
RESUMEN METEOROLOGICO ANUAL

Estación: - MUY MUY / MUY MUY — Latitud: 12° 45' 48" N
Código: 55 027 — Longitud: 85° 37' 36" W
Años: 1970 - 2009 — Elevación: 320 msnm
Parámetro: precipitación (mm) — Tipo: HMP

Año	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre
1970	-	-	-	-	-	203.80	307.10	260.50	373.80	124.10	60.80	121.20
1971	35.90	18.70	8.60	25.60	57.80	367.00	240.90	204.00	365.50	273.30	29.00	99.90
1972	76.60	18.00	0.50	16.50	137.80	149.90	263.60	202.60	125.00	146.30	165.20	89.50
1973	22.30	2.60	5.40	0.30	112.80	301.50	237.40	114.60	240.90	336.50	113.50	30.40
1974	92.80	23.60	17.80	32.20	52.90	205.00	157.80	266.00	313.80	161.60	31.70	48.80
1975	113.20	12.70	3.80	8.00	32.80	190.90	238.30	230.50	340.30	229.50	199.50	15.70
1976	30.60	13.10	20.60	20.70	135.40	323.70	192.60	311.90	147.20	165.40	79.10	69.00
1977	3.40	8.20	0.60	33.90	108.20	467.80	212.50	153.30	207.30	98.60	61.30	30.70
1978	33.40	5.80	11.90	10.00	148.90	201.70	310.80	254.70	113.50	163.30	92.40	77.70
1979	24.00	5.80	31.50	226.50	112.60	265.40	-	-	126.80	377.70	45.00	68.90
1980	40.40	13.70	20.90	13.50	499.60	309.10	334.30	188.50	332.70	313.70	218.10	32.20
1981	5.90	30.10	63.70	69.30	253.70	415.70	117.70	259.70	93.70	149.10	86.20	56.70
1982	41.70	56.80	20.20	15.20	166.90	300.70	270.40	127.60	162.90	107.60	62.60	64.60
1983	13.70	2.50	5.70	-	5.60	258.60	295.10	285.00	264.30	204.20	124.40	99.40
1984	34.80	30.90	12.10	1.00	87.70	170.40	247.30	224.30	216.90	130.30	53.90	103.20
1985	13.20	49.60	24.30	12.90	41.70	241.10	278.90	248.50	145.40	180.10	75.70	76.90
1986	20.70	11.20	3.00	5.60	69.60	211.40	322.90	140.20	170.20	131.50	165.50	41.70
1987	17.60	0.50	3.70	0.40	69.30	258.40	478.00	280.90	194.10	119.50	49.50	37.80
1988	81.00	34.90	3.80	49.20	108.10	239.80	255.10	349.70	223.60	353.40	38.60	54.90
1989	75.20	48.10	12.40	1.00	139.80	268.30	280.20	249.90	190.60	42.30	116.20	47.60
1990	79.90	61.80	22.40	16.30	174.40	282.60	139.90	265.70	143.10	162.70	135.70	98.80
1991	49.50	22.50	0.10	9.20	127.70	225.60	191.70	158.10	188.70	206.30	44.30	78.10
1992	32.40	17.80	3.80	-	156.40	172.10	310.50	242.40	279.60	133.20	63.20	69.20
1993	100.20	16.60	7.30	14.10	309.10	313.80	209.30	322.30	351.40	138.90	80.10	64.40
1994	43.40	49.60	27.60	11.60	59.00	240.80	169.40	243.50	239.10	283.60	125.50	39.00
1995	16.30	24.10	17.00	178.20	38.50	161.60	276.90	243.40	286.60	210.60	107.50	31.70
1996	48.80	10.90	9.00	8.10	233.90	206.50	156.50	317.80	212.60	158.00	231.50	39.40
1997	33.50	33.00	43.70	15.30	53.20	316.70	245.30	174.20	198.70	256.90	149.80	3.90
1998	9.00	-	9.80	11.60	78.40	185.60	188.20	199.60	167.60	627.00	166.10	65.10
1999	66.80	25.20	36.60	19.00	142.90	228.00	209.40	195.20	280.10	170.30	66.60	21.30
2000	23.40	31.10	3.00	5.00	83.10	272.10	188.20	195.50	183.80	155.80	100.10	40.50
2001	43.60	41.00	4.30	6.50	208.50	190.60	216.10	263.60	132.70	165.30	19.10	18.90
2002	45.00	58.50	42.80	13.80	121.20	353.60	271.50	225.70	72.40	362.80	97.10	28.50
2003	22.20	11.40	1.20	15.20	170.80	492.70	256.20	215.10	180.30	159.40	74.10	-
2004	50.10	26.20	22.60	93.40	255.70	285.60	228.40	238.10	188.70	112.90	146.80	34.50
2005	24.30	0.20	2.40	72.30	197.10	419.30	211.50	180.70	201.80	247.60	82.30	46.90
2006	62.10	5.90	17.20	4.40	130.90	114.90	279.80	166.40	125.50	114.90	85.70	85.90
2007	27.20	6.20	30.50	27.40	32.70	147.20	234.10	301.80	253.20	275.90	128.90	50.00
2008	40.50	31.70	43.10	38.10	96.00	356.50	398.70	210.00	140.20	299.10	9.00	42.60
2009	33.30	30.20	5.70	14.00	232.50	-	-	-	-	-	-	-
Suma	1,627.90	890.70	620.60	1,115.30	5,243.20	10,316.00	9,422.50	8,711.50	8,174.60	8,049.20	3,781.60	2,125.50
Media	41.70	22.80	15.90	28.60	134.40	264.50	248.00	229.30	209.60	206.40	97.00	55.90
Máximo	113.20	61.80	63.70	226.50	499.60	492.70	478.00	349.70	373.80	627.00	231.50	121.20
Mínimo	3.40	-	0.10	-	5.60	114.90	117.70	114.60	72.40	42.30	9.00	3.90

Table 1: Annual weather summary, Veryverystation.

Source: INETER (2015).

The month will analyze January, June, October and December in the period 1970-2009, this process is repeated for the remaining months, giving it a pseudocode with (mod 31), then apply the RNA when the RNA learns the normal distribution applies and adjusting it closer to a polynomial curve is verified.

Distribución de Probabilidad Normal											
N	X	TR	P(x≥Xm)	Pe(x≤Xm)	Xi-X̄	$(Xi-\bar{X})^2$	z=(x-X̄)/S	Pt(x≥Xm)	Δdesviación	Δmáx	Δcrítico α=0.05
1	113.20	41.00	0.0244	0.9756	72.50	5256.61	2.662	0.0115	-0.9641		
2	100.20	20.50	0.0488	0.9512	59.50	3540.55	2.185	0.0367	-0.9145		
3	92.80	13.67	0.0732	0.9268	52.10	2714.67	1.913	0.0640	-0.8628		
4	81.00	10.25	0.0976	0.9024	40.30	1624.29	1.480	0.1335	-0.7689		
5	79.90	8.20	0.1220	0.8780	39.20	1536.84	1.439	0.1416	-0.7364		
6	76.60	6.83	0.1463	0.8537	35.90	1288.99	1.318	0.1673	-0.6863		
7	75.20	5.86	0.1707	0.8293	34.50	1190.42	1.267	0.1788	-0.6504		
8	66.80	5.13	0.1951	0.8049	26.10	681.34	0.958	0.2520	-0.5528		
9	62.10	4.56	0.2195	0.7805	21.40	458.07	0.786	0.2930	-0.4875		
10	50.10	4.10	0.2439	0.7561	9.40	88.41	0.345	0.3759	-0.3802		
11	49.50	3.73	0.2683	0.7317	8.80	77.48	0.323	0.3786	-0.3531		
12	48.80	3.42	0.2927	0.7073	8.10	65.65	0.297	0.3817	-0.3256		
13	45.00	3.15	0.3171	0.6829	4.30	18.51	0.158	0.3940	-0.2889		
14	43.60	2.93	0.3415	0.6585	2.90	8.42	0.107	0.3967	-0.2619		
15	43.40	2.73	0.3659	0.6341	2.70	7.30	0.099	0.3970	-0.2372		
16	41.70	2.56	0.3902	0.6098	1.00	1.01	0.037	0.3987	-0.2111		
17	40.50	2.41	0.4146	0.5854	(0.20)	0.04	-0.007	0.3989	-0.1864		
18	40.40	2.28	0.4390	0.5610	(0.30)	0.09	-0.011	0.3989	-0.1621		
19	35.90	2.16	0.4634	0.5366	(4.80)	23.02	-0.176	0.3928	-0.1438		
20	34.80	2.05	0.4878	0.5122	(5.90)	34.78	-0.217	0.3897	-0.1225	0.1177	0.210
21	33.50	1.95	0.5122	0.4878	(7.20)	51.80	-0.264	0.3853	-0.1026		
22	33.40	1.86	0.5366	0.4634	(7.30)	53.25	-0.268	0.3849	-0.0785		
23	33.30	1.78	0.5610	0.4390	(7.40)	54.72	-0.272	0.3845	-0.0545		
24	32.40	1.71	0.5854	0.4146	(8.30)	68.85	-0.305	0.3809	-0.0338		
25	30.60	1.64	0.6098	0.3902	(10.10)	101.96	-0.371	0.3724	-0.0178		
26	27.20	1.58	0.6341	0.3659	(13.50)	182.18	-0.496	0.3528	-0.0130		
27	24.30	1.52	0.6585	0.3415	(16.40)	268.88	-0.602	0.3328	-0.0086		
28	24.00	1.46	0.6829	0.3171	(16.70)	278.81	-0.613	0.3306	0.0135		
29	23.40	1.41	0.7073	0.2927	(17.30)	299.20	-0.635	0.3261	0.0334		
30	22.30	1.37	0.7317	0.2683	(18.40)	338.47	-0.675	0.3176	0.0493		
31	22.20	1.32	0.7561	0.2439	(18.50)	342.16	-0.679	0.3168	0.0729		
32	20.70	1.28	0.7805	0.2195	(20.00)	399.90	-0.734	0.3047	0.0852		
33	17.60	1.24	0.8049	0.1951	(23.10)	533.49	-0.848	0.2785	0.0833		
34	16.30	1.21	0.8293	0.1707	(24.40)	595.24	-0.896	0.2671	0.0964		
35	13.70	1.17	0.8537	0.1463	(27.00)	728.87	-0.991	0.2441	0.0978		
36	13.20	1.14	0.8780	0.1220	(27.50)	756.11	-1.010	0.2397	0.1177		
37	9.00	1.11	0.9024	0.0976	(31.70)	1004.73	-1.164	0.2027	0.1051		
38	5.90	1.08	0.9268	0.0732	(34.80)	1210.87	-1.278	0.1764	0.1032		
39	3.40	1.05	0.9512	0.0488	(37.30)	1391.10	-1.369	0.1562	0.1074		
40	-	1.03	0.9756	0.0244	(40.70)	1656.29	-1.494	0.1307	0.1063		

MEDIA	40.70
DESVIACIÓN	27.24
MÁXIMO	113.20
MÍNIMO	-

Table 2: Verification of precipitation data for the period January 1970 to 2009
Source: Made by myself. (2015).

As rainfall data for the month shown in the result January fits a normal distribution.

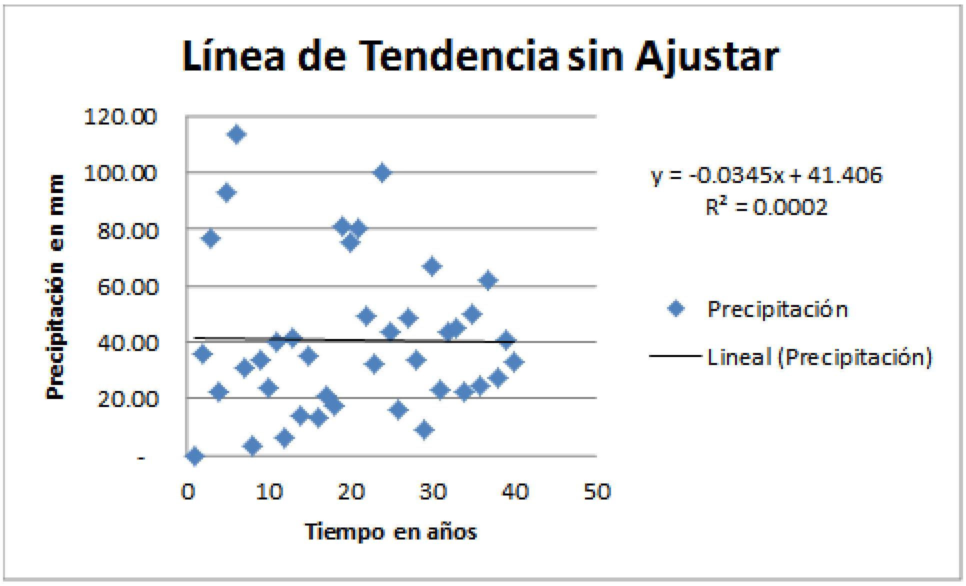

Figure 5: Trend line data of precipitation in January unadjusted
Source: Made by myself. (2015)

Ajuste a una Distribución Normal			
x	Y	Yajustada	
1	-	41.41	0.014642
2	35.90	40.17	0.014644
3	76.80	38.76	0.014610
4	22.30	40.64	0.014647
5	92.80	38.20	0.014588
6	113.20	37.50	0.014546
7	30.80	40.35	0.014646
8	3.40	41.29	0.014643
9	33.40	40.25	0.014645
10	24.00	40.58	0.014647
11	40.40	40.01	0.014642
12	5.90	41.20	0.014644
13	41.70	39.97	0.014642
14	13.70	40.93	0.014646
15	34.80	40.21	0.014644
16	13.20	40.95	0.014646
17	20.70	40.69	0.014647
18	17.80	40.80	0.014647
19	81.00	38.61	0.014604
20	75.20	38.81	0.014612
21	79.90	38.65	0.014605
22	49.50	39.70	0.014637
23	32.40	40.29	0.014645
24	100.20	37.95	0.014572
25	43.40	39.91	0.014641
26	16.30	40.84	0.014647
27	48.80	39.72	0.014637
28	33.50	40.25	0.014645
29	9.00	41.10	0.014645
30	66.80	39.10	0.014622
31	23.40	40.60	0.014647
32	43.80	39.90	0.014641
33	45.00	39.85	0.014640
34	22.20	40.64	0.014647
35	50.10	39.68	0.014637
36	24.30	40.57	0.014647
37	62.10	39.26	0.014627
38	27.20	40.47	0.014646
39	40.50	40.01	0.014642
40	33.30	40.26	0.014645

Table 3: Adjusting precipitation from January to a probability distribution Normal, period 1970-2009
Source: Made by myself. (2015).

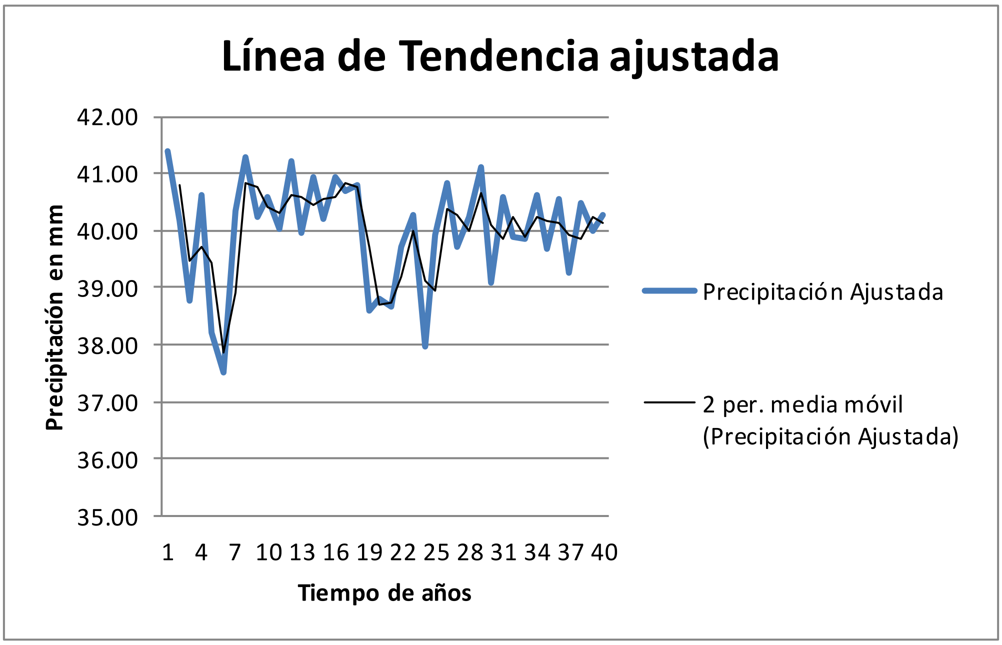

Figure 6: Line moving average trend for precipitation of the month january adjusted
Source: Made by myself. (2015).

V. SUMMARY OF RESULTS

Mes	Media	Desviación	Máximo	Mínimo	Δmáx	Δcrítico	Condición
Febrero	22.80	17.50	61.80	0.00	0.153	0.210	Se acepta el ajuste
Marzo	15.90	14.99	63.70	0.10	0.209	0.210	Se acepta el ajuste
Abril	28.60	45.81	226.50	0.00	0.307	0.210	No se acepta el ajuste
Mayo	134.40	93.98	499.60	5.60	0.157	0.210	Se acepta el ajuste
Junio	264.50	96.86	492.70	114.90	0.134	0.210	Se acepta el ajuste
Julio	248.00	87.19	478.00	117.70	0.149	0.210	Se acepta el ajuste
Agosto	229.30	74.24	349.70	114.60	0.127	0.210	Se acepta el ajuste
Septiembre	209.60	83.90	373.80	72.40	0.133	0.210	Se acepta el ajuste
Octubre	206.40	110.61	627.00	42.30	0.186	0.210	Se acepta el ajuste
Noviembre	97.00	55.53	231.50	9.00	0.101	0.210	Se acepta el ajuste
Diciembre	55.90	29.77	121.20	3.90	0.112	0.210	Se acepta el ajuste

Table 4: Comparation deviation for accept the condition of adjusted, January to December
Source: Made by myself. (2015).

- RNA MODEL WITH FORECAST

Data preparation

To him data preparation months is chosen to try and project, in this case it will work with the months of January, June, October and December, which are representative months where low and high rainfall in the year occurs. Once selected the months "0" is set when there is no rain, and "1" when there is rain, according to "0" and "1" the different possible combinations are made to generate the last permissible, which will be the projection the future from the base year. In the case it sets 2007 as the base year, and then projected. See Table 5, 6.

AÑO	PRECIPITACIÓN (mm)			
	ENERO	JUNIO	OCTUBRE	DICIEMBRE
	X1	X2	X3	X4
2007	27.20	147.20	275.90	50.00

Table 5: Precipitation data to project, base 2007 year is assigned a variable in this case Xi
Source: Made by myself. (2015). Managua Nicaragua.

	ENERO	JUNIO	OCTUBRE	DICIEMBRE	VALORES DE PESOS INICIALES			
N	X1	X2	X3	X4	w1	w2	w3	w4
1	27.20	147.20	275.90	50.00	1	0	0	0
2	27.20	147.20	275.90	50.00	0	1	0	0
3	27.20	147.20	275.90	50.00	0	0	1	0
4	27.20	147.20	275.90	50.00	0	0	0	1
5	27.20	147.20	275.90	50.00	0	0	0	0
6	27.20	147.20	275.90	50.00	1	0	1	0
7	27.20	147.20	275.90	50.00	0	1	0	1
8	27.20	147.20	275.90	50.00	1	1	0	0
9	27.20	147.20	275.90	50.00	1	0	0	1
10	27.20	147.20	275.90	50.00	0	1	1	0
11	27.20	147.20	275.90	50.00	1	1	1	1
12	27.20	147.20	275.90	50.00	0	0	1	1
13	27.20	147.20	275.90	50.00	0	1	1	1
14	27.20	147.20	275.90	50.00	1	1	1	0

Table 6: Values of 0 and 1, to generate the time series, in this case 14 possible combinations of precipitation were generated.

Source: Made by myself. (2015). Managua Nicaragua.

As seen in Table 7, were generated 14 possible combinations of the occurrence of precipitation, this allocation is called pesos, which will be the initial to build the model.

Generation Data precipitation 31 Mod.

ENERO	JUNIO	OCTUBRE	DICIEMBRE
XI1	XI2	XI3	XI4
353.6	**1913.6**	**3586.7**	**650.0**
163.8	293.8	282.1	390.0
114.4	192.4	40.3	234.0
278.2	83.2	120.9	221.0
392.6	275.6	362.7	52.0
267.8	358.8	282.1	273.0
257.4	231.4	40.3	325.0
122.2	187.2	120.9	195.0
379.6	15.6	362.7	117.0
98.8	202.8	282.1	312.0
75.4	218.4	40.3	26.0
174.1	18.0	120.6	338.0
248.8	234.5	358.5	364.0
10.5	227.3	227.0	299.0

Table 7: Initial table to convert Mod 31, ie Xi + 1 = Xi * 13

Source: Made by myself. (2015). Managua Nicaragua

This table shows the data base year 2007 January, June, October and December reflected and given the multiplier 13, ie to the data of 27.20 mm * 13 = 353.6 mm, the mod 31 is 12.6: said otherwise 353.6 (Mod 31 = 12.6), and so for each column. Below it is presented in Table 8 mod 31 values.

Mod 31			
ENERO	JUNIO	OCTUBRE	DICIEMBRE
XI1	XI2	XI3	XI4
12.6	**22.6**	**21.7**	30.0
8.8	14.8	3.1	18.0
21.4	6.4	9.3	17.0
30.2	21.2	27.9	4.0
20.6	27.6	21.7	21.0
19.8	17.8	3.1	25.0
9.40	14.4	9.3	15.0
29.20	1.2	27.9	9.0
7.60	15.6	21.7	24.0
5.80	16.8	3.1	2.0
13.40	1.4	9.3	26.0
19.14	18.0	27.6	28.0
0.81	17.5	17.5	23.0
10.47	10.3	10.0	20.0

Table 8: Values of 31 Mod projected rainfall.

Source: Made by myself. (2015). Managua Nicaragua.

As shown in Table 8 each rainfall are converted to Mod 31, these values are used to validate the model Nuronales Artificial Network (ANN).

RNA forecast model

ENERO	JUNIO	OCTUBRE	DICIEMBRE	VALORES DE PESOS A Mod 31			
Xi1	**Xi2**	**Xi3**	**Xi4**	**w1**	**w2**	**w3**	**w4**
12.6	**22.6**	**21.7**	30.0	0.41	0.73	0.70	0.97
8.8	14.8	3.1	18.0	0.28	0.48	0.10	0.58
21.4	6.4	9.3	17.0	0.69	0.21	0.30	0.55
30.2	21.2	27.9	4.0	0.97	0.68	0.90	0.13
20.6	27.6	21.7	21.0	0.66	0.89	0.70	0.68
19.8	17.8	3.1	25.0	0.64	0.57	0.10	0.81
9.40	14.4	9.3	15.0	0.30	0.46	0.30	0.48
29.20	1.2	27.9	9.0	0.94	0.04	0.90	0.29
7.60	15.6	21.7	24.0	0.25	0.50	0.70	0.77
5.80	16.8	3.1	2.0	0.19	0.54	0.10	0.06
13.40	1.4	9.3	26.0	0.43	0.04	0.30	0.84
19.14	18.0	27.6	28.0	0.62	0.58	0.89	0.90
0.81	17.5	17.5	23.0	0.03	0.56	0.56	0.74
10.47	10.3	10.0	20.0	0.34	0.33	0.32	0.65

Table 9: Table with precipitation values projected Mod 31, and weights assigned to pseudocode with Mad 31. Source: Made by myself. (2015). Managua Nicaragua.

Table 9 shows the input values are observed, and the weights assigned from pseudocode for each of the entries.

ENERO	JUNIO	OCTUBRE	DICIEMBRE	VALORES DE PESOS A Mod 31				T	Σ	Función	e
XI1	XI2	XI3	XI4	w1	w2	w3	w4	Deseada		Sigmoide	error
12.6	**22.6**	**21.7**	30.0	0.41	0.73	0.70	0.97	1	65.82	1	0.00000
8.8	14.8	3.1	18.0	0.28	0.48	0.10	0.58	1	20.33	1	0.00000
21.4	6.4	9.3	17.0	0.69	0.21	0.30	0.55	1	28.21	1	0.00000
30.2	21.2	27.9	4.0	0.97	0.68	0.90	0.13	1	69.54	1	0.00000
20.6	27.6	21.7	21.0	0.66	0.89	0.70	0.68	1	67.68	1	0.00000
19.8	17.8	3.1	25.0	0.64	0.57	0.10	0.81	1	43.34	1	0.00000
9.40	14.4	9.3	15.0	0.30	0.46	0.30	0.48	1	19.59	1	0.00000
29.20	1.2	27.9	9.0	0.94	0.04	0.90	0.29	1	55.27	1	0.00000
7.60	15.6	21.7	24.0	0.25	0.50	0.70	0.77	1	43.48	1	0.00000
5.80	16.8	3.1	2.0	0.19	0.54	0.10	0.06	1	10.63	0.999976	0.00002
13.40	1.4	9.3	26.0	0.43	0.04	0.30	0.84	1	30.43	1	0.00000
19.14	18.0	27.6	28.0	0.62	0.58	0.89	0.90	1	72.13	1	0.00000
0.81	17.5	17.5	23.0	0.03	0.56	0.56	0.74	1	36.78	1	0.00000
10.47	10.3	10.0	20.0	0.34	0.33	0.32	0.65	1	23.06	1	0.00000

Table 10: Data inputs with their respective weight, and output data, what you want to learn the RNA. Source: Made by myself. (2015). Managua Nicaragua.

Table 10 entries is observed, the values of the weights and the learning level is 0.4, following, is set the desired T, which for all inputs is 1, ie there is rain, following the procedure It is the sum function and then the sigmoid function, which will output the desired T.

Analyzing the table, it is observed that there is a slight difference in the inlet 10 of 0.999976, giving an error very, very decimal of 0.00002, to validate learning Artificial Neural Network is continuing to correct the values of the weights of the input 10 Network. the results in table 11.

NUEVOS VALORES DE PESOS A Mod 31			
w1	**w2**	**w3**	**w4**
0.41	0.73	0.70	0.97
0.28	0.48	0.10	0.58
0.69	0.21	0.30	0.55
0.97	0.68	0.90	0.13
0.66	0.89	0.70	0.68
0.64	0.57	0.10	0.81
0.30	0.46	0.30	0.48
0.94	0.04	0.90	0.29
0.25	0.50	0.70	0.77
0.19	0.54	0.10	0.06
0.43	0.04	0.30	0.84
0.62	0.58	0.89	0.90
0.03	0.56	0.56	0.74
0.34	0.33	0.32	0.65

Table 11: Values of weights are fixed in Mod 31.
Source: Made by myself. (2015). Managua Nicaragua.

Calculated fixed weights are similar to previous pesos in Mod 31, for this reason it is asserted that the network has learned, meaning that validates the data generated precipitation for the next few years in the months studied.

Analysis and graphics

AÑOS	ENERO Xi1	DATOS ORDENADOS	DISTRIBUCIÓN NORMAL	JUNIO Xi2	DATOS ORDENADOS	DISTRIBUCIÓN NORMAL	OCTUBRE Xi3	DATOS ORDENADOS	DISTRIBUCIÓN NORMAL	DICIEMBRE Xi4	DATOS ORDENADOS	DISTRIBUCIÓN NORMAL
2008	163.8	10.5	0.000927407	293.8	15.6	0.000820331	282.1	40.27	0.001382338	390.0	26.0	0.0006150
2009	114.4	75.4	0.001955053	192.4	18.0	0.000855692	40.3	40.30	0.001382687	234.0	52.0	0.0009068
2010	278.2	98.8	0.002370385	83.2	83.2	0.002135872	120.9	40.30	0.001382687	221.0	117.0	0.0019259
2011	392.6	114.4	0.002635373	275.6	187.2	0.003917028	362.7	120.57	0.002540738	52.0	195.0	0.0031549
2012	267.8	122.2	0.00276014	358.8	192.4	0.003927921	282.1	120.90	0.002544957	273.0	221.0	0.0033669
2013	257.4	163.8	0.003274713	231.4	202.8	0.003918836	40.3	120.90	0.002544957	325.0	234.0	0.0034139
2014	122.2	174.1	0.00334987	187.2	218.4	0.003829262	120.9	227.01	0.003080997	195.0	273.0	0.0033081
2015	379.6	248.8	0.003123111	15.6	227.3	0.003739691	362.7	282.10	0.002586092	117.0	299.0	0.0030365
2016	98.8	257.40	0.003017363	202.8	231.4	0.003688856	282.1	282.10	0.002586068	312.0	312.0	0.0028575
2017	75.4	267.8	0.002873178	218.4	234.5	0.003647588	40.3	282.10	0.002586068	26.0	325.0	0.0026559
2018	174.1	278.2	0.002714154	18.0	275.6	0.002874152	120.6	358.46	0.001487818	338.0	338.0	0.0024380
2019	248.8	379.6	0.001025767	234.5	293.8	0.00245446	358.5	362.70	0.001427721	364.0	364.0	0.0019792
2020	10.5	392.6	0.000857161	227.3	358.8	0.001074452	227.0	362.70	0.001427719	299.0	390.0	0.0015287
MEDIA	198.74		MEDIA	195.30		MEDIA	203.11		MEDIA	242.00		
DESVIACIÓN	116.46		DESVIACIÓN	101.52		DESVIACIÓN	127.22		DESVIACIÓN	116.58		

Table 12: Summary table of projected data and adjusted to a Normal Distribution
Source: Made by myself. (2015). Managua Nicaragua.

The data in this table are used to generate the curve of a normal distribution, then graphed and bring it closer to a polynomial trend, and thus to evaluate the occurrence of precipitation along the projected time. the graph for the month of January comes, all other graphics for the months of June, October and December are in Annex 7.

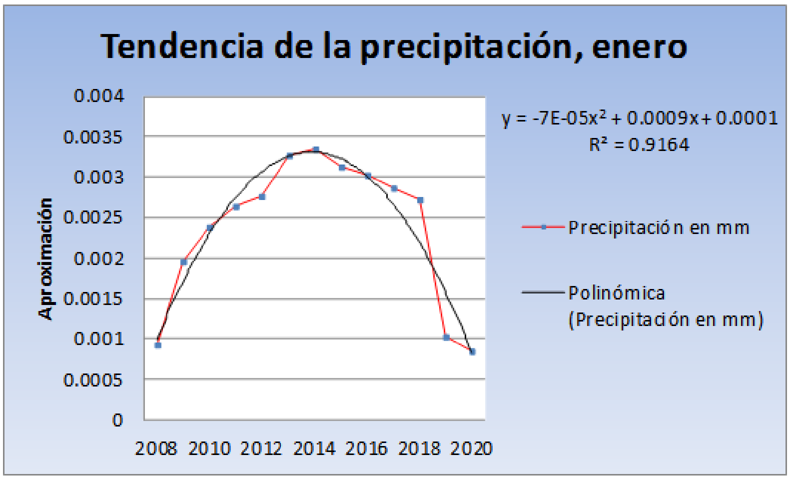

Figure 7: Trend of precipitation in mm, of January.
Source: Made by myself. (2015). Managua Nicaragua.

The graph shows that: the polynomial trend is how it should behave precipitation in January for the period 2008-2020, and the trend of precipitation in mm that has is almost the same behavior, means what is below polynomial line indicates a deficit of precipitation, and what is above polynomial line indicates that there will be an excess of water. Everything is correlated with a coefficient equal to 0.91.

VI. CONCLUSION

For the preparation of the data is chosen month project to treat and, in this case it will work with the months of January, June, October and December, which are representative months where low and high rainfall in the year occurs. Once selected the months "0" is set when there is no rain, and "1" when there is rain, according to "0" and "1" the different possible combinations are made to generate the last permissible, which will be the projection the future from the base year. In the case it sets 2007 as the base year, and then projected. See Table 7, 8.

As seen in Table 8, were generated 14 possible combinations of the occurrence of precipitation, this allocation is called pesos, which will be the initial to build the model.

This table 9 shows the data base year 2007 January, June, October and December reflected and given the multiplier 13, ie to the data of 27.20 mm * 13 = 353.6 mm, the mod 31 is 12.6: said otherwise 353.6 (Mod 31 = 12.6), and so for each column. Below it is presented in Table 11 mod 31 values.

As shown in Table 10 each rainfall are converted to Mod 31, these values are used to validate the model Nuronales Artificial Network (ANN).

Table 11 shows the input values are observed, and the weights assigned from pseudocode for each of the entries.

Table 12 entries is observed, the values of the weights and the learning level is 0.4, following, is set the desired T, which for all inputs is 1, ie there is rain, following the procedure It is the sum function and then the sigmoid function, which will output the desired T.

Analyzing the table, it is observed that there is a slight difference in the inlet 10 of 0.999976, giving an error very, very decimal of 0.00002, to validate learning Artificial Neural Network is continuing to correct the values of the weights of the input 10 Network. the results in table 12.

Calculated fixed weights are similar to previous pesos in Mod 31, for this reason it is asserted that the network has learned, meaning that validates the data generated precipitation for the next few years in the months studied.

The data in this table 12 are used to generate the curve of a normal distribution, then graphed and bring it closer to a polynomial trend, and thus to evaluate the occurrence of precipitation along the projected time. the graph for the month of January comes, all other graphics for the months of June, October and December are in Annex 7.

The graph 4 shows that: the polynomial trend is how it should behave precipitation in January for the period 2008-2020, and the trend of precipitation in mm that has is almost the same behavior, means what is below polynomial line indicates a deficit of precipitation, and what is above polynomial line indicates that there will be an excess of water. Everything is correlated with a coefficient equal to 0.91.

Gratitude

First, I express my thanks to my mother who has been a person who has managed to induce this deadly simple, by the shining path to achieve its objectives and goals; who, despite his illness, has left traces of the great faith that has to continue educating myself, and that without basilar has given me the best thing a person may wish to have and is the greatest treasure that can exist in the universe, "the knowledge". Thank you, Dona Beatriz Picado.

Then, I thank one of the women who, at the time, did not hesitate to make me happy and it was a wonderful woman, whose intelligence was able to master all the stressful and difficult times we can have a relationship, thanks Paty for the love you gave me, that God may save you well wherever you are. Paty (q.e.p.d). My thanks to my children: ItziarDafined Tirado Tirado Manuel Flores and Victor Flores, the two person to serve as an example and overcoming soyfuente. Success in overcoming it.

And of course, I can not forget my house home: the National Autonomous University of Nicaragua UNAN-Managua, Alma Mater that opened the doors to excel and knowledge, I opened the door of opportunity, without it I would not be here writing these paragraphs of mind, I know that this work will serve for the next generation of professionals. Thanks UNAN.

Financing

Funding for this research was to own resources.

BIBLIOGRAFÍA

[1]. ANA. (2014). Agencia Nacional de Aguas. En Codificación de Hoyas Hidrograficas por el Método de Otto Pfafstetter (pág. 8). Brasília.

[2]. Aparicio, F. (1992). Fundamentos de Hidrologia de Superficie. Mexico: LIMUSA S.A. de C.V.

[3]. AYALA, L. (1973). Análisis de frecuencia de datos hidrológicos mediante computación. Santiango. Chile: Facultad de Ciencias Físicas y Matemáticas, Departamento de Obras Civiles.

[4]. BOBEE, B. R. (1977). The use of the Person type 3 and Pearson type 3 distributions revisied. Water Resources Research 13.

[5]. CHOW, V., & MAIDMENT, D. y. (1994). Hidrología Aplicada. Traducido por Saldarriaga. J. Bogotá: McGraw-Hill.

[6]. Froilan, F. B. (1985). Hidrologia General. Habana: Editorial Científico-Técnico.

[7]. KITE., G. (1976). Reply to comment on "Confidence limits for design events". Resources Research 12.

[8]. Monsalve, G. (1999). Hidrología en la Ingeniería. México: Alfaomega Grupo Editor S.A. de C.V.

[9]. NAVARRO, M. A. (2007). Estimación de funciones de distribución de probabilidad, para caudales máximos, en la región del Maule. Memoria para obtar al título de Ingeniero Forestal. Chile: Escela de Ingeniería Forestal.

[10]. Pfafstetter, O. (2014). Codificación de Hoyas Hidrograficas por el Método de Otto Pfafstetter. Brasília.

[11]. Sauer, T. (2013). Análisis Numérico. México: Pearson Educación.

[12]. Torres, J. M. (1977). http://es.wikipedia.org/wiki/Precipitaci%C3%B3n_%28meteorolog%C3%ADa%29. Recuperado el Viernes 20 de Mayo de 2015

Victor Rogelio Tirado Picado" Precipitation forecast model for hydrological units using artificial neural networks (ANN)." The International Journal of Engineering and Science (IJES), 8.10 (2019): 22-34